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THE JAPANESE SCIENCE AND TECHNOLOGY INDICATOR SYSTEM

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43070023E Tokyo NISTEP REPORT in English Sep 91 pp 1-449

[An Analysis of Science and Technology Activities prepared by the Second Theory-Oriented Research Group, Fujio Niwa, et al; National Institute of Science and Technology Policy (NISTEP)]

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[Text]

Preface

Advances in science and technology (S&T) result in expanding roles for scientific and technological activities in socioeconomic development. It is therefore important to objectively assess S&T activities. S&T indicators are seen as a means of assisting in these assessments. The publication of this report on Japanese S&T indicators, the first of its kind, is in response to this pressing social need. Indicators are developed to quantitatively examine country trends in S&T activities from diverse angles. Moreover, because S&T activities are related in complicated ways and comprise extensive and diverse activities, assessment must be from a long-term viewpoint. The objective of this macro analysis therefore goes beyond the inappropriate compiling of fragmentary indicators.The major objective of this report is thus the development of systematically structured indicators.

In preparing this report efforts have been made to systematically construct S&T indicators by collecting and classifying related data based on this system. S&T indicators have already been published in the U.S., OECD and by other governments and organizations. UNESCO studies are also available in providing indicators covering, in particular, developing countries. However, classification is often in input/output form, and moreover an integrating system is often lacking.Therefore there have been criticisms such as the criteria for selecting of indicators is not clear or that only easy-to-collect data are used. The development of indicators attempted in this report is designed to respond to such criticisms. The indicator system and the specific indicators themselves are believed to exceed many of those now available. The present indicator system structure referred to here is called the *cascade structure*. The Introduction which follows outlines the characteristics and objectives of the cascade structure.

In addition to development of indicators, this report also has the following characteristics. Based on the system, new indicators are developed which were previously not in existence. For example most of the indicators presented in the chapter on science, technology and society (Chapter 8) are not found in similar works. Also, in other chapters several new indicators have been developed and added and novel analyses regarding existing indicators is presented. For example, Japanese R&D trends are clarified in the context of the international community from a multilateral viewpoint. Moreover, in conducting international comparisons, the report attempts to adhere to international standards as much as possible.

Much time and effort has been spent in developing specific indicators and preparing this report. Collecting diverse and acquiring up-to-date statistical data and preparing and analyzing tables based on such data is a time consuming process. Despite these constraints, this indicator report has been published for the first time in Japan. Science and technology indicators would be meaningless if they are published only once, therefore the writers would like to receive frank opinions and criticisms from readers for future editions. The hope is to receive the opinions of others in order to improve future editions. Fortunately this report will be published regularly allowing for this exchange of opinions and suggestions to contribute to future reports.

In preparing this report, a Science and Technology Indicators Study Group has been established within the National Institute of Science and Technology Policy (NISTEP) as of January 1990. Members examined and presented diverse opinions and cooperated in many ways such as reading and checking the prepared manuscripts. Their names are listed on the following page. We would like to express our appreciation for their assistance and advice.

Science and Technology Indicator Study Group

Members *

Professor Y. Nishikawa	Kyoto University, Department of Engineering
Professor K. Uno	Keio University, Multidisciplinary Policy Department
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This report has been prepared by the Second Theory-Oriented Research Group. A major work such as this however is not accomplished by just one research group made up of several members. It is a result of cooperation by many NISTEP members. Below are the names of those who cooperated directly in the writing of this report. We would like to express our appreciation to them.

Contributing Authors

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We would also like to express appreciation to NISTEP's Information Division for their efforts in collecting data, inputting them into the computer, conducting analyses and preparing many of the tables.

INTRODUCTION

HISTORY OF S&T INDICATOR DEVELOPMENT

0.1 System of S&T Indicators

0.1.1 Indicators

An indicator is a group of statistical values that together give an indication of an object's state. Population is a well known indicator of national power and GNP of economic activities. Hence, if a scalar quantity such as population or GNP can represent the object's state it is considered an appropriate indicator. However, the state of an economy cannot be represented using a single quantity, thus the limitation of GNP as an indicator is reflected in the fact that it is not being used as often as before.

The same applies when trying to understand the state of a country's science and technology (S&T) activities. S&T activities cannot possibly be grasped using a single indicator. Because S&T activities are complicated and their supporting infrastructure and scope of influence extensive, they must be viewed from a long-term viewpoint.

Given such circumstances the object's many facets must be represented using a number of quantities. The S&T indicators developed in the U.S. or by OECD have been constructed based on such an idea. However, understanding the nature of an object in question using a number of indicators requires examination of the following issues: appropriateness of indicators, mutual relationships, comprehensiveness of measurement, measurement objectives and construction priorities. In satisfying such requirements it is necessary to establish indicator development principles. Required is systematic development of S&T indicators.

If indicators are systematically developed, each indicator's significance can be clarified based on its relative position in the system. Even if it becomes impossible to develop the initially planned indicator, it becomes possible to judge what the best alternative indicator will be. Also, by combining indicators according to an integrated system it becomes possible to construct integrated indicators which measure such things as internationalization or harmony between science, technology and society. In fact indicator users often demand integrated and concise representation. Yet combining indicators in this way requires utmost care and detailed examination. For example the most extreme example of simplification is to represent the state of a country's S&T using a single indicator.

The importance of developing a S&T indicator system is outlined below.

(1) The increasing importance of S&T activities is not only confined to issues of industrial growth but also to social development. An indicator system which accurately reflects the macro aspects S&T activities will not only contribute toward quantitative assessments but will also be useful in formulating and evaluating S&T policies.

(2) The growing influence of Japan's S&T activities are increasingly international. With this growing influence come higher expectations from abroad for Japan to contribute in the area of S&T. Japan can contribute in the area of policy studies and aid in seeking appropriate solutions for S&T issues by conducting quantitative international comparisons or presenting objective data. Moreover, while there is recognition of the importance of S&T in developing countries, the reality is there is a lack of necessary statistical data. Japan can contribute by exchanging information on S&T indicator development and use of S&T indicators.

(3) There has been a strong tendency for existing S&T indicators to be constructed using easy-to-collect data. Many have dealt with the input side of R&D such as R&D expenditures and number of R&D scientists and engineers. These do not allow a balanced assessment of S&T activities as a whole. Also, due to lack of a systemic viewpoint there has been a tendency to lack

consistency in evaluating indicator importance. In approaching these problems it is meaningful to set forth the concept of systematizing indicators. Moreover systematization will serve of charting and analyzing the relationship among indicators. If the relationship among a great many indicators can be clarified, the use of an indicator system is believed to be of great significance.

0.1.2 Principles in Systematizing S&T Indicators

What must first be considered in systematizing S&T indicators are Objective and Function. Indicator use can roughly be divided them into reporting, judgement and evaluation type indicators.

(1) Reporting type : These indicators are designed to present a balanced and quantitative representation of the state of S&T activities as a whole. They will enable quantitative assessment of the state and direction of change of a country's S&T activities. These indicators are believed to be useful in identifying problems at an early stage and thus become basic data in formulating S&T policies and in understanding S&T activities.

(2) Judgement type : This purpose is achieved by combining indicators using a number of indicators for specific purposes (such as for measuring the degree of internationalization or harmony between science, technology and society or for comprehensive assessment). The value of such indicators will represent for example the degree of internationalization (international comparison) or harmony between science, technology and society (time-series analysis). Such indicators are expected to comprehensively represent the level of S&T activities or policy objectives.

(3) Policy Evaluation type : This requires a sophisticated knowledge of the relationship among indicators (e.g. causal). Based on such knowledge, implementation of specific policies is understood quantitatively and the indicators are expected to enable evaluation of the policy's effects and progress.

Table 0-A shows the objectives and likely functions of S&T indicators.

Table 0-A. Objectives and Functions of S&T Indicators

FUNCTION / OBJECTIVE	General macro understanding	Early identification of issues	Establishment of policy goals	Evaluation of policy
REPORTING	○	○	×	×
JUDGEMENT	○	○	○	×
EVALUATION	○	○	○	○

Note : A (○) indicate the indicator type serves the given function,
a (×) indicate the indicator type does not serve the given function.

Since this is the first attempt in Japan to systematize science and technology indicators and because the type of indicators to report the present state is the basic type this report presents a reporting type of indicator system. The basic ideas in systematizing indicators can be summed up as follows.

(I) Rather than just dealing with R&D activities the report sought to cover science and technology activities in general.

In the past science and technology indicators have mainly dealt with R&D activities. The actual R&D activities however are carried out based on extensive and multi-layered S&T support infrastructure. The scope of the influence of these achievements are long term and extensive including direct outcomes such as academic papers and patents as well as indirect outcomes which give impact on society through production processes and may even public opinion. While the indicator system mainly covers R&D activities it also covers the infrastructure and influences.

(II) Classification scheme of objectives should be built into the scheme of activities.

S&T activities are made to achieve diverse objectives. It is not possible to view S&T activities apart from their objectives. The study has attempted to classify indicators by infrastructure and impact (such as "S&T infrastructure" or "contributions of S&T" as will be mentioned later). The connection between infrastructure and impact is also viewed in the form of a hierarchical structure of ends and means. Only such an approach will enable identification of problems at an early phase and facilitate the use of indicators in evaluating S&T policies.

(III) S&T activities should be analyzed in term of infrastructure and impact.

The concept of input and output is used in economics. However, since R&D activities deal with the unknown, the input/output concept is inappropriate. In contrast the concept of infrastructure and impacts is believed more appropriate as it does not establish a fixed input/output relationship. Hence the report divides S&T activities into R&D infrastructure and R&D impacts.

(IV) Due consideration should be paid to stock and subjective as well as flow and objective indicators.

Most of the indicators developed to date have been objective, quantitative and flow indicators (for example R&D expenditures is an indicator having all three of these characteristics). These indicators are easier to measure, highly reliable and easy to use. However it is difficult to see S&T activities in a larger framework using only these indicators. It is necessary to compensate for their defects by actively using subjective indicators (such as popular opinion regarding S&T), qualitative indicators (such as evaluation regarding technological levels) and stock indicators (such as R&D facilities used).

(V) The indicator system should not solely rely on the available data

Many of the available S&T indicators have relied on statistical data collected for administrative purposes. Such data however are collected for purposes other than to grasp a country's S&T activities as a whole. This report developed an indicator system which did not solely rely on available administrative purpose data but collected original data, using other available data and international data bases.

(VI) Indicators should be classified according to purpose

It is impossible to classify all the indicators using a single classification system (such as industrial classification). Classification systems most suited for the the particular indicator purpose are developed. In conducting analyses however it is desirable to use a single classification system. Hence a single classification system was used for each area. For example, classification is made by research area in the case of knowledge production indicators, academic classification in the case of educational indicators and industrial classification in the case of economic activity indicators.

0.1.3 S&T Indicator System Cascade Structure

The report develops S&T indicators systematically based on their objectives and functions and includes basic ideas regarding their development and on selection criteria. In carrying out the work two methods were used--the bottom-up method of randomly proposing indicators by organizing a study group of experts (references 1 through 8) and the top-down method of starting from the indicator theoretical structure which includes classification by sub structure. In addition, the report also uses available S&T indicators, statistics and papers on S&T indicators.

As a result of such work, the following structure of indicators was obtained (Figure 0-1-1).

Indicators are arranged to take on characteristics of a waterfalls where indicators are arranged in a series of stages whereby each stage derives from or acts upon the product of the preceding stage. Hence the name cascade structure (see Note). The original system consists of a total of 103 individual indicators.

As the figure shows the structure consists of the following six major categories.

(1) Societal infrastructure: The indicators which belong to this major category indirectly support the country's S&T activities.

(2) Scientific and technological infrastructure: The indicators in this category indirectly support the country's R&D activities. This is made up of three sub-categories; "educational", economic, and cultural infrastructures.

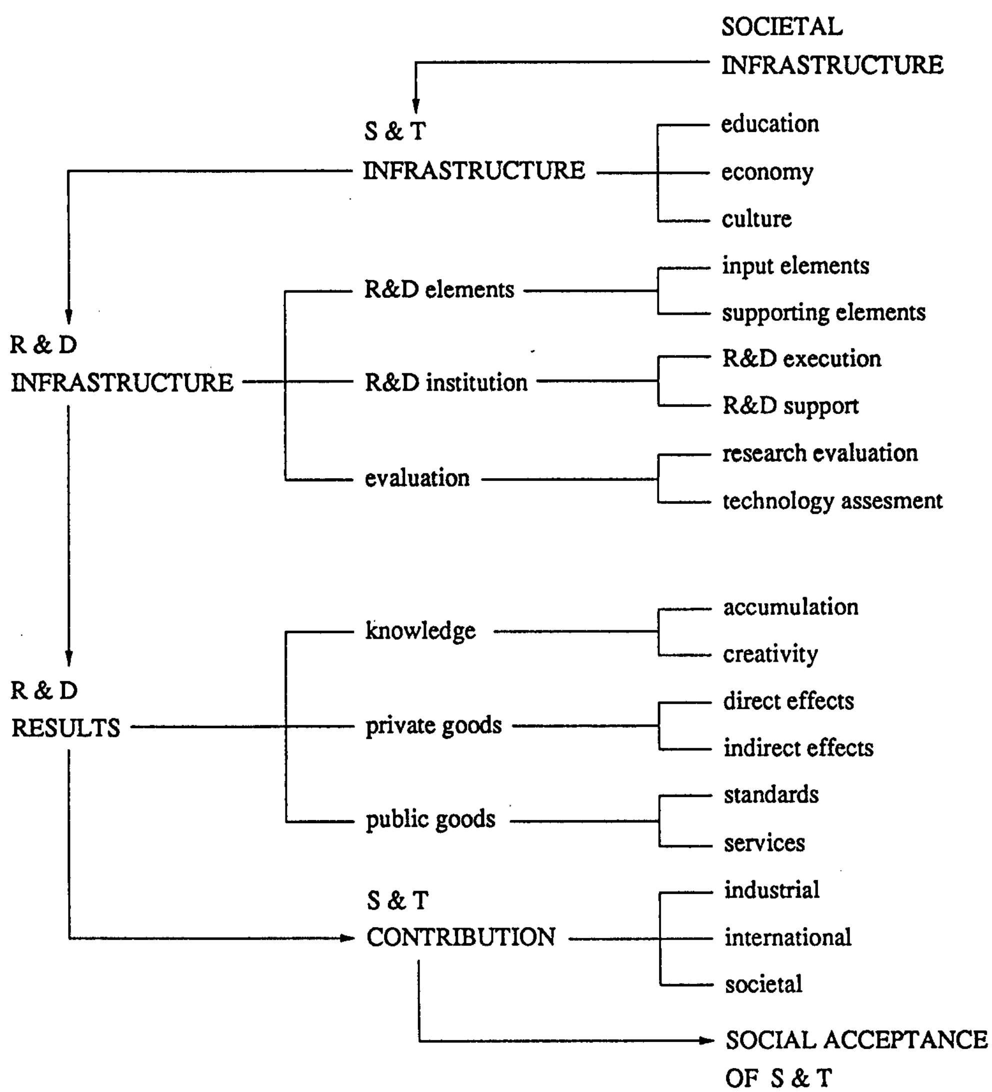
(3) Research and Development infrastructure: The indictors in this category directly support R&D activities. This major category is comprised of three sub-categories; (a) "R&D elements" such as manpower and funds, (b) "institutional framework," which organizes these system elements for a specific purpose, and (c) "evaluation scheme," which determines how effectively R&D activities will be performed.

(4) R&D results: The direct results of R&D activities are comprised of knowledge values. The three subcategories include "knowledge value" such as scientific and technical papers, "private goods value" such as patents and "public good value" such as standards.

(5) S&T Contribution: The indirect results of R&D activities, made up of industrial contributions are reflected in this category. This is divided into three levels of contributions, i.e. industrial, international and societal.

(6) Societal Acceptance of S&T: The indictors in this category measure the indirect impacts of S&T on society and their acceptance.

Figure 0-1-1 Cascade Structure of the Science and Technology Indicator System



The following five criteria were used in selecting S&T indicators:

(1) Causality and relevancy: in terms of causality, the more the indicator is located at the center of the indicator system (Figure 0-1-1) the closer it is associated with R&D activities. Also, the relationship between causality and relevancy is closer the closer the indicators are to each other. In terms of relevancy, the more the indicator is located away from the R&D activities at the center, the less the direct relationship and the more the long-term relationship.

(2) Distribution of indicators: more indicators were arranged at the center of the system and less at the ends. This means that the number of indicators was determined in proportion to the size of their relationship with S&T activities.

(3) Indicator level: the indicators are all constructed using directly measured data and do not include integrated indicators. Efforts were made to enrich the stock and flow quantity comprising time series of flow quantity. Efforts were also made to enrich subjective data.

(4) Classification method: efforts were made to use typical classification methods (such as speciality area, characteristics of R&D, academic field, industrial sector, organizational categories i.e. industry, academia and government). Also, appropriate classification levels were used.

(5) Data: The data used in this report are highly accurate, accessible and impartial. In constructing indicators newly collected data, as well as processed/available and unprocessed/available data are used.

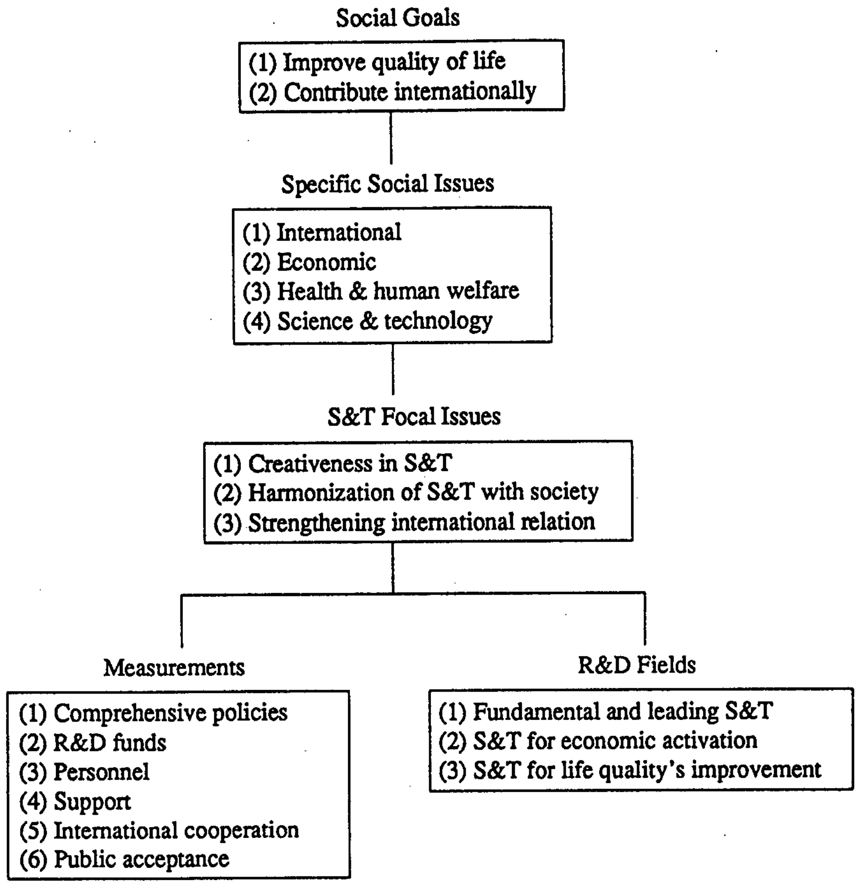
0.1.4 Relevance to S&T Policies

Be it a policy reporting, judgement or evaluation type of indicator, the S&T indicator system is expected to contribute toward formulation and evaluation of S&T policies. In examining how S&T indicators can contribute in the process of formulating policy it is first necessary to analyze the policies.

Needless to say policies are always formulated keeping in mind the limits of a system. This is because a policy must be structured with ends and means and because its objective has some kind of structure. Decision-maker(s) should be clearly aware of the ultimate objectives and have sorted out the means of achieving those objectives. A clear awareness of their relationship and the necessary cost and likelihood of achievement should be kept in mind. An examination of the 11th Recommendation of the Council for Science and Technology will clarify such a structure (see Figure 0-1-2). The Council is now working on the 18th Recommendation, a follow up to the 11th. While differing in format, the 18th Recommendation follows the same principles as the previous one thus allowing for compatibility.

The 11th Recommendation was presented in 1984 and later adapted as the General Guidelines for Science and Technology Policy. Figure 0-1-2 clarifies this hierarchical structure made up of social goals, specific social issues, S&T focal issues, and measurements and R&D fields. In this structure the items become more goal-oriented, general and abstract toward the top, and more means-oriented, individual and specific toward the bottom. Such a structure is nothing but a system of ends and means. It also shows that factors other than science and technology become more influential toward the top and the tendency that the item can be handled within the scope of S&T policies strengthens toward the bottom. For example, social goals are achieved not only through S&T policies but through integrated management of diverse economic, industrial, social, cultural, international and regional development policies. Compared to social goals, specific social issues are more short-term and specific, they also require inputs from diverse policies. In contrast, while S&T focal issues or measurements are designed to address social goals or national goals, they can be handled within the scope of S&T policies.

Figure 0-1-2 A Structure of Science and Technology Policy



Specifically examining policy structure shows that the 11th Recommendation does not use the term "social goals" even once. The term is also almost never used in Japanese theories on policies. However there are two items which are closely used in the same sense when discussing "social goals". These are "improving quality of life" and "contributing internationally".

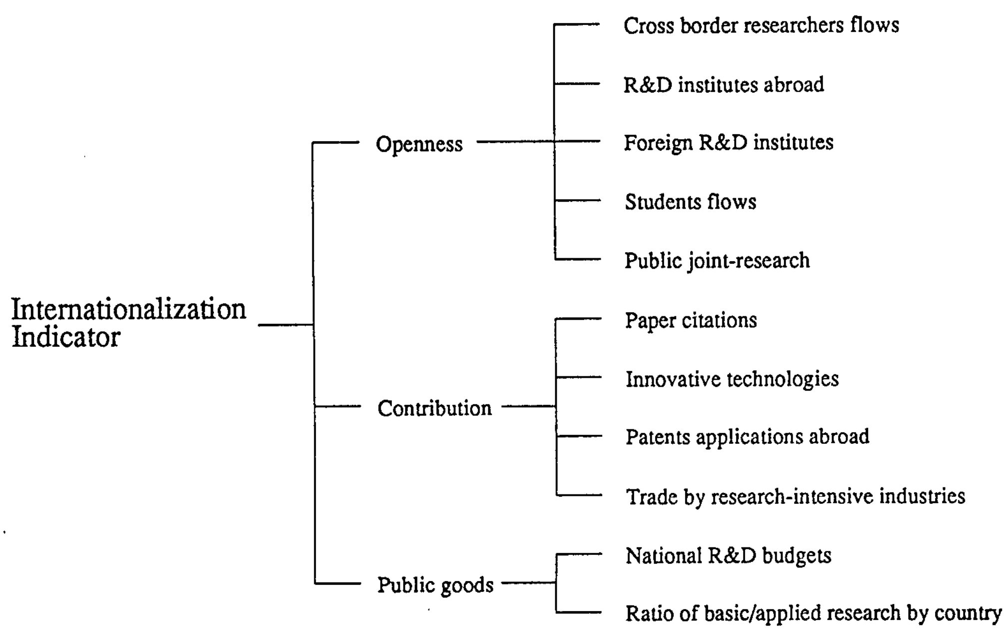
Next, the Recommendation discusses specific social issues in the form of major issues or problems associated with Japan. Conversely these can be seen as the social issues to be solved by Japanese society. They can be seen as somewhat medium-term issues. As specific areas the recommendation points out the international environment, the economy, health and human welfare and science and technology.

In addressing these issues the recommendation points out promotion of creativeness in S&T, harmonization of S&T with man and society, and strengthening international cooperation as being the S&T focal issues for Japan. Six measurements and three R&D fields are also pointed out in achieving these S&T policy goals.

Looking at the relationship of S&T policy with S&T indicators shows that first, social goals and specific social issues cannot be represented solely through S&T indicators. Perhaps it will be necessary to represent the degree of social goal achievement or the specific social issues in combination with other indicators such as economic or social. Hence it is believed necessary to examine this issue after the system of S&T indicators has been established.

Pending questions related to S&T indicators are found in the strata of S&T focal issues. Key words related to S&T focal issues are creativity, harmony with society and internationalization. It is not appropriate to represent these concepts using single indicators. This is because they cover broad and diverse areas. Hence it will be necessary to construct integrated indicators using strongly related ones. For example, the indicator reflecting internationalization may have to cover three areas of "openness" for the environmental factor, "contributions" for the results factor and "public goods" for the degree of contribution of S&T in the international public goods-like area. Based on such an idea, the structure as shown below is an example of an integrated indicator reflecting the degree of internationalization of S&T in Japan (see reference 3 and Figure 0-1-3).

Figure 0-1-3 An Example Integrated Indicators for Internationalization



Perhaps it is appropriate to divide the creativity indicators into "creativity development infrastructure" indicators to represent the state of development of the environment reflecting creativity and "creative effects" indicators to represent the "results" of creativity. In measuring harmony with society a subjective indicator of how people understand the positive and negative effects of S&T is believed necessary in addition to objective indicators such as the rate of recovery from highly fatal diseases.

Such issue-oriented integrated indicators often cannot be constructed solely using the indicators included in the indicator system. This is because the indicator system designed for long-term and overall assessment often cannot cope with issue-oriented indicators which are constructed with clear problem-awareness. In such cases it will be necessary to construct the indicator by including those not included in the system and by collecting data most suited for the issue.

Lastly, policy measures and areas covered can more or less be addressed with individual indicators by specific area. It becomes possible to grasp the present state of S&T activities, assess trends and future policies through time-series analysis. Also it is possible to discover problem signs through international comparison and measure the policy effects by comparing the before and after of policy implementation.

0.2 History of Development

The impetus for research in Japan to develop S&T indicators was the Science and Technology Indicator Study Group started in September of 1984 within the Science and Technology Agency's National Institute of Resource Studies (now the National Institute of Science and Technology Policy). The group was chaired by Professor Yoichi Kaya of Tokyo University and proposed a draft of the S&T indicator system presented in the previous section. The group also published "Report on Development of Science and Technology Indicators" in October 1985 with the cooperation of the Watanabe Memorial Foundation for Promotion of New Technology.
On this basis the council's technology committee, an S&T indicators subcommittee was established (also chaired by Professor Kaya) in November 1985 and further developed the indicator system and examined its use. The contents were submitted and approved on November 25, 1986, as the Science and Technology Agency, "National Institute of Resources' Report No. 104". With this beginning the Science and Technology Agency became involved full-scale in promotion in the development of Japanese S&T indicators.

The report mandates a three year program to examine the nature and method of data collection in constructing the 103 indicators which would comprise the indicator system. An interim report was published in October of 1987 which examined 44 of the 103 indicators. At the same time the group studied the S&T indicators constructed by the National Science Foundation (NSF) of the U.S. and published a report titled "Report of Science and Technology Indicators in the United States" in January of 1987 also with the cooperation of the Watanabe Memorial Meeting for Promotion of New Technology. The "Study of Comparison of R&D Activity Statistics in Western Countries and Japan" was also published in March of 1987 by commissioning a study of S&T indicators in Western countries to the Institute of Future Technology. Finally, based on these results the "Study of Methods to Compare R&D Activity Statistics in Western Countries and Japan" was published in March 1988.

As data and knowledge on S&T indicators were accumulated, in July 1988 the National Institute of Resources was reorganized into the National Institute of Science and Technology Policy (NISTEP). One of the purposes in establishing NISTEP was to develop S&T indicators and this was mainly to be carried out by the Second Policy-Oriented Research Group. Ever since, the indicators have been developed mainly by the S&T indicator study group chaired by Professor Keichi Nishikawa of Kyoto University by obtaining the cooperation not only of the Second Policy-Oriented Research Group but all NISTEP members.

0.3 Report Profile

This report has been prepared in the framework described above. Composition is considerably different from the initially submitted system. There were several reasons. One was that since the report was designed to be read, therefore sole description is believed inappropriate. For the same reason some of the proposed indicators were omitted.The second reason was that data initially believed accessible proved difficult to collect. Moreover, as a result of reexamining the contents of the initially proposed indicators some were found inappropriate On the other hand new indicators were added that were not in the original structure. Throughout the examination and review, the indicator system's cascade structure was very useful because indicator significance and roles could be understood from their relative position in the system and subsequently alternative indicators could appropriately be evaluated (refer to Figure 0-1-1).

The following is a brief description of each chapter contents.

0 Introduction: History of S&T Indicator Development

Explanation S&T indicator system, study and research and report contents.

1 Overview of Science and Technology Activities in Japan

Summary of Chapters 2 through 9.

2 Human Resources Development in Science and Technology

Presentation of indicators related to the most important infrastructure of S&T activities namely primary and secondary education, higher education and careers of those completing higher education. In terms of this chapter in relation to the indicator system, (Figure 0-1-1) this chapter deals with (2) S&T infrastructure indicators related to the educational infrastructure.

3 Supports for R&D

Analysis of the government's R&D budget as an infrastructure directly supporting S&T as well as presentation of indicators related to learned societies and related foundations as comprising societal support. As regards the government's R&D budget, the report pursues the possibility of international comparison by, for example using the OECD classifications by socioeconomic goals. In terms of the indicator system this chapter deals with (2) S&T infrastructure indicators related to social and economic infrastructure.

4 R&D Activities in Industry, Academia and Government

Indicators for R&D human resources, R&D expenditures and number of R&D institutes are constructed and presented as direct inputs of S&T. these are divided national inputs as a whole (including for international comparisons), businesses, academia and government. This chapter deals with indicators related to (3) R&D infrastructure.

5 Regional R&D Activities

Promotion of R&D activities in local areas has become an important policy issue. This chapter constructs and presents indicators of R&D activities in local areas which is a novel attempt not reported previously in Japan. In terms of the indicator system the indicators in this chapter refer to (3) R&D infrastructure and are analyzed by region.

6 Achievements of R&D Activities

Not many indicators have been developed regarding results of R&D. Concerted efforts were made to develop results-related indicators. In particular thee is a rich base of indicators related to scientific and academic paper citations and patents. Moreover, by adding indicators related to an science and technology awards and standards, the report presents indicators unique internationally. In terms of the indicator system the chapter deals with indicators related to (4) R&D results.

7 Internationalization of R&D

Indicators were constructed regarding internationalization of R&D. Both infrastructure- and results-related indicators are included such as researcher and engineer exchanges, holding of international conventions related to S&T, number of corporate R&D facilities abroad and of foreign affiliated research facilities in Japan, technology trade and internationalization of academic papers. A questionnaire survey of foreign firms conducting R&D activities in Japan was also conducted and regarding other indicators, innovative approaches were taken in constructing them and representing the results in tables. In terms of the indicator system the chapter deals with internationalization indicators related to (3) R&D infrastructure and (4) R&D results as well as (5) S&T contribution indicators related to international issues.

8 Science, Technology and Society

While parts of Chapters 6 and 7 report on direct result indicators of S&T, this chapter deals with indirect results. Chapter 8 is made up of four parts namely contributions to industry, impacts on life styles, contributions toward conservation of the global environment and effects of S&T on culture. Since these all deal with a wide range of effects it is difficult to construct integrated indicators. Hence the chapter used the method of selecting representative indicators and providing the explanation using them. Most of the indicators presented in this chapter reflect an full-fledged attempt to bring together indicators not reported in this way before. In terms of the indicator system the chapter deals with indicators related to (1) S&T's social support infrastructure and (5) contributions of S&T of the indicator system.

9 Public Opinion on Science and Technology

Based on an opinion polls of S&T, this chapter constructs and presents indicators related to understanding and perceptions regarding S&T in general and in individual areas of S&T such as information and life sciences. In terms of the indicator system the chapter deals with (6) Societal acceptance of S&T.

CONCLUSION : Outlook for Science and Technology Indicator Development

Based on the experience developing S&T indicators and by with the expectation that the indicator report will be published regularly in the future, the chapter sorts out and discusses future issues such as improvements of the statistical data related to S&T, further enrichment of the indicators themselves, development of data bases and international cooperation in developing indicators.

CHAPTER 1

OVERVIEW OF SCIENCE AND TECHNOLOGY ACTIVITIES IN JAPAN

CHAPTER 1

AN OVERVIEW OF SCIENCE AND TECHNOLOGY ACTIVITIES IN JAPAN

This chapter provides an overview of Japan's scientific and technological activities. It is a summary of Chapters 2 to 9 from the original report. Each section number in this summary corresponds to its respective chapter number from the original. Section 1. 1 of this summary chapter, however, corresponds to Chapter 4 Section 4. 1 "R&D Investments and Activities" thus, Section 1. 4 corresponds to Chapter 4, Sections 4-2 to 4-4 of the original. All other sections correspond to their respective chapters.

1.1 R&D Investments and Activities

This section looks at the basic components of national R&D structure: expenditures and personnel. The focus is on R&D expenditures and the number of R&D Scientists and Engineers (R&D S/E) in time series and also through international comparison. International comparison, however, calls for the modification of Japanese R&D data using a Full-Time Equivalent (FTE) conversion ratio; a convention used in OECD S&T data to determine the actual number of R&D personnel. Estimates of R&D expenditures and number of R&D S/E in Japan converted to FTE figures are provided at the end of this section.

National R&D Expenditures

Since national R&D expenditures are reported in each country's respective currency, comparisons are made by converting the data using purchasing power parities (PPP). Figure 1-1-1 indicates the United States spends an amount far exceeding other countries for R&D (26.5 trillion yen in 1989). Japan follows with 11.8 trillion yen, representing 44.6 percent of the R&D in the United States. The increase in Japanese R&D expenditures, almost nine-fold in the past two decades, surpasses the increases in other countries, particularly in the 1980's. The exception of 1985-86 reflects depreciation of the yen relative to the dollar which caused a decrease in absolute terms. The increase after 1986 has been far greater than the preceding period. Meanwhile, the growth rate of R&D expenditures in the United States has stagnated since 1985.

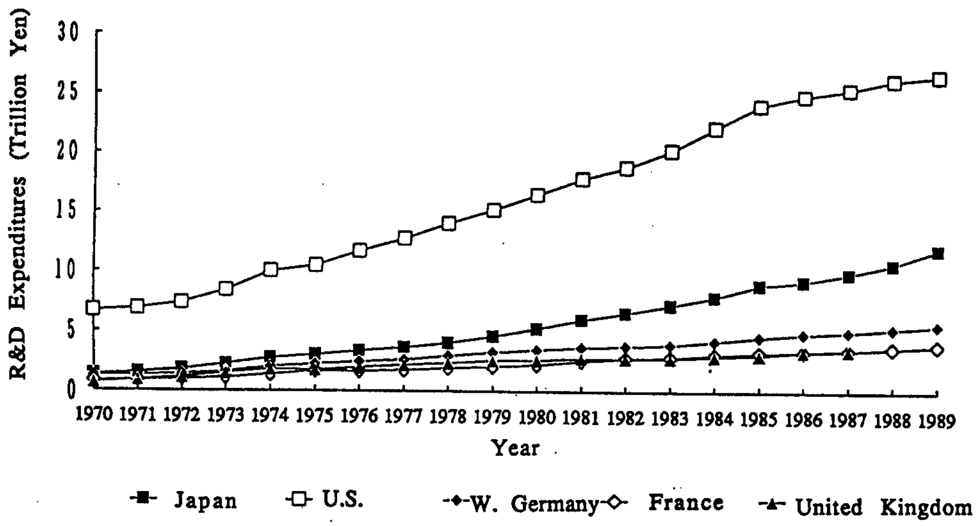
The relative amount of R&D expenditures in the national economy can be measured by their proportion to GNP (Figure 1-1-2). In the case of Japan, the ratio of R&D expenditures to GNP increased from 1.8 percent in 1970 to over 2.5 percent in 1983, and has remained approximately at that level. In the United States, the ratio of R&D to GNP has been declining slightly in the past two decades. The result in this decline in R&D expenditures shows the US being surpassed by Germany in 1974 and by Japan in 1983. In the United Kingdom, meanwhile, the share of R&D to GNP has decreased by 0.2 percent from 1980 to 1982. It has been recording slight increases since 1983, but has not recovered to the 1980 level.

A Noted feature of R&D expenditures in Japan is the relatively small amount of R&D expenditures related to defense. Concerning R&D expenditures for civilian purposes, the United States' amount of 18.4 trillion yen is much greater than that of other countries. Japanese civilian R&D expenditures (11.8 trillion yen) are almost equal to the total R&D expenditures, but still lags behind the United States total by about 7 trillion yen. It is thus evident that the United States is also dominant in civilian-use R&D.

R&D Expenditures of Industrial, Academic and Government Sectors

In comparing R&D expenditures by sectors (industrial, academic and government), two aspects need to be examined; providers of resources for R&D (sources), and users of such resources (performers). Focusing on R&D sources, industry is the major contributor in Japan (about 70 percent) and in Germany (about 60 percent).The importance of the industrial sector in

Figure 1-1-1 National R&D Expenditures in Selected Countries



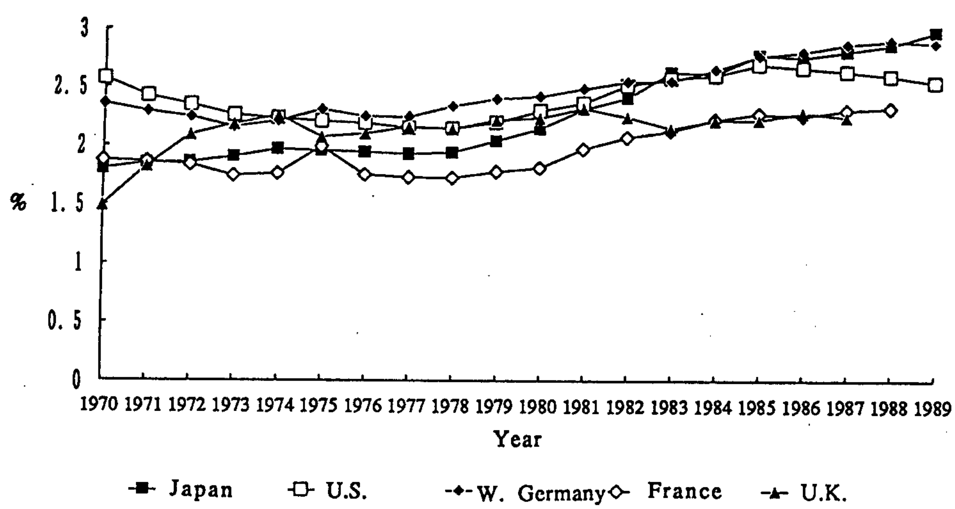
Science and Technology Agency, "White Paper on Science and Technology"

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

OECD, "Main Economic Indicators", 1989 ık," 1991.

OECD, "International Sectorial Data Bank", 1991

Figure 1-1-2 Ratio of R&D Expenditures to GNP in Selected Countries



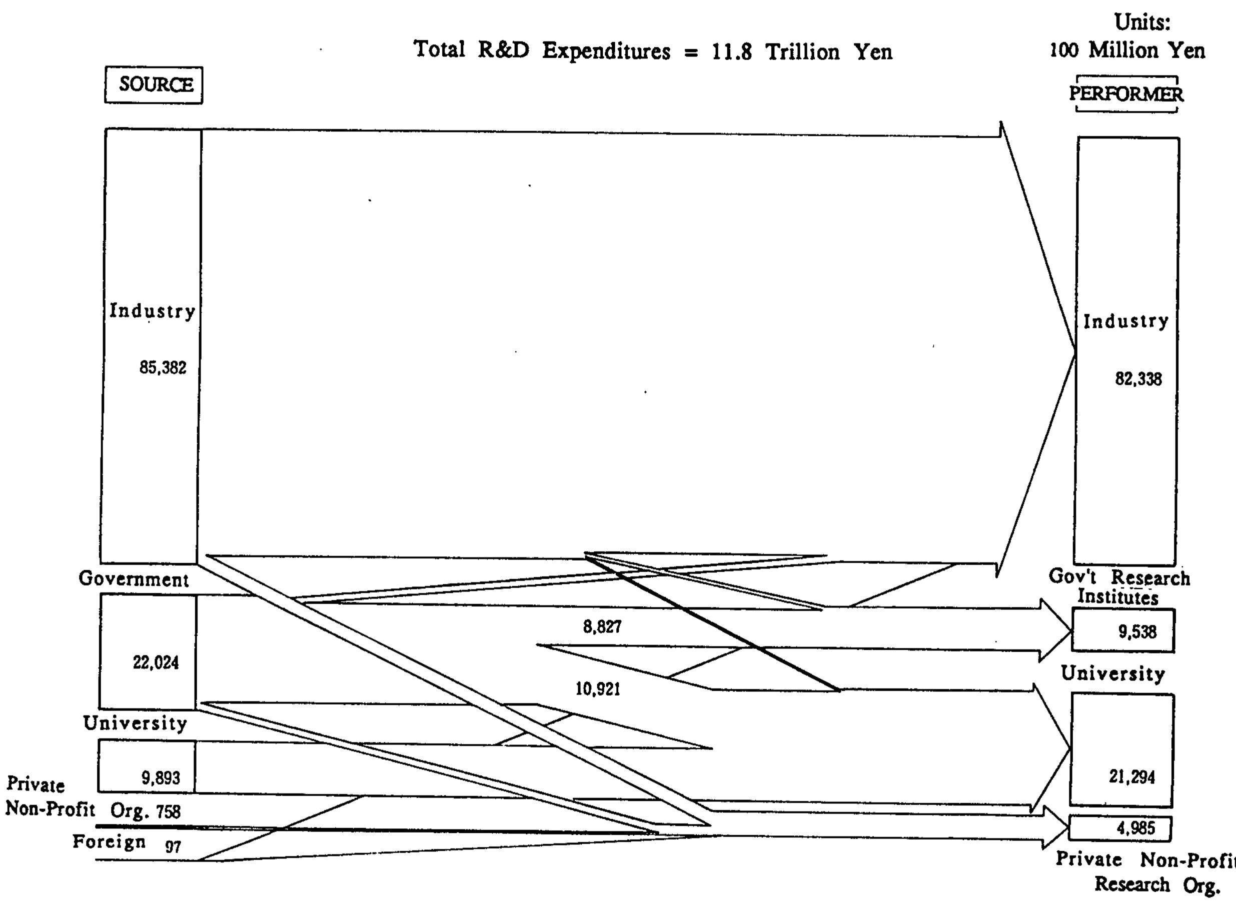
Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"

Science and Technology Agency, "White Paper on Science and Technology" those two countries (40-50 percent) far exceeds the role played by this sector in other Western countries. Government bears the largest share in France (just over 50 percent), followed by the United States and the United Kingdom. Thus, it becomes clear that in Japan, the proportion of the R&D borne by government is small compared to other Western countries. Furthermore, the Japanese government's share in R&D has fallen almost 10 percentage points in the past 10 years.

Industry uses the largest amount of R&D resources both in Japan and the United States.In Japan, industry's share in R&D has increased by almost 10 percent, up from just over 60 percent in 1970 to nearly 70 percent in 1989. This tendency has even accelerated since 1987, whereas the share of academia (colleges and universities) has been constantly decreasing, down by 9 percentage points in the same period. In the United States on the other hand, industry takes up a slightly larger share than in Japan with over 70 percent in 1989. Over time, industry's share has either remained static or has recorded minimal increases.

R&D expenditures flow from source to performer as shown in Figure 1-1-3. In Japan, industrial R&D expenditures are borne almost entirely by industry. Thus, while a large part of Japanese R&D resources flow from industry to industry, in the United States a large amount of R&D

Figure 1-1-3 Sectorial Flows of R&D Expenditures by Source and Performer (FY 1989)



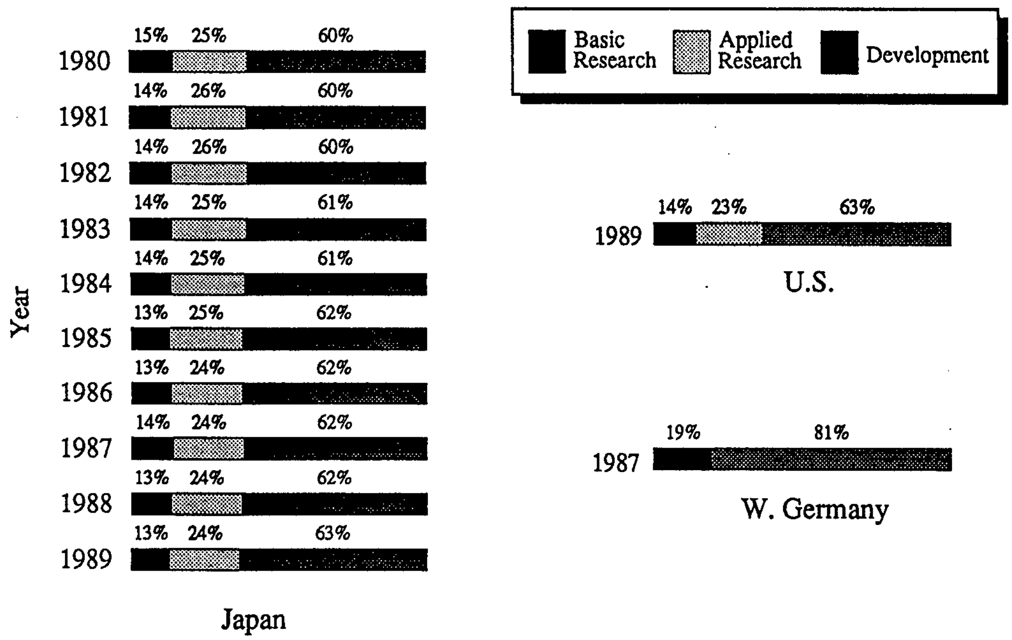
Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"

resources flow from government to industry. In 1989, over 50 percent of governmental R&D resources were provided to industry, representing about 30 percent of total industrial R&D expenditures. It can therefore be observed that the U.S. government provides a much larger proportion of industry's R&D expenditures than in Japan. Similarly, considerable flows of R&D resources from government to industry are recorded in Germany, France and the United Kingdom.

National R&D Expenditures by Characteristic of Work

R&D activities can be classified into three work characteristics; basic research, applied research and development. Looking at R&D expenditures by R&D characteristics in selected countries (Figure 1-1-4), basic research takes up 13 to 14 percent of total R&D in Japan and the United States, while in W. Germany (1987) and France, the share of basic research amounts to almost 20 percent of total R&D, largely surpassing the levels of the two former countries.

Figure 1-1-4 R&D Expenditures by Characteristics of Work



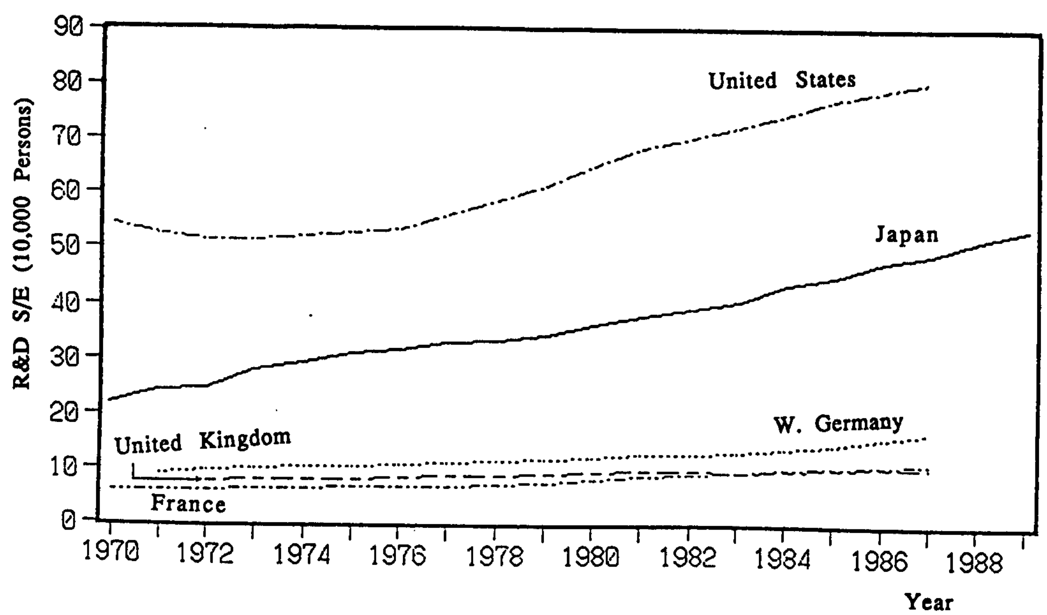
Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"

Since increasing attention is being paid these days to basic R&D expenditures, international comparisons should look at expenditures by sector for Japan and the United States. First, expenditures for basic research in industry represent about 6.5 percent of total R&D in Japan, and about 3 percent in the United States. The share of basic research in colleges and universities in Japan has been declining constantly in the past decade, falling under 50 percent in 1988. In the United States meanwhile, the academic sector uses over 60 percent of total basic R&D expenditures and the share continues to increase.

R&D Personnel

The numbers of R&D S/E in major industrialized countries are as follows; in Japan, 535,000 in 1989 and 560,000 in 1990; in the United States, 950,000 in 1988; in Germany, 166,000 in 1987; and in France, 115,000 in 1988. These numbers show that the United States has far more R&D S/E than the other countries shown. Concerning changes in the numbers over time (Figure 1-1-5), the United States has not only been dominant in the 1970's and 1980's, but it even accelerated the increase since the late 1970's. Japan has the second largest number of R&D S/E, a figure which has been steadily increasing. Looking at the changes in the number of R&D S/E by sector in each country through the 1970's and 1980's, the number has increased both in Japan and the United States in industry by about 200,000, thus contributing to the overall expansion of R&D S/E personnel. On the other hand, the increases in Germany (50,000) and in the United Kingdom (less than 30,000) have been much smaller in scale than Japan and the U.S. In France, the number of R&D S/E in both industry and in government facilities has increased by 20,000 during the same period. Colleges and universities in Japan have recorded a major increase of 80,000 R&D S/E in the past two decades.

Figure 1-1-5 Number of R&D Scientists and Engineers in Selected Countries



Science and Technology Agency, "White Paper on Science and Technology"

In making an international comparison on the number of R&D S/E, their relative number in relation to the labor force and to total population are as important as their absolute number. In this sense, the following two indices have been adopted; the number of R&D S/E per 10,000 employees (hereinafter referred to as number of R&D S/E per labor force) and number of R&D S/E per 10,000 persons (hereinafter referred to as number of R&D S/E per population). Japan is ahead of the United States in each of these two indices. In 1988, the number of R&D S/E per labor force was 83 in Japan and 65 in the United States, while the number of R&D S/E per population was 42 and 33 respectively. Indices in Germany and in France also show upward tendencies.

Finally, because Japan does not adopt the same measurement methods as undertaken in other OECD countries concerning the number of R&D S/E personnel and the amount of R&D expenditures, direct international comparison is difficult. In fact, simple head counting of the number of R&D S/E is used in Japan, whereas other OECD countries utilize a ratio referred to as Full-Time Equivalent (FTE); the number of R&D S/E calculated on the basis of their actual time devoted to R&D activities and thus the FTE concept draws a distinction between R&D and other activities. The result is that in countries like Japan, where the FTE convention is not adopted, the number for R&D S/E and R&D expenditures end up being comparatively overestimated. However, simple head-counting is as important as FTE adjusted statistics. It is thus recommended for Japan to use the FTE concept in addition to the traditional head counting method, and in turn for the other OECD members to report head count as well as FTE adjusted R&D S/E personnel data.

Calculations applying the FTE conversion ratio to the latest Japanese data for the purpose of international comparability are shown. Conversion of Japanese data to FTE adjustments for number of R&D S/E is tentatively made using the following coefficients; 0.7 for R&D S/E in industry, 0.5 for college and university R&D S/E and 1.0 for government sector R&D facilities. As a result, Japan's R&D expenditures for 1990 amount to about 10.1 trillion yen, representing 85 percent of the non-FTE modified figure for R&D S&E cited previously. The ratio of FTE adjusted R&D S/E to GNP is about 2.5 percent (2.9 percent in the non-FTE figure), a similar level to that of the U.S. The number of R&D S/E converted to FTE is about 360,000 in 1990, 65 percent of the original non-FTE calculation, indicating that there are over 50 R&D S/E per labor force, and less than 30 per population; both figures do not reach the U.S. FTE-adjusted levels.

1.2 Human Resource Development in Science and Technology

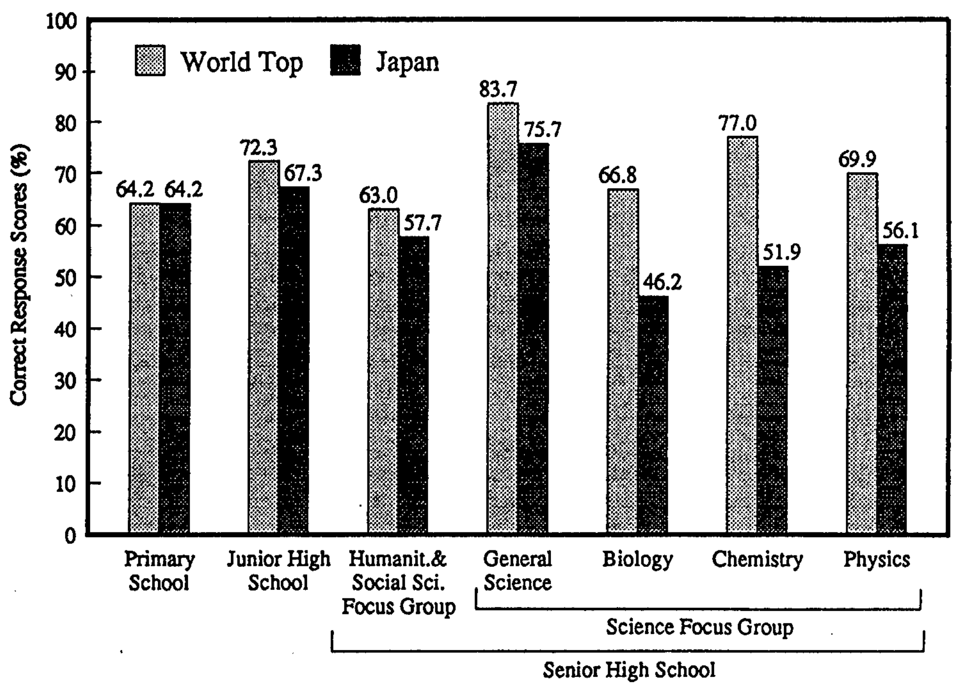
Science and Technology activities are fundamentally nurtured by promotion of human resources. This section looks at trends in three crucial aspects of S&T education: educational achievement in primary and secondary schools, higher education resource trends and employment of graduates from higher education.

Primary and Secondary Education

Science and Technology related curricula are included in the mathematics and science subjects of elementary, junior and senior high schools. In recent years there has been little change in the number of lessons in these two subject areas, which are supervised in accordance to the study guidelines established by the Ministry of Education.

An international comparison of student performance at the primary and secondary levels shows Japanese students outperform all others in mathematics but this favorable position changes in science with performance deteriorating at higher grade levels. In international comparisons of mathematics subjects, Japanese junior high school students have the highest correct answer percentages while senior high students are ranked a close second. In science related subjects, Japanese and Korean student performances are highest at the primary level, while at the junior high level Japan is second to Hungarian students who maintain a slight lead. At the senior high school level, although the performance of students in the Social Science and Humanities-Focus Group is ranked third in Required Science, Natural Science-Focus Students are ranked only between 5th and 11th respectively, with considerable difference in correct answers compared with those who ranked first (Figure 1-2-1).

Figure 1-2-1 Performance in Science Subjects by Primary and Secondary School Students: International Comparison



Source: National Institute of Educational Research, "IEA International Mathematics and Science Education Survey, Midterm Report", 1988

See Table 2-1-3

The installation of computers for pedagogic purposes at the primary and secondary levels is expected to give students more interest in and familiarization with computers thereby raising interest and knowledge concerning science and technology. Computer related education can also contribute to meeting the increasing demand for information engineers by promoting professional capabilities from an early stage. Subsidies for the installation of computers in government elementary and junior high schools have been initiated by the Ministry of Education in 1985 and again more recently. As a result of this governmental support, as of March 1989 more than 20 percent of the elementary schools and almost 50 percent of all junior high schools are equipped with computers. Nevertheless, the number of computers installed in elementary schools is on the average only 3 per elementary school and just over 4 for junior high schools. In commercial and industrial senior high schools, introduction of computers for education started a little earlier than in elementary and junior high schools, and consequently, over 96 percent of those schools are now equipped with computers, though their number per school (just over 25) is still considered to be modest.

Information science courses are expanding at the senior high school level in order to meet changing social demands. At this level of education, both the number of courses related to information science and data processing and the number of students in these courses have nearly tripled from fiscal year (FY) 1980 to FY 1989. Furthermore, as demands for information engineers become more pressing, human resource development needs related to higher education are expected to increase. Because of the expansion of these information science and data processing subjects, the focus of human resource development in vocational education is expected to change.

Technical courses at senior high schools, especially at technical high schools play a fundamentally crucial role in the support of education and development of engineers. The number of students in these schools peaked in 1965, surpassing 620,000 due greatly to the large enrollment of students born in the baby-boom period after World War II. While the ratio and the enrollment numbers in senior high schools have both increased rapidly in the 1960's, the proportion of technical high school students to total students has shown a downward trend after hitting a peak in 1970. A time lag of five years between peaks of absolute number and relative proportion seems to reflect the relative emphasis placed on vocational education in certain prefectures and the general attractiveness of technical high schools in general.

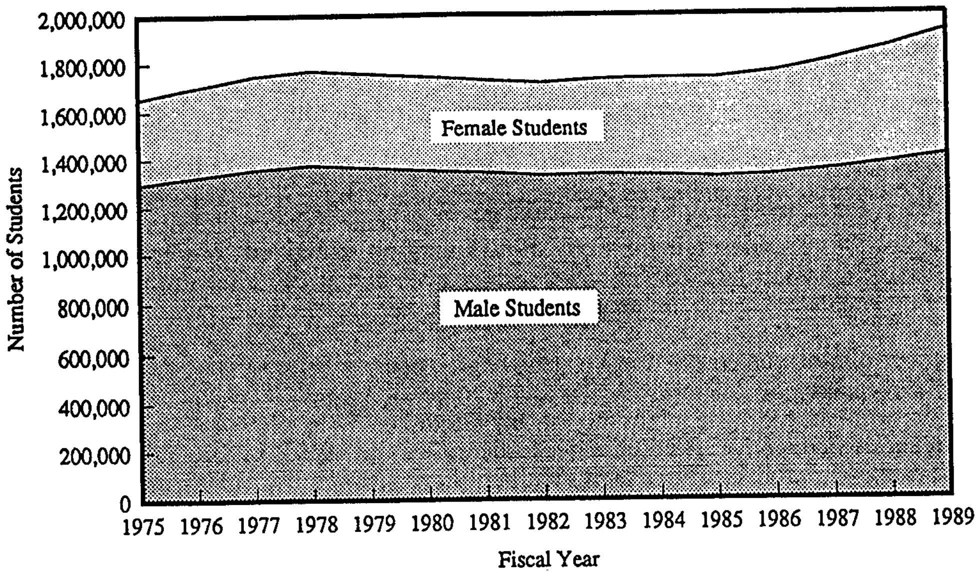
The decline in the number of students and courses in technical high schools is coming to a temporary halt, as students born in the second baby-boom period are currently of high school age. But with a rapid decrease of high school students expected after 1995, enrollment in technical high schools is expected once again to decline.

Higher Education

Academic department preferences by aspirants to college and university education can gage the popularity of science and engineering departments and in general reflects the popularity of S&T related professions. The number of students seeking entrance to engineering departments has fluctuated in the 1965-1989 period; increasing in the late 1960's, recording a constant decline until the late 1970's, then expanding rapidly until the late 1980's, only to make a downward turn after hitting a peak in 1988. The increase in the late 1960's can be explained in part by a period of economic boom and expansion, the constant decline from the early 1970's by a recession in the manufacturing industry due to the oil crisis, and the upward trend in the early 1980's by conditions of economic prosperity. However, in 1988 and 1989, despite favorable conditions for manufacturers and consequently for graduates from engineering departments, applications from new students to engineering departments have decreased. Similar tendencies can be Noted for applicants of natural sciences departments.

Enrollment statistics for colleges and universities (Figure 1-2-2) indicate an upward trend in the late 1970's, a static trend after a peak in 1978, and a rapid increase since 1985. Factors such as a stable business climate and improved conditions for receiving students in colleges and universities are reflected in these enrollment changes.

Figure 1-2-2 Number of Students in Colleges and Universities



Source: Ministry of Education, "Report of Basic Survey on Schools", various editions
See Table 2-2-2

Of all the departments in colleges and universities, social sciences departments receive the largest number of students, followed by engineering, humanities, medical and pharmaceutical sciences, agriculture and natural sciences. There are twice as many students enrolled in social sciences departments as there are in the second ranking engineering departments. Statistics also suggest that the number of students in social sciences and humanities have recorded an increase similar to the increase in the total number of college and university students in the late 1980's, while those of engineering and natural sciences have remained almost static. The waning popularity of science and engineering is conversely reflected in an increase of students entering the social sciences and humanities.

Human resource development in higher education requires infrastructure investments. Educational infrastructure can be assessed in terms of expenditures for education and R&D. As for national and local government colleges and universities, growth in the scale of higher education is translated in increases of expenditures for education and R&D. The largest increase (about 550 billion yen) is seen in the period from 1975 to 1980. In 1987, expenditures for education and R&D increased 5.1 times. In nominal terms, it has increased by 2.2 times the 1970 level. Also the number of students and real expenditures per student have both grown 1.5 times. Looking at expenditures by department, hospitals attached to universities not only spend an increasing amount of resources, but their share in expenditures is larger than that of other departments. Expenditures for all natural sciences and engineering related departments are increasing constantly both in real terms and in proportion to expenditures, reflecting a policy which emphasizes education and R&D in natural sciences and engineering.

Examination of expenditures for education and R&D by private colleges and universities shows how these institutions play an increasingly important role in Japanese higher education. However, it is only after 1980 that their expenditures have come to surpass those of national and local government colleges and universities. The share of R&D expenditures by science and engineering and other natural science related departments is much the same in national and local government as well as private colleges and universities.

Employment of University Graduates and Enrollments in Graduate Schools

In 1970, 68 percent of the graduates from higher education science and engineering departments of higher education were employed in the manufacturing sector. This proportion dropped to 43 percent in 1980, recovered to 57 percent in 1985, but made a downward turn after 1986 to 51 percent in 1988. Trends until the early 1980's may be explained by improving economic conditions, but in the late 1980's, they reflect a tendency of alienation by science and engineering graduates from manufacturing towards service sector employment.

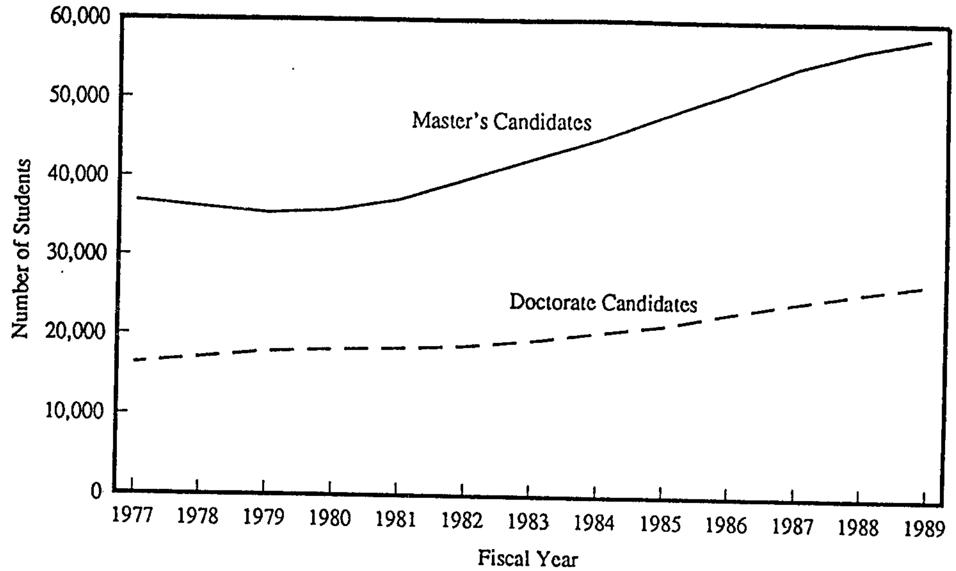
The number of students enrolled in master's degree courses (Figure 1-2-3) shows an increase since 1979, reaching 58,228 in 1989. The total number of master's level students in engineering-related departments has been increasing since 1979 to 26,777 in 1989 or a 46 percent increase. The number of students in agricultural departments has fluctuated considerably since 1980, but after peaking at 5,500 in 1987, their numbers have declined to 3,800 in 1989. In other departments, the number of students has remained nearly steady.

The number of students enrolled in doctorate courses has increased yearly, reaching the 27,000 mark in 1989. Medial departments have a large and steadily increasing share (43 percent in 1989) in the total number of students (1,500 in 1989). Within these departments, medical sciences takes up the largest proportion (79 percent in 1989). Engineering related departments account for 2,600 students in 1977, but only 2,200 in 1982. This number is currently showing an upward movement and has risen to 3,900 in 1989. These trends in doctorate and master's courses reflect favorable conditions in the manufacturing sector and the rising demand for students with sophisticated professional knowledge.

The number of degrees conferred to students reflects the results of developing human resources for science and technology and is used as an indicator of S&T activities (Figure 1-2-4). The number of master's degrees conferred to candidates has doubled in 15 years; up from 11,605 in 1971 to 22,354 in 1986. Engineering departments confer the largest number of master's degrees (10,361 in 1986), representing 46 percent of the total.

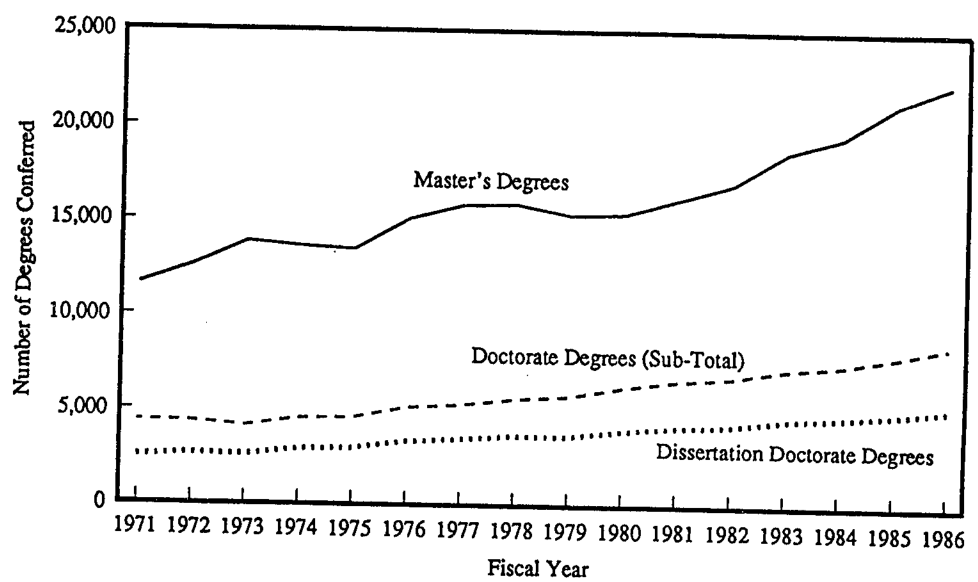
As is the case of master's degrees, growth in the number of doctorate degrees has doubled in the same period; up from 4,407 in 1971 to 8,533 in 1986. 5,281 Dissertation Doctorate degrees (61.9 percent of the total) were conferred, representing 1.5 times the number of Course-work Doctorate degrees. Dissertation Doctorate degrees awarded in medical sciences (2,713) take up 51 percent of the total number of conferred degrees, followed by engineering, agriculture, dentistry, pharmaceutical and health sciences, and humanities and social sciences.

Figure 1-2-3 Number of Students in Graduate Courses



Source: Ministry of Education, "Report of Basic Survey on Schools", various editions
See Table 2-3-2

Figure 1-2-4 Number of Degrees Conferred



Source: Hiroshima University - University Education Center, "Compilation of Higher Education Statistical Data", 1989
See Table 2-3-3 and Table 2-3-4

1. 3 Supports for R&D

Social supports for R&D refers mainly to financial support provided to institutions engaged in R&D activities. A characteristic of R&D in Japan shows that the private sector conducts R&D activities using primarily industry resources with little help from other sectors. In fact, R&D resources provided by the government for the private sector represent less than 2 percent of the total budget for science and technology in Japan. In contrast, R&D activities in colleges and universities and in national R&D institutes are mainly supported by governmental R&D expenditures which are secured in the budget for science and technology. Most R&D activities in these academic institutions are not directly regulated by market principles, thus academic R&D calls in principle for government support. In addition, financial support from foundations and the activities of academic communities such as learned societies are considered social supports for science and technology, specifically for academic R&D. In the context of support from the public, learned societies provide both needed financial support and also are important in that they provide a forum for information exchange among scientists and engineers. These R&D promotion functions are considered to supplement government support for academic R&D.

Governmental Budget for Science and Technology

In Japan, the budget for science and technology consists of the General Account and Special Accounts. The budget for science and technology included in the General Account is divided into Expenditures for the Promotion of Science and Technology, R&D Expenditures Included in the Energy-related Expenditures, and Other R&D Related Expenditures. The following are descriptive details of items included in the science and technology budget.

(1) The Budget for the Promotion of Science and Technology consists of expenditures for national R&D facilities and various subsidies.

(2) The Energy Budget for R&D item includes new energy technology and energy conservation technology. This budget area was part of Expenditures for the Promotion of Science and Technology until 1978, after which it was established as a new budget category.

(3) The category of Other R&D Related Expenditures include the costs for educational support, for economic assistance, and for small-to-medium-sized enterprises, among others.

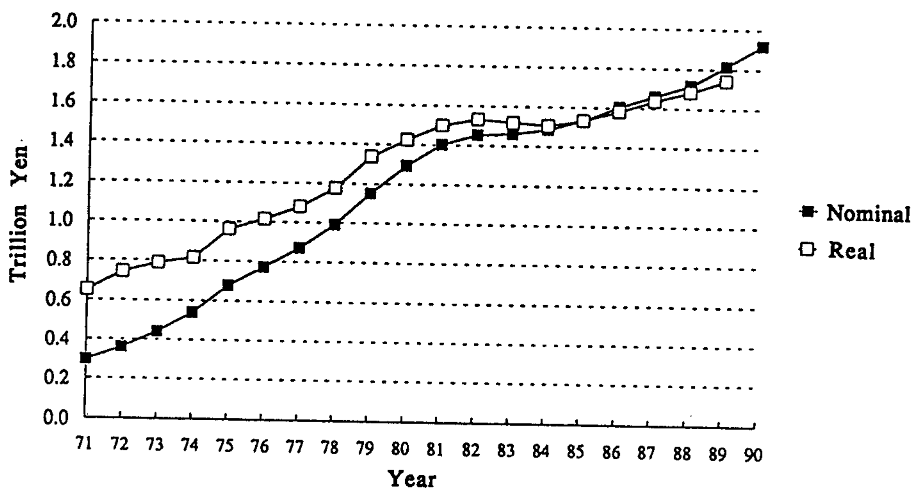
(4) Science and Technology Related Expenditures in the Special Accounts consist of the Special Account for National Schools, for the Promotion of Power Resource Development, and for Coal and Oil and Alternative Energy, as well as the Expenditures for R&D included in the Special Account for Industrial Investment.

The budget for science and technology represents about 3 percent of the General Account in the national budget, a percentage which has changed very little in the past decade. The S&T budget ratio to GNP is 0.4-0.5 percent. In the United States, W. Germany, France and the United Kingdom, the ratio of science and technology budget to GNP is between 1.0 and 1.2 percent.

In Japan, implementation of large scale projects such as energy development and space development take up a large portion of the budget for science and technology. R&D expenditures of national R&D facilities and colleges and universities are dependent on the governmental budget, and funds spent on R&D activities in these institutions represents about 50 percent of the total budget for science and technology. Colleges and universities are engaged in academic R&D in basic research as well as in other aspects of higher education, while the principal task of national R&D facilities is to conduct experimental R&D in line with administrative needs. R&D activities in these academic institutions are not directly determined by market mechanisms and therefore have a different characteristic from industrial R&D activities. On the assumption that the budget of national colleges and universities and R&D facilities represent a direct support for basic research by the central government, about 50 percent of the total budget for science and technology is estimated to be spent for basic research. In FY 1989, this sum was approximately 910 billion yen, representing only 8 percent of total R&D expenditures in Japan.

In the past two decades, the budget for science and technology (in the General and Special Accounts) has increased over 6 times in nominal terms, up from 300 billion yen in FY 1971 to 1.9 trillion yen in FY 1990 (Figure 1-3-1). Considering inflation in this period and calculating expenditures in real terms using GNP deflators (benchmark: 1980 figures), in the last five years (FY 1985-90), the share by component in the total budget for science and technology has been as follows: 14-15 percent for national R&D facilities, 35-36 percent for national colleges and universities (including subsidies for private and government schools), 47-49 percent for the category of various subsidies and governmental investment, and 1 percent for administrative costs. These shares have changed very little in the last five years. As regards allocation of the science and technology budget among ministries and agencies, the Ministry of Education has the largest share with 47 percent, followed by Science and Technology Agency with 26 percent, and the Ministry of International Trade and Industry with 13 percent. Expenditures by these three government agencies represent over 80 percent of the total budget for science and technology in Japan. Each of the other ministries and agencies uses no more than 5 percent of the total budget for science and technology: the Defence Agency with 5 percent, the Ministry of Medical and Welfare with 3 percent, the Ministry of Agriculture, Forestry and Fisheries with 4 percent, the Ministry of Posts and Communications with 2 percent and the Ministry of Transportation with 1 percent. These figures have remained almost unchanged in the past five years.

Figure 1-3-1 Budget for Science and Technology in Japan



Science and Technology Agency, "Indicators of Science and Technology"

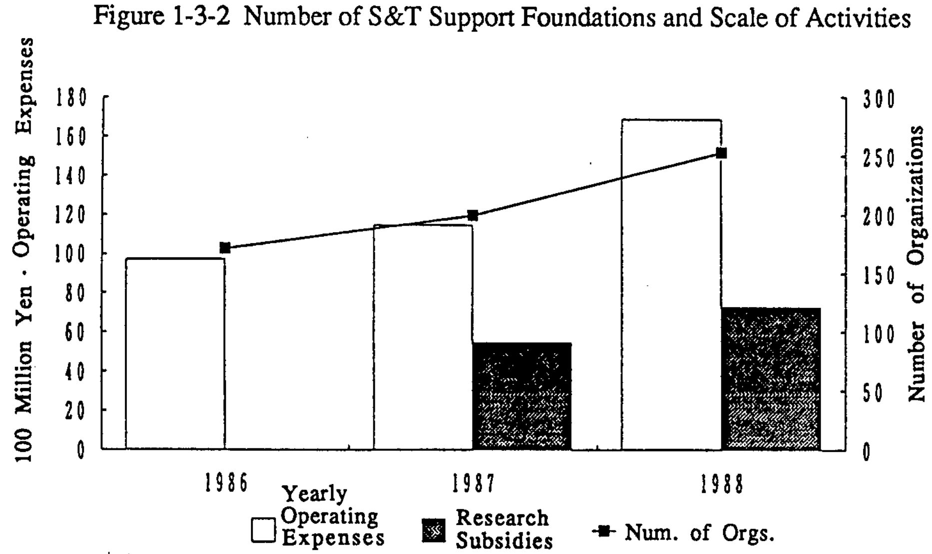
Promotion of S&T by Foundations and Learned Societies

Support for R&D activities from various foundations and the activities of learned societies are considered to have functions complementary to government support for academic R&D related to science and technology.

In FY 1988, 246 incorporated foundations are reported to be mainly engaged in supporting R&D activities. In addition, one corporate judicial body and six social welfare corporations are providing similar R&D subsidies, which brings the total number of incorporated bodies engaged in this kind of support to 253 (Figure 1-3-2). These foundations concerned with science and technology implement a total of 642 projects. However, taking into account the fact that some projects take multiple execution forms, the aggregate number of such projects comes to 708 (Figure 1-3-2). Foundations providing support for R&D are increasing in number recently as shown by the fact that 87 have been newly established since 1980. In FY 1988, the total operating expenditures of these support foundations amounted to 16.87 billion yen, of which 7.27 billion yen (about 43 percent) was spent as subsidies for R&D. This amount is smaller in scale compared with the Grant-in-Aid for Scientific R&D provided by the Ministry of Education, but is considered nonetheless to play an important part as a source for basic research funds. Engineering and medical sciences are the two most prominent beneficiaries of these R&D subsidies, followed by natural and agricultural sciences, social sciences and humanities. When subsidized projects are classified according to their R&D subjects, medical sciences comes out on top (taking up 39.6 percent of the total project number and 36.7 percent of the total resources in 1989), followed by engineering (24.1 percent and 24.7 percent respectively) and natural science (10.5 percent, 13.9 percent).

The number of registered learned societies in 1976 was 785, 1,003 in 1980 and 1,236 in 1986 for an increase of over 200 for each period. Humanities-related are the most numerous learned societies, closely followed by medical sciences. In total, 2,096,000 individuals and 90,000 organizations comprise these societies with 151 for natural science, 143 for engineering and 122 for agriculture. Concerning the number of individual members in these societies, medical sciences has the most with 870,000 persons, followed by engineering with 520,000, humanities with 250,000 and natural science with 220,000. The learned societies with the highest average number of members is engineering (3,600 members) followed by medical sciences (2,500).

Figure 1-3-2 Number of S&T Support Foundations and Scale of Activities



Foundation Center Library of Japan, "Grant-Making Organizations in Japan"

Foundation Center Library of Japan, "The Directory of Grant-Making Organizations in Japan"

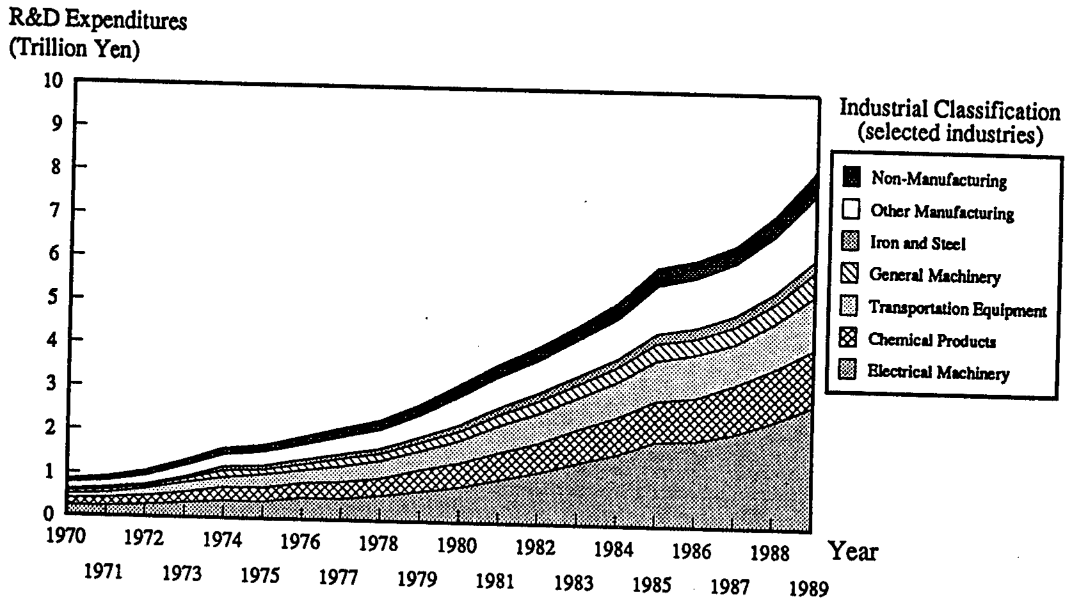
1. 4 R&D Activities in Industry, Academia and Government

Industrial R&D

Intramural R&D expenditures by Japanese industry in FY 1989 amounted to a little more than 8.2 trillion yen, representing 70 percent of total R&D and largely exceeding the amounts spent in academia and government.

The growth of R&D expenditures in industry has been remarkable from the latter half of the 1970's. Despite a period of stagnation from 1985-1987, growth of R&D expenditures in industry since 1988 has accelerated once more. The electronic machinery industry maintained the largest sectorial share, showing a considerable increase since 1980, followed by the chemical products and transportation machinery industries (Figure 1-4-1). These three industries take up 65 percent of total industrial R&D expenditures in FY 1989.

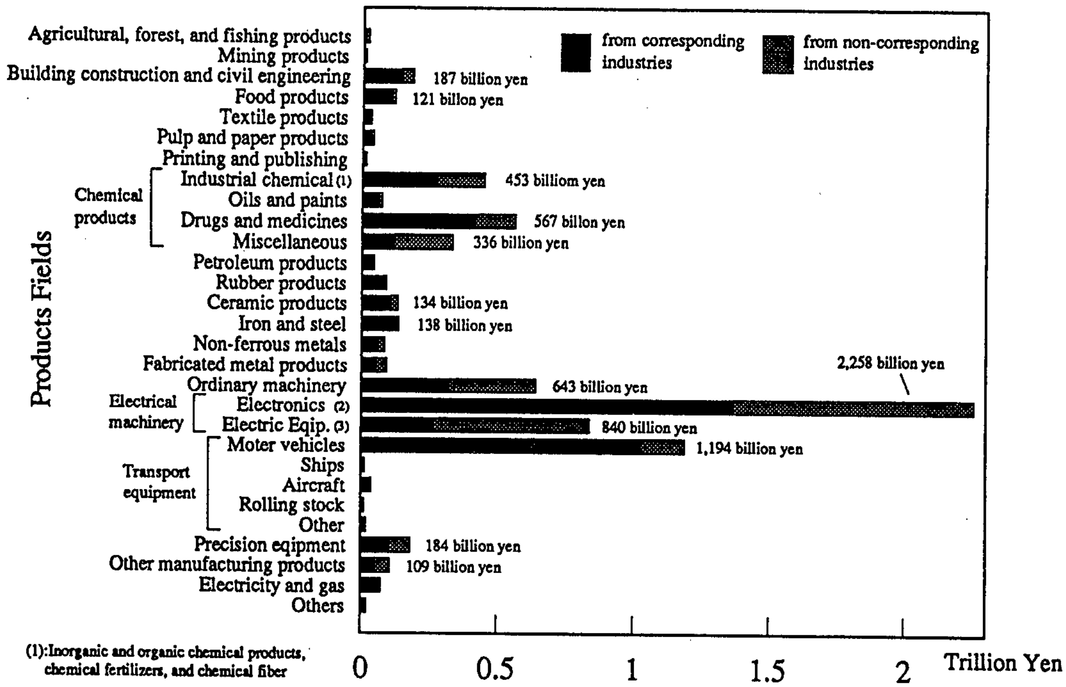
Figure 1-4-1 R&D Expenditures in Industry (by Industrial Sector)



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

When R&D expenditures are examined by product categories (Figure 1-4-2), communication and electronics equipment products take up almost 30 percent of total with 2.25 trillion yen, an amount far exceeding other categories. This R&D growth in communication and electronics equipment *products* is due to growth of R&D expenditures originating from its corresponding *industry* (i.e. communication and electronics equipment industry). Moreover, this product category has the largest amount of "penetrated R&D expenditures" (expenditures originating from non-core industries). The majority of these penetrated expenditures originate from the household electric appliances and other electric equipment industry. Two technologically similar industries, the communication and electronics equipment industry and the household electric appliances and other electric equipment industry, both mutually penetrate each other in terms of R&D expenditures.

Figure 1-4-2 R&D Expenditures by Product Categories (FY 1989)



(1):Inorganic and organic chemical products, chemical fertilizers, and chemical fiber

(2):Communication and electronics equipment

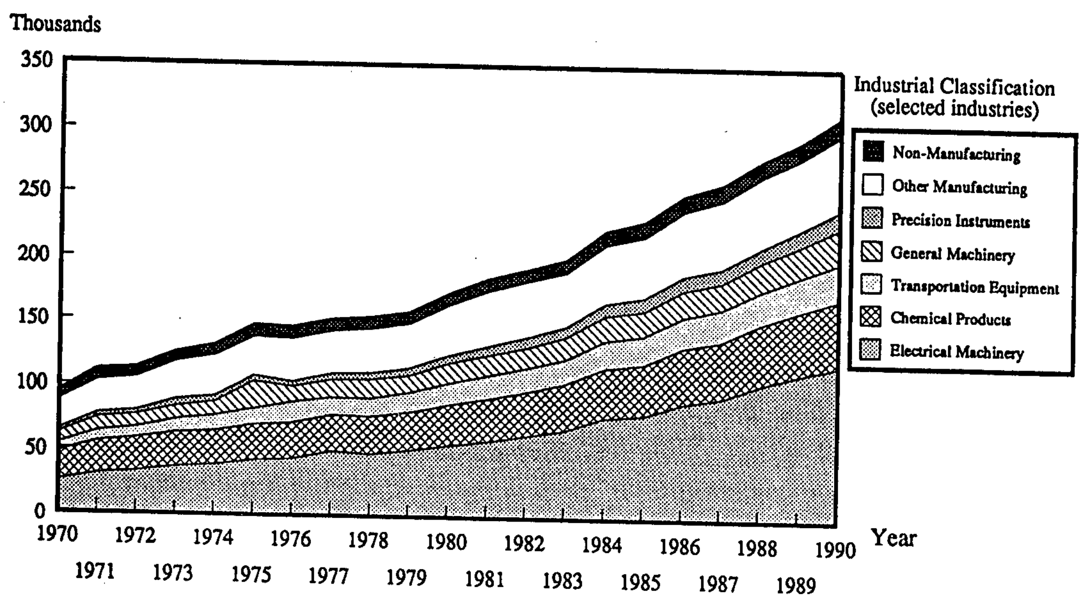
(3):Household electric appliances and other electric equipment

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

The non-core business ratio of R&D expenditures, which indicates the diversification level of R&D expenditures by a specific *industry*, forms the other side of the coin to the penetrated R&D expenditures ratio by a product category. The electrical machinery, chemical and transport equipment industries; the three industries with the largest R&D expenditures, are also the industries with the lowest non-core business ratio of R&D expenditures (electrical machinery , with about 8 percent, chemical products with close to 10 percent, transportation equipment machinery with about 11 percent). The non-core business ratio of R&D expenditures in these industries has been low since the late 1970's. It can thus be observed that these three key industries in the Japanese manufacturing sector spend large amounts of R&D funds primarily for their core businesses.

In 1971 the number of manufacturing industry R&D Scientists and Engineers (R&D S/E) surpassed 100,000. In the following two decades, the number increased three-fold to 300,000 in 1990, a fact which reflects a constant upward trend and underlines a great importance attached to R&D in the manufacturing industry. According to Figure 1-4-3, which shows trends by selected industries, the share of the industrial chemicals and synthetic fibers industry, and the electric machinery equipment and supplies industry decreased in 1990, despite high levels in 1970. The communications and electronic equipment industry, on the other hand, has witnessed a significant increase in the number of R&D S/E (by a factor of 6) and in its industrial share (by 1.6 times), whereas increases in the motor vehicles industry were by a factor of 5 in absolute terms and by 3 percent in total share. In 1990, 60 percent of all R&D S/E specialized in engineering.

Figure 1-4-3 Number of R&D Scientists and Engineers in Industry (by selected industry)

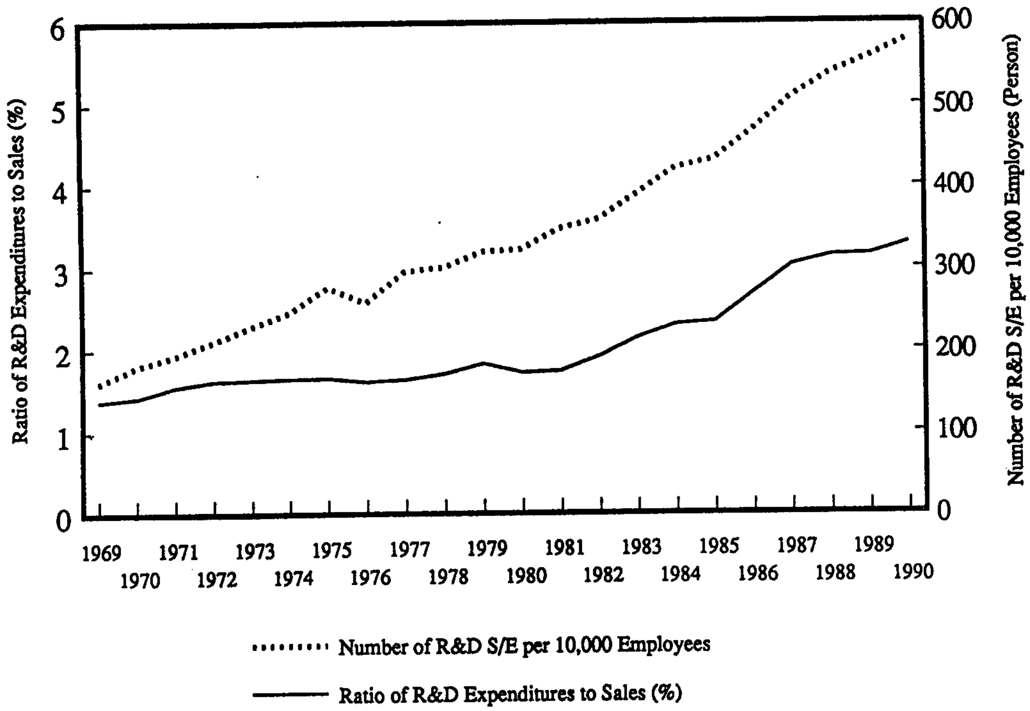


Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"

The ratio of R&D expenditures to sales and the ratio of number of R&D S/E per 10,000 employees are adopted in order to measure "R&D intensiveness". In all of manufacturing, R&D expenditures relative to sales remained almost static in the 1970's but recorded significant increases in the 1980's. The number of R&D S/E per 10,000 employees has stayed approximately at the same level in the past two decades. As a consequence, a constant growth of R&D intensiveness in the manufacturing industry is observed.

The R&D intensiveness in R&D expenditures by industry in decreasing order is as follows: drugs and medicines, communication and electronics equipment, electric machinery equipment and supplies and precision instruments. The order of R&D intensiveness in R&D expenditures is different from that of R&D intensiveness in R&D S/E. R&D S/E intensiveness is highest in the oils and paints industry, followed by the other chemical products industry, the communication and electronics equipment industry and the industrial chemicals and chemical fibers industry. R&D intensiveness in expenditures is highest in chemical-related industries which can be classified as process-dominant industries.

Figure 1-4-4 R&D Intensiveness



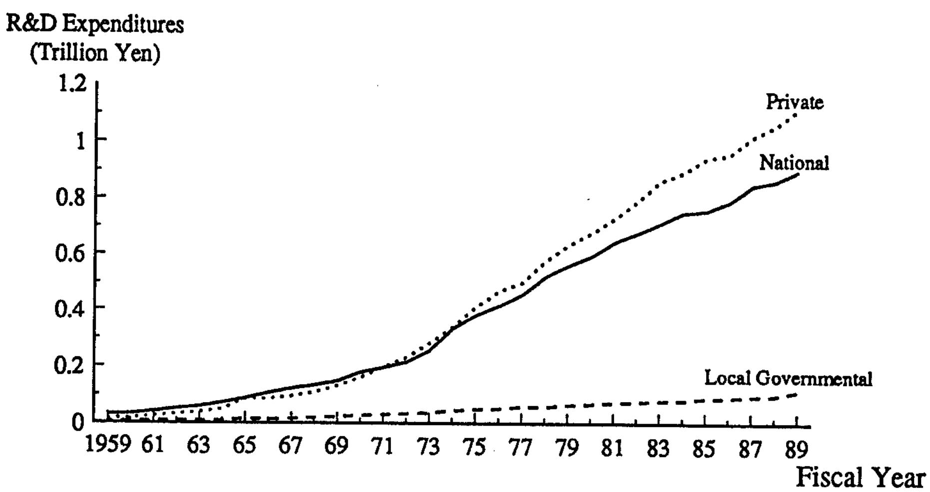
Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"

An R&D facility is an indispensable element in the infrastructure supporting R&D activities. A large number of these facilities can be found in the chemicals and electric machinery industries. The number of R&D facilities per enterprise is largest in the communications and shipping industries. The two dominant R&D subjects areas on the other hand, are chemistry and electricity/electronics.

R&D in Academia

As regards the amount of R&D expenditures by establishing academic body, since 1974 the increase in private colleges and universities has been larger than that of national colleges and universities. From FY 1970 to FY 1980 expenditures in national, local government and private colleges and universities increased by a factor of 5, 4.5 and 7 respectively. The breakdown of R&D expenditures at national, local and private colleges and universities in FY 1989 was 0.9, 0.1, 1.1 trillion yen respectively. R&D expenditures in private colleges and universities are the largest for the three categories. These increases underscore the growing prevalence of private educational institutions in the total R&D effort.

Figure 1-4-5 R&D Expenditures in Colleges and Universities



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

Looking at R&D expenditures by academic field, it becomes clear that growth in agriculture is stagnating. Compared to the FY 1970 levels, the FY 1989 levels of R&D were higher by factors of 7 in natural sciences, 6 in engineering, 4 in agriculture and 6 in medical sciences. In all natural sciences and engineering and in humanities and the social sciences, comparable levels were 6 and 5.5 times higher in FY 1989. R&D expenditures in FY 1989 were nearly 200 billion yen in natural sciences, a little less than 500 billion yen in engineering, 100 billion yen in agriculture, nearly 550 billion yen in medical sciences. In other words, in all natural sciences and engineering, total R&D expenditures were 1.3 trillion yen. R&D expenditures in agriculture are lowest of all academic fields.

R&D S/E in academic institutions, including teaching staff and medical staff, totaled nearly 200,000 in 1990. Over 70 percent of these R&D S/E (150,000 persons) are teaching staff with the number of students and medical staff at 30,000 each. The trend in the total number of R&D S/E personnel shows a constant upward movement.

By academic field, 130,000 R&D S/E (about 65 percent) are engaged in natural sciences, while 70,000 focus on humanities and social sciences. In 1961, the ratio of R&D S/E in all natural sciences and engineering versus humanities and social sciences was 48:52 in favor of the latter. In the subsequent years, however, this ratio was reversed (54:46) and the share of all natural science and engineering R&D S/E has been increasing gradually ever since. Within all natural science and engineering subjects, medical sciences have the largest share (40 percent) with 80,000 R&D S/E, recording a 6 percent increase over the last 15 years. Engineering, natural sciences and agriculture follow in order with 30,000, 10,000, and 8,000 R&D S/E respectively. Medical sciences have a high growth rate as well as a high share, while natural sciences, notwithstanding a small share, are showing an even larger growth rate than that of medical sciences.

By establishing body, intramural R&D expenditures per R&D S/E have increased rapidly in private colleges and universities since 1971. In the period from FY 1970 to FY 1989, these expenditures increased 2.5 times for national and local government colleges and universities and by almost 3.5 times for private colleges and universities. In FY 1989, this number amounted to only 9.6 million yen and 8.5 million yen respectively for national and government colleges and universities, while their private higher education counterparts spent 11 million yen. Intramural R&D expenditures increased almost 4 times in natural sciences and engineering respectively, doubled in medical sciences and grew over 2.5 times in all natural sciences and engineering. These trends indicate medical sciences grew slowest by academic subject area. Expenditures in FY 1989 amounted to 14 million yen for both natural science and engineering, 13 million yen for agriculture, 7 million yen for medical sciences and 10 million yen for all natural sciences and engineering areas.

The number of departments, defined as a unit of a R&D organization in colleges and universities, exceeds 2,000. A majority of departments (1,200) belong to 4-year colleges and universities, followed by junior colleges with 600, and departments attached to universities with 200. Organizationally, over 600 departments belong to national colleges and universities, while 1,400 (over 60 percent) belong to private colleges and universities. There are 900 humanities and social science departments, which take up 40 percent of the total number, followed by all natural sciences and engineering departments. The analysis shows, engineering-related departments have the largest share within all natural sciences and engineering.

R&D in Governmental Institutes and R&D Foundations

This category of R&D organization includes (1) national R&D institutes, (2) semi-governmental corporations which conduct R&D as their principal activity (hereinafter referred to as semi-governmental R&D organizations) (3) public R&D organizations established by local governmental authorities, and (4) private R&D institutes mainly foundations.

The amount of R&D expenditures spent in these R&D organizations was 1.45 trillion yen in 1989, representing more than 10 percent of total R&D expenditures, but this percentage has been declining in recent years. Private and semi-governmental R&D organizations have a large amount of R&D expenditures compared to local government institutes. The growth rate of R&D expenditures is high among private facilities and low among national and local government institutes.

40,000 R&D S/E or 7 percent of the total work in these R&D facilities, but recent trends show that their increase is smallest compared to R&D S/E in industry and colleges and universities. In particular, R&D S/E in national R&D institutes are increasing very slightly, and the number of R&D S/E in local government R&D facilities has remained almost static since 1970. R&D S/E in private R&D institutes increased rapidly, particularly in the 1980's.

Looking at the number of R&D S/E and the amount of R&D expenditures in detail, self-government R&D organizations and private R&D institutes have currently a larger share in the total amount of R&D expenditures than in the number of R&D S/E. National and local government institutes, on the contrary, have a larger ratio of R&D S/E than of R&D expenditures. These facts reflect the particular characteristics of R&D activities in each type of institute. For example, national R&D institutes show a propensity to use R&D expenditures for equipment and facilities more than local government R&D institutes.

The number of national and self-governmental R&D institutes has changed little over time. The number of local government institutes, however, has fluctuated to a certain degree, and is currently showing a downward trend after a peak at 642 in FY 1983. The number of private R&D institutes has been increasing greatly with a significant increase since FY 1983. When classified according to academic field (natural sciences, engineering, agriculture and medical sciences), engineering and agriculture are dominant in national R&D facilities, agriculture at national R&D institutes, agriculture in local government institutes and natural sciences in self-government R&D institutes.

1.5 Regional R&D Activities

Interest in regional science and technology activities is growing in recent years. Policies such as the Fourth Comprehensive National Development Plan have focused on regional development wherein the main objective is to reverse the tendency to concentrate activities in Tokyo and consequently to promote a multipolar pattern of national land use throughout Japan. Concurrently, developments in science and technology have been significant, contributing for example to the rapid formation of new social infrastructures including information and communication networks. In addition, the important role of technological innovation in the advancement of industrial technology and in the development of the economy as a whole are gaining widespread recognition, and as a consequence, science and technology are considered to be main contributors to the revitalization of regional economies. In recent years, local government authorities are drawing up regional development plans centered upon R&D activities and are implementing regionally oriented policies for the promotion of science and technology, including the establishment of councils for that purpose.

In this section, the discussion will focus on some of the features of technological activities in Japan by adopting indicators based on science and technology related data in each region.

Human Resources for R&D in Colleges and Universities

There is no significant regional gap in the number of teaching staff in engineering departments at national colleges and universities, though compared with the national average, the number is slightly smaller in the regions of Shikoku and Kanto, excluding the Tokyo Regional Area, and slightly higher in the Hokuriku region. For private colleges and universities however, the Tokyo Regional Area (TRA - Tokyo Municipality and Kanagawa Prefecture) has twice the number of both teaching staff and students as the national average, indicating a concentration of private academic institutions in the TRA.

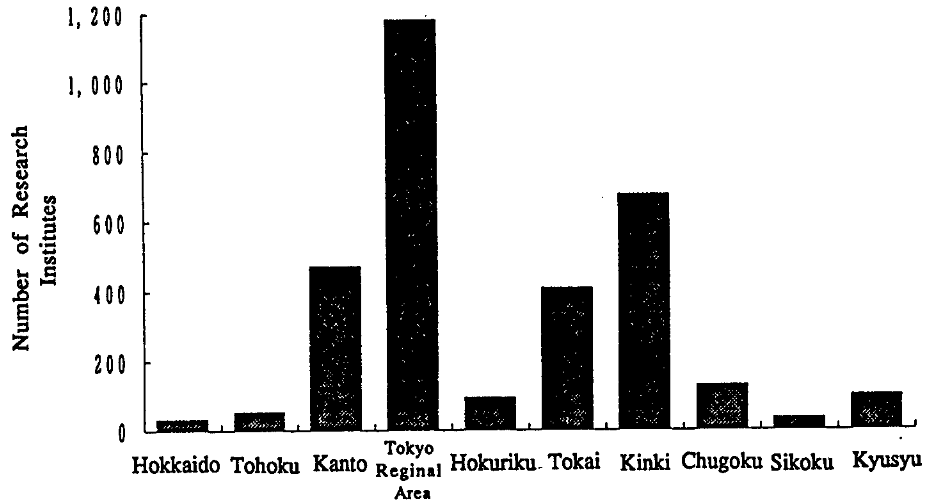
While comparisons of the number of students in undergraduate courses show no major regional gaps for national colleges and universities, a significant concentration of undergraduates in the TRA is seen for private colleges and universities. As for the number of students at the graduate level, most students in doctorate courses are concentrated in the TRA and Kinki region, while in masters courses, trends show a mixture of undergraduate and doctorate courses, reflecting a certain extent of imbalance among regions. Graduate students, along with teaching staff, are considered to contribute to R&D activities; therefore, the TRA and the Kinki region show the highest potential for R&D activities as estimated from their human resources available for R&D in colleges and universities.

Regional Distribution of Private Sector R&D Facilities

There are 3,179 private R&D facilities in Japan as of FY 1989 (Figure 1-5-1) Tokyo Municipality has one quarter of those facilities (763), followed by Kanagawa Prefecture with 13 percent (417) and Osaka Prefecture with 12 percent (374). Taking into account the fact that the head offices of most enterprises are concentrated in these three areas, it can be understood that factors such as availability of information, human resources and R&D equipment are essential in determining the location of R&D facilities. A study on the relationship between industrial production and R&D expenditures indicates that R&D activities and production facilities are not always located close to each other. Particularly, R&D facilities in metropolitan areas tend to be located separately from production facilities. The number of R&D facilities in metropolitan areas is 1,554, representing almost one-half (49 percent) of the total number of private sector R&D facilities.

R&D facilities in places other than metropolitan areas are considered to have somewhat stronger ties to production activities, i.e. they tend to be located closer to production facilities. 1,096 R&D facilities are located in these areas, representing over one third (34.5 percent) of the total private R&D facilities.

Figure 1-5-1 Number of Private R&D Facilities



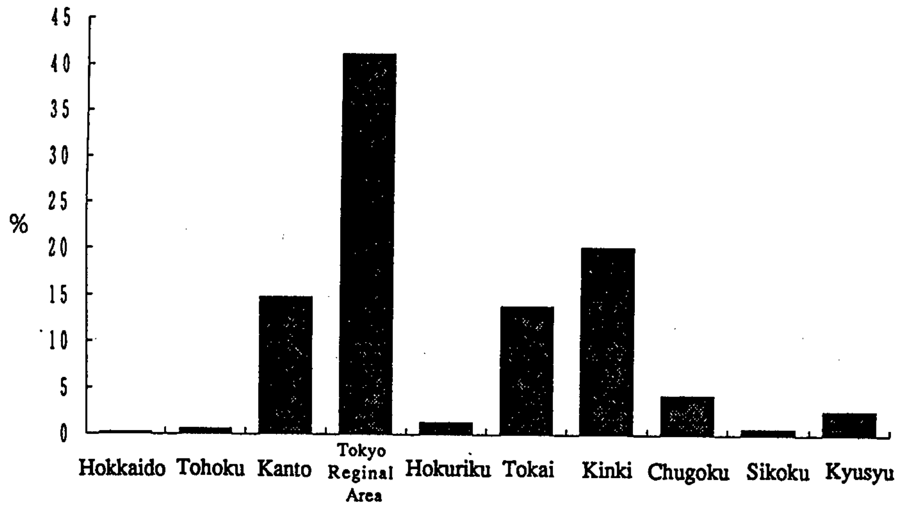
National Institute of Science and Technology Policy, "Basic Survey of Regional Science and Technology Promotion - Preliminary Report"

R&D Activities in Private R&D Facilities by Region

41 percent of the R&D Scientists and Engineers (R&D S/E) in private R&D facilities are concentrated in the TRA, followed by the Kinki region with 21 percent, Kanto with 15 percent, Tokai with 14 percent, Chugoku with 4 percent and Kyushu with 3 percent. Each of the other regions (Hokkaido, Tohoku, Hokuriku and Shikoku) have no more than 1 percent each of the total number of R&D S/E (Figure 1-5-2).

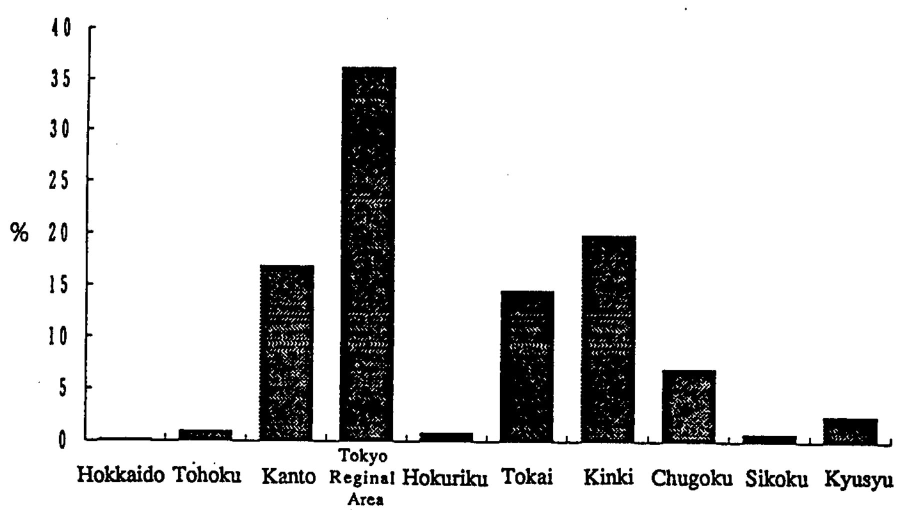
Looking at R&D expenditures by region, of all private R&D facility expenditures, 36 percent is spent in the TRA followed by Kinki with 20 percent, Kanto with 17 percent, Tokai with 15 percent, Chugoku with 7 percent and Kyushu with 3 percent. As shown in Figure 1-5-3, the share in the remaining regions does not exceed 1 percent each. Thus R&D S/E and R&D resources are concentrated to a considerable extent in the TRA, and the Kinki, Kanto and Tokai regions. The share of R&D S/E is almost proportionate to that of R&D expenditures, though the amount of R&D expenditure per R&D S/E are somewhat larger in the Kanto and Tokai regions than the national average.

Figure 1-5-2 Regional Shares in Total Number of R&D Scientists and Engineers



National Institute of Science and Technology Policy, "Basic Survey of Regional Science and Technology Promotion - Preliminary Report"

Figure 1-5-3 Regional Shares in Total R&D Expenditures



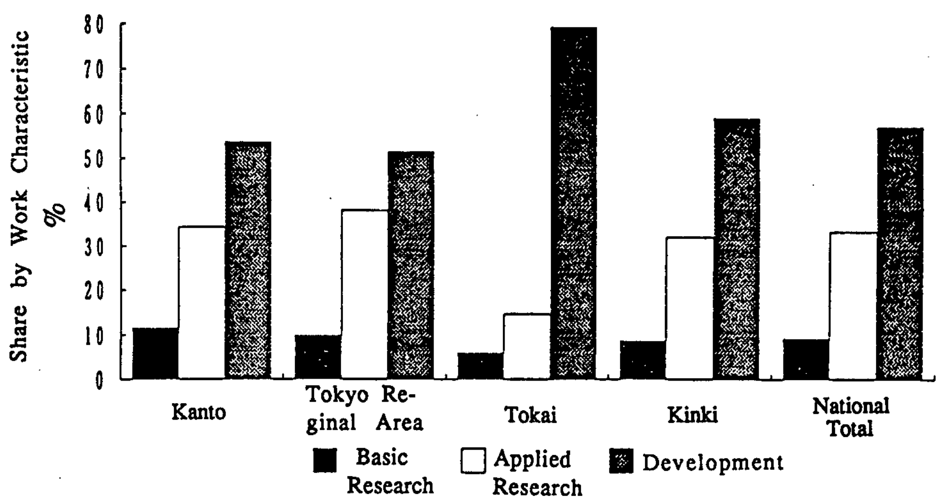
National Institute of Science and Technology Policy, "Basic Survey of Regional Science and Technology Promotion - Preliminary Report"

R&D S/E age composition show similarities in all regions. On the national average, 12 percent of all R&D S/E are less than 25 years old, 43 percent are 25-34 years old, 29 percent are 35-44 years old, 14 percent are 45-54 years old, and 2 percent are over 54 years old. In the TRA, the proportion of R&D S/E between 25 and 34 years of age is slightly larger than on the national average, while the 35-45 age group has a larger share in the Kinki region compared to the national average. When classified according to characteristics of R&D, on the national average, 10 percent of all R&D S/E are engaged in basic R&D, 36 percent in applied research and 55 percent in development. The proportion of R&D S/E engaged in basic research is around 10 percent in the TRA, Kanto, Tokai and Kinki regions. Again, compared with the national average, the TRA has a higher percentage of R&D S/E engaged in applied research, whereas in the Tokai region, more R&D S/E are engaged in development.

R&D subjects can be classified into chemicals and fibers, bio-medical and pharmaceuticals, materials-related, mechanical engineering, electronics and electrical engineering. 41 percent of all the R&D S/E in Japan are located in the TRA. In the national total of R&D S/E engaged in chemicals and fibers, bio-medical and pharmaceuticals and materials-related subjects, 30% are concentrated in the TRA. 40 percent of the national total engaged in mechanical engineering and 50 percent of those in electronics and electrical engineering are also concentrated in the TRA. In the Kinki region, on the other hand, bio-medical and pharmaceuticals R&D S/E are underrepresented.

On the national average, the shares of basic research , applied research and development in total R&D expenditures are 9 percent, 34 percent and 57 percent respectively (Figure 1-5-4). The share of basic and applied R&D is higher in the TRA than in the Kinki region, whereas development expenditures indicate a larger share in the latter region. The share of basic R&D expenditures is smaller in the Tokai region than the national average, while it is approximately at the national average in the TRA and the Kanto and Kinki regions. As far as development expenditures are concerned, however, the share is much higher in the Tokai region than at the national average.

Figure 1-5-4 R&D Expenditures by Characteristic of R&D



National Institute of Science and Technology Policy, "Basic Survey of Regional Science and Technology Promotion - Preliminary Report"

In the Kanto region, more R&D expenditures go to chemicals and fibers, bio-medical and pharmaceuticals and materials-related subjects than for mechanical engineering and electrical engineering. An extremely high percentage of R&D expenditures are being spent for electronics and electrical engineering in the TRA. In the Tokai region, mechanical engineering R&D has the largest share, while in the Kinki region, chemicals and fibers and materials-related R&D have even higher shares than in TRA.

From regional standpoints, R&D activities of private sector R&D facilities are concentrated in the TRA and Kinki. This seems to be because metropolitan areas provide more advantages than other regions in carrying out R&D activities such as access to science and technology information and relative ease in recruitment of R&D personnel.

1.6 Achievements of R&D Activities

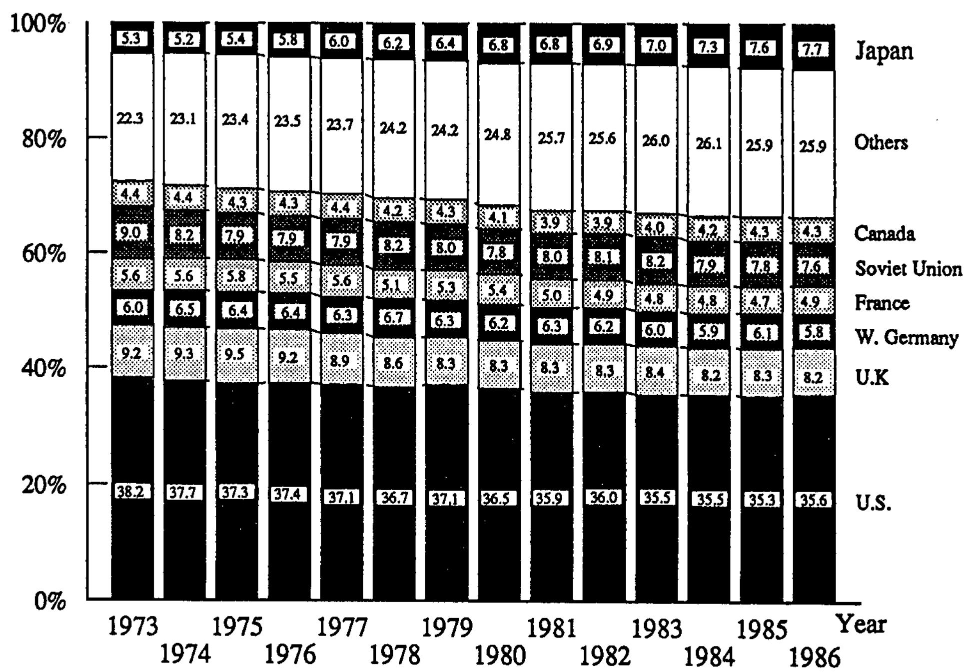
This section discusses R&D output indicators.These include the number of scientific papers and their citation frequencies, the number of application grants and number of new botanical species, and the number of technological standards and awards for scientific and technological achievement.

Scientific Papers

Indicators concerning scientific papers are essential in revealing the level of achievement in R&D and the contributions to expansion of human knowledge of science and technology. This section employs indicators relative to scientific papers based on a data base compiled by Computer Horizons Inc. (CHI).

In 1986, Japan ranked 3rd behind the United Kingdom in output of scientific papers, representing 7.7 percent of the world total. Japan is the only country among major industrial countries that is currently increasing its world share of scientific and technical papers, and its growth has been significant (Figure 1-6-1).

Figure 1-6-1 Country Share Trends in the Output of Scientific Papers



Country	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Japan	5.3	5.2	5.4	5.8	6.0	6.2	6.4	6.8	6.8	6.9	7.0	7.3	7.6	7.7
Others	22.3	23.1	23.4	23.5	23.7	24.2	24.2	24.8	25.7	25.6	26.0	26.1	25.9	25.9
Canada	4.4	4.4	4.3	4.3	4.4	4.2	4.3	4.1	3.9	3.9	4.0	4.2	4.3	4.3
Soviet Union	9.0	8.2	7.9	7.9	7.9	8.2	8.0	7.8	8.0	8.1	8.2	7.9	7.8	7.6
France	5.6	5.6	5.8	5.5	5.6	5.1	5.3	5.4	5.0	4.9	4.8	4.8	4.7	4.9
W. Germany	6.0	6.5	6.4	6.4	6.3	6.7	6.3	6.2	6.3	6.2	6.0	5.9	6.1	5.8
U.K	9.2	9.3	9.5	9.2	8.9	8.6	8.3	8.3	8.3	8.3	8.4	8.2	8.3	8.2
U.S.	38.2	37.7	37.3	37.4	37.1	36.7	37.1	36.5	35.9	36.0	35.5	35.5	35.3	35.6

Source : Computer Horizons, Inc. "Science & Engineering Literature Data Base 1989"

Japan has a large share of scientific papers in the so-called 'substance series' sciences such as engineering, chemistry and physics, while in mathematics and earth and space science, its world share is relatively small. The Japanese share in engineering recorded a particularly significant increase in the 1976-86 period, doubling in that decade. In the same period, the increase of publications in life sciences such as medical sciences and biology surpassed the increase of the Japanese share in all other subjects combined.

The output of scientific and technical literature concerns only quantitative aspect of R&D achievements. It is therefore necessary to present qualitative indicators of scientific publications. The premise taken is that the impact of papers depends on the number of times they are cited in other articles, and that this frequency of citation

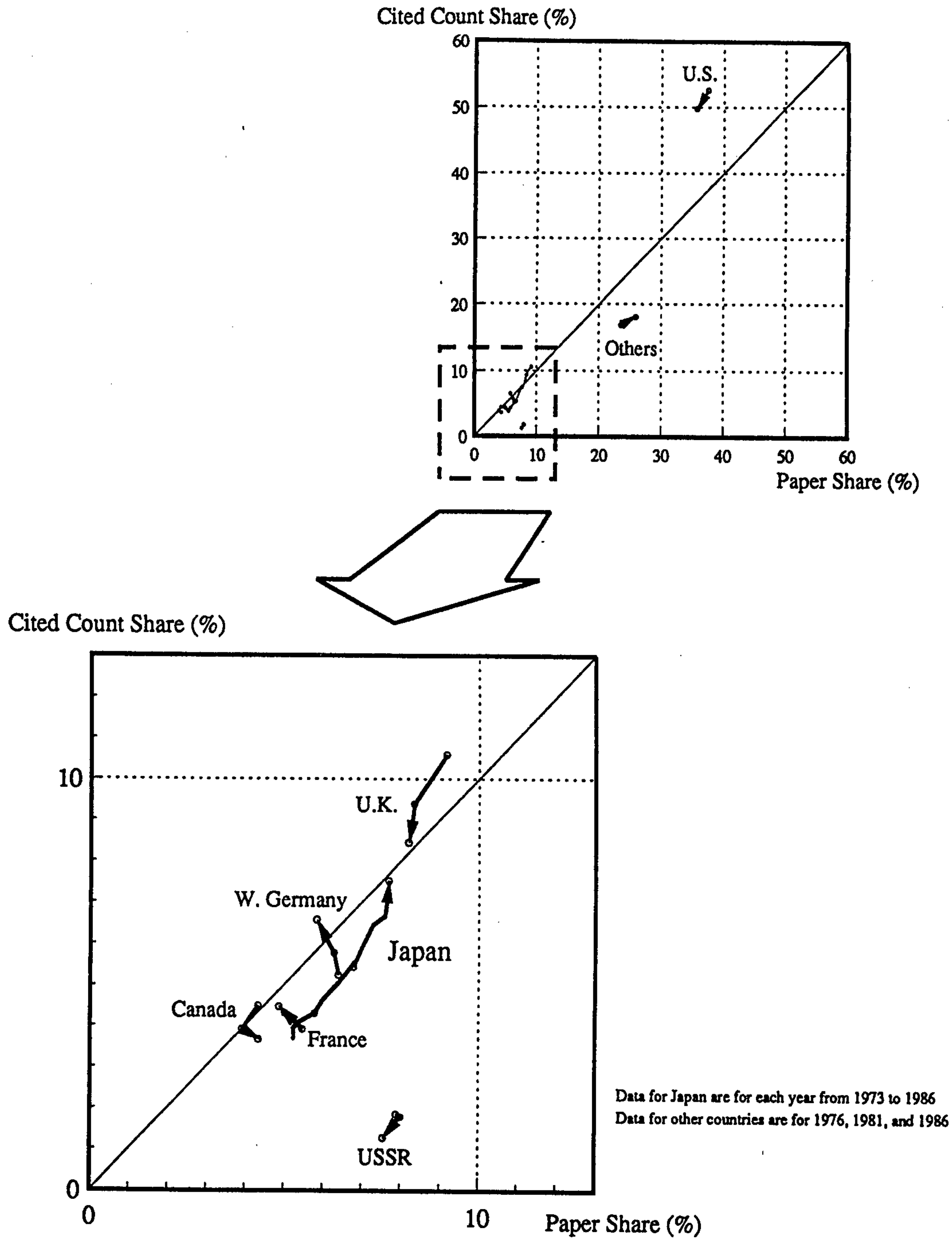
per scientific paper represents recognized "quality". Japanese scientific papers are the third most cited in the world, cited more than those from Germany and other countries, reflecting their large-scale global impact. On the other hand, the frequency per paper is rather low, thus indicating that their quality has not quite reached international standards. However, quality seems to be improving as Japanese papers are being cited recently far more frequently than in the past (Figure 1-6-2).

A separate result indicator which reflects the status and extent of internationalization in R&D is the number of international scientific and technical publications in a country. The following are statistics concerning the number of such journals and magazines published in each country based on the CHI data base. Japan's share in the number of scientific journals and magazines does not reach even one half of its share in the output of papers, which suggests that only a small number of international scientific publications are published in Japan. Thus, it appears that Japan needs to make greater contributions in publishing of international scientific literature, which is important for global distribution of R&D achievements.

Cross-border submissions of scientific and technical papers are frequently made these days. The level of internationalization of papers and scientific magazines in a country may be measured by the number of papers carried in overseas publications and the number of foreign origin papers carried in domestic publications. Many Japanese papers are published in foreign publications and their number is increasing, which means that Japan is not only increasing but also internationalizing its output of science. Conversely, it can also be said that only a small number of non-Japanese origin papers are contributed to scientific publications published in Japan.

Citation frequencies of papers at the international level show that even though many Japanese papers are being carried in scientific and technical publications overseas, they are much less frequently cited in foreign publications. This low citation frequency, however, is reversing significantly, reflecting a dramatic improvement of the international status of Japan in science and technology.

Figure 1-6-2 Citation Frequency Trends of Scientific Papers in Selected Countries



Source : Computer Horizons, Inc. "Science & Engineering Literature Data Base 1989"

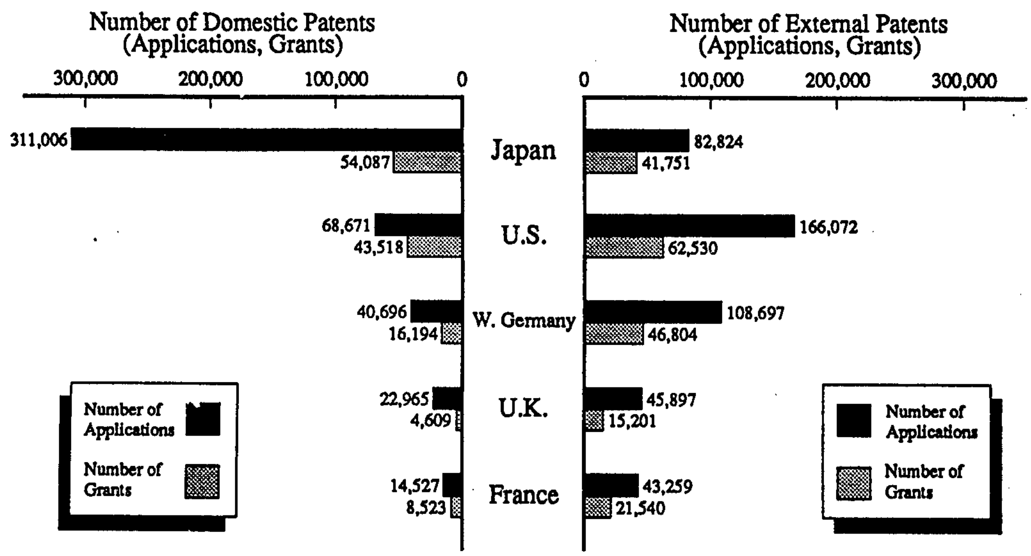
Patents

Among R&D achievements, patents have a close relationship with industrial competitiveness. Statistics concerning patents are relatively reliable, as applications and grants of patents are made through governmental organizations. This section analyzes patenting in Japan and other selected countries.

The number of patent applications in Japan recorded a particularly remarkable increase in the 1980's, while the number of patent grants remained relatively unchanged over the same period. By categories, patent applications were highest for both physics and electricity, whereas the two categories of chemistry/metals/fibers/treatment and operations/transportation have the largest shares of patent grants.

Each country has its own patent system, thus direct comparison of patents is difficult at the international level. Comparison here is made on the number of patent applications submitted externally by country (Figure 1-6-3). Most patent applications in Japan are made by Japanese applicants and the number of patents submitted abroad is relatively small. In total number of external patent applications, Japan does not reach the levels of the United States and Germany. More than 30 percent of Japanese-origin patent applications made abroad are in the United States, followed by Germany, the United Kingdom, France and South Korea.

Figure 1-6-3 The Number Domestic and External Patent Applications and Grants in Selected Countries

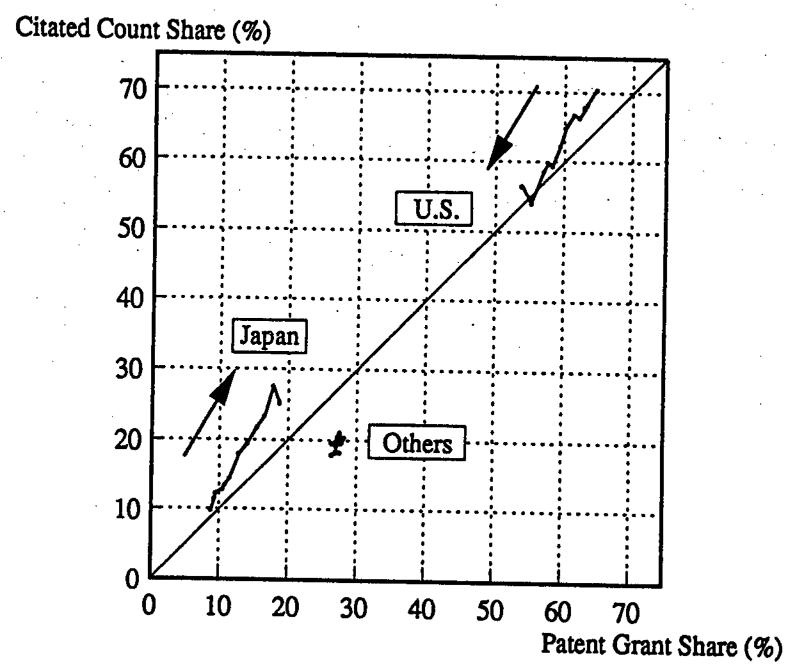


Source : Patent Agency, Japan, "Patent Agency Year Book 1989"

In order to clarify the status of Japanese-origin patents applied for in countries with different patenting systems, analysis is by country showing the number of patent applications and grants in the United States' and the European Patent Offices. According to the analysis, 20 percent of all patent applications made in the United States are from Japan, the largest source of foreign applications in that country. The United States has the largest share of patent applications in the European Patent Office, followed by Germany, Japan, France and the United Kingdom.

The growth in the number of foreign patents granted in the United States is mainly due to the increase of Japanese-origin patents, reflecting the relative importance of Japanese- origin patent activity in that country. In order to compare patent quality, analysis is on the frequency of each patent cited by examiners in the U.S. patent screening process. The share of Japanese patents cited was greater than in the share of patent grants, reflecting the high quality of Japanese patents (Figure 1-6-4).

Figure 1-6-4 Frequency of Patents Cited in the United States



Source : Computer Horizons, Inc. "Science & Engineering Literature Data Base 1989"

R&D activities in Japanese industry can be measured by the number of patent applications made by Japanese companies. The analysis shows the largest number of patent applications come from the electric machinery industry, followed by the transportation, precision and general chemicals industries. Furthermore, the electric machinery industry has a considerable share in almost every category of patents, particularly in patent categories related to electricity. On the other hand, the transportation machinery and general chemical industries make patent applications in their related industrial categories. However, the integrated chemicals industry and other related industries such as the medical products and oil and paints industries, are recently applying for patents in non-related industrial categories.

Registration of Botanical Species

A different R&D result indicator is registration of botanical species. The number of such registration grants increased by 200-300 cases each year from FY 1984 to FY 1990. Registrations are made mainly from individuals, botanical nursery companies and local governments. In recent years, the share of individuals and agricultural cooperatives has been declining in favor of botanical nursery companies, which are known to have specialized and organized R&D activities. Flowering plants represent 50 percent of newly registered species, followed by decorative trees and vegetables. Development of botanical species in the past was made principally through classical crossbreeding methods. In recent years however, biotechnology methods such as cell and tissue culture, embryo and ovule culture and cell fusion are more frequently utilized and could result in an even larger number of registered species in the foreseeable future

Industrial Standards

The number of JIS (Japanese Industrial Standards) can be used as an indicator of the public property value place on R&D activity achievements by the government. By sectors: chemistry, general machinery, electronics equipment and electrical equipment have a large number of standards included in the JIS. Most of the standards in the chemical sector were established in the early 1950's, but for the general machinery and public works and construction sectors, the establishment of standards is spread out over several years. A large number of standards were established in the 1980's for electronics equipment and electrical equipment as well as for data processing, a fact which indirectly reveals the rapid changes in the forms of industrial production caused by the advancement of electronics. A large number of standards for medical safety devices were also established in the 1980's, possibly reflecting the growing interest in safety related technology.

Awards for Scientific and Technological Achievement

Science and technology can also be evaluated through discussion of scientific award systems, specifically through the "Award for Persons of Scientific and Technological Merit,"an award given by the Minister of State for Science and Technology. In the 31 year period from the establishment of the award system in 1959 to 1989, 637 awards related to science and technology were included. The trends in each decade can be examined according to available data. In the 1960's, most of the awards went to techniques in categories of "precision machinery," "organic chemistry," "transport machinery" and "iron and steel," reflecting the fact that science and technology in heavy
industries played a central role in that period. In the 1970's, "electronics and parts" of telecommunication equipment came on top of the list, underscoring the advancement of electronic technology as compared to the 1960's. In the 1980's, chemistry-related awards show a low representation.

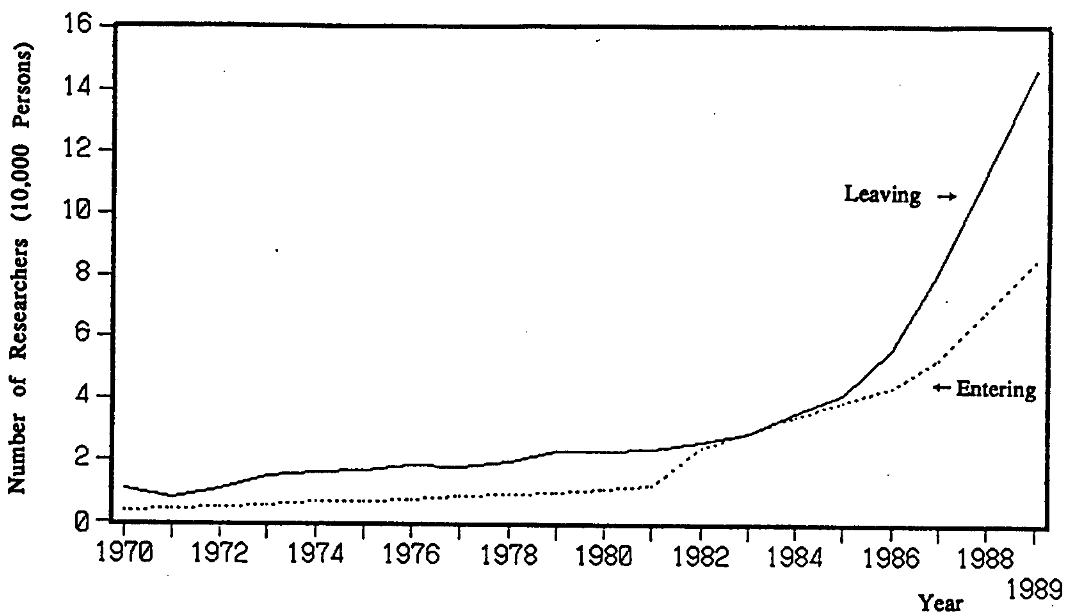
1.7 Internationalization of Research &Development

Exchange of R&D Personnel

For several years, voices in the United States and other countries have pointed out the imbalance in the exchange of researchers and engineers (R/E) (See original text Chapter 7) The argument is that Japan dispatches a large number of R/E abroad while itself being relatively closed to non-Japanese R/E. This criticism, however, is not based on the quantitative analysis on the situation research exchange. This section analyzes the actual conditions concerning the exchange of R/E between Japan and other countries, according to the "Statistics on Immigration Control" published by the Ministry of Justice.

Figure 1-7-1 shows the number of Japanese R/E leaving Japan and of non-Japanese R/E entering the country. The number of both leaving and entering R&E personnel increased gradually from the 1970's to the mid-1980's, has been growing rapidly since the late 1980's. Although the increase in the number of leaving exceeded that of those entering, the ratio of the latter to the former has shifted from 1:1.1 in 1985 to 1:1.7 in 1989.

Figure 1-7-1 Number of Researchers and Engineers Leaving and Entering Japan



Ministry of Justice, "Statistics on Immigration Control".

Looking at the destinations and origins, Japanese R/E almost always go to North America or Europe, while most non-Japanese R/E coming to Japan come from other Asian countries, indicating a considerable disparity among regions. By country, about half of the R/E personnel leaving Japan are bound for the United States, whereas R/E from the U.S. represent less than 10 percent of the personnel entering the country, underscoring the significant imbalance in R/E exchange between the two countries. As far as R/E from Japan to Europe and North America are concerned, the U.S. receives 60 percent of the total from the two regions. On the other hand, R/E from the U.S. represent 50 percent of those entering Japan from Europe and North America. Thus, it can be understood that Japan undertakes more active exchange of R/E with the United States than with Europe.

It should be Noted that Japan makes efforts to absorb new knowledge by dispatching a large number of R/E to industrialized countries, particularly in Europe and North America trying at the same time to transfer technological knowledge to other Asian countries.

Cross-border Flows of Research and & Development

Flows of R&D are indicated by trends in the R&D activities of Japanese company affiliates abroad. Flows of R&D are also indicated by examining the R&D activities of foreign affiliates in Japan and of trends in technology trade by industry.

According to the "Statistics on Foreign Investment" published by the Ministry of International Trade and Industry, 367 Japanese affiliates abroad (almost 6 percent of the total Japanese affiliates abroad) are engaged in R&D activities as of FY 1989. The total R&D expenditures in these affiliates amounted to 64.6 billion yen in that same year, and almost 60 percent was spent in electrical machinery, general machinery, chemistry and precision instruments. R&D expenditures of manufacturing industries increased by 20 percent in 3 years (from FY 1986 to FY 1989), while those of non-manufacturing industries decreased by 20 percent. As a result, the share of manufacturing industries in total R&D expenditures increased from 76 percent in FY 1986 to 82 percent in FY 1989.

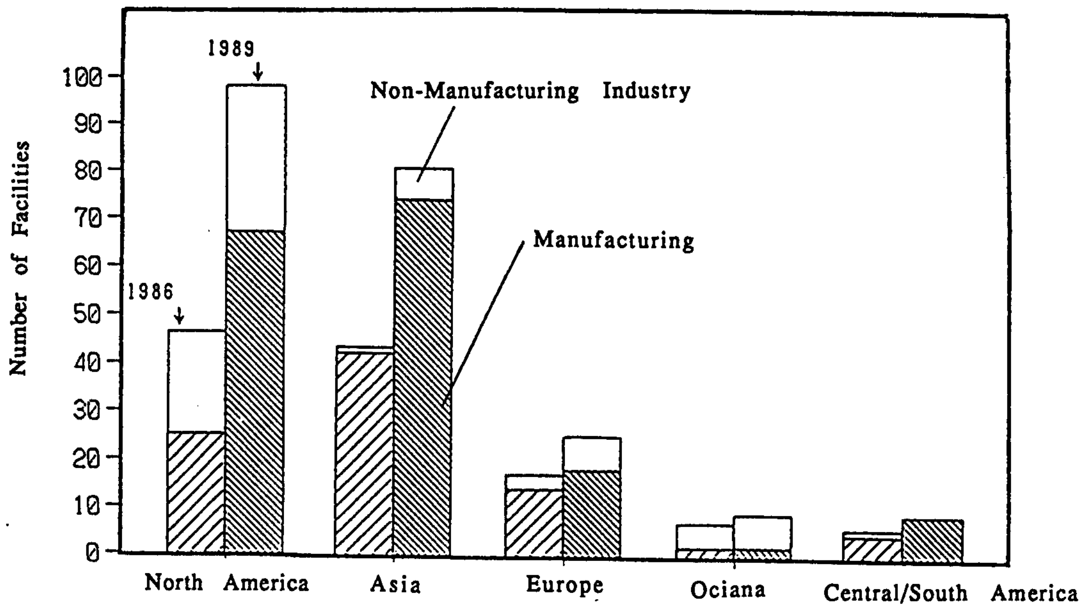
As of the end of FY 1989, there were 222 R&D facilities of Japanese affiliates, of which about 90 percent are located in North America, Asia and Europe (Figure 1-7-2). Manufacturing accounts for more than 90 percent of these R&D facilities in Asia, and 70 percent of the facilities in Europe. As for facilities in North America, about 50 percent were engaged in R&D in non-manufacturing in FY 1986, but according to a survey in FY 1989, almost 70 percent of them are now engaged in R&D in manufacturing.

Thus, Japanese R&D corporate facilities, manufacturers in particular, are becoming more actively involved in R&D. However, the ratio of R&D sales for Japanese affiliates of manufacturers is much lower than the similar ratio for their parent companies and even for establishments of foreign-affiliated companies in Japan.

In Japan, foreign-affiliated chemical and electronic companies are also active in the creation of R&D facilities.

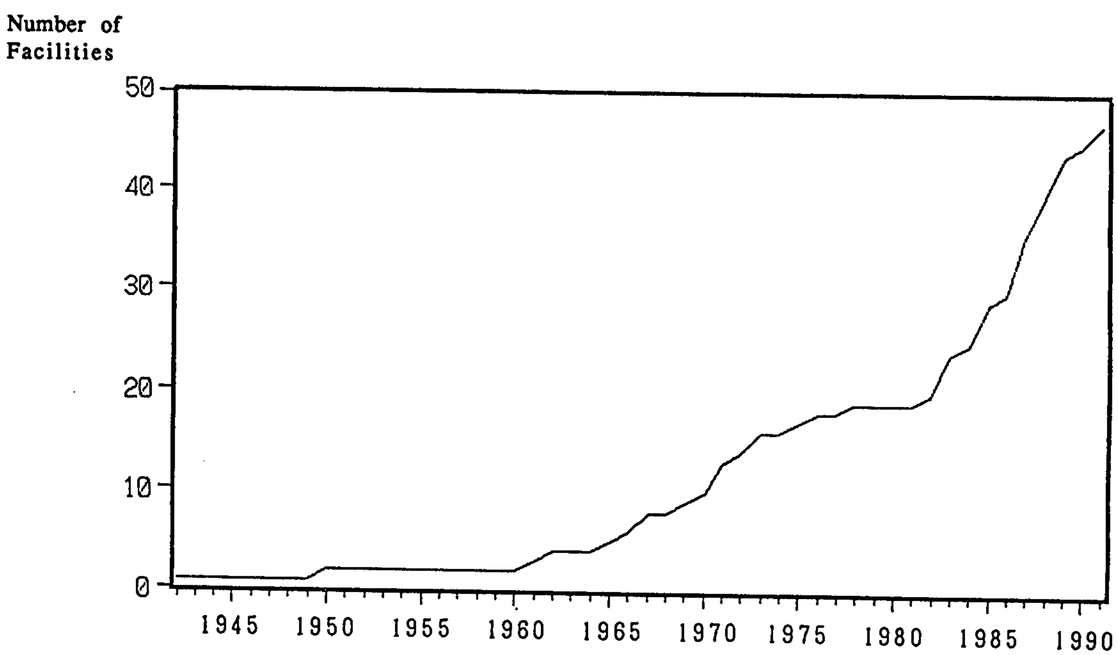
In 1989, National Institute of Science and Technology Policy (NISTEP) conducted a survey of the R&D activities of 132 foreign-affiliated companies in Japan. Most of the facilities (research centers, technical centers etc.) of foreign-affiliated companies have been established in the periods from the mid-1960's to the early 1970's (1st period), and from the early 1980's on (2nd period); the same two periods in which Japanese private enterprises were actively engaged in the establishment of their own R&D facilities. It seems typical of foreign-affiliated companies which established operations after the mid-1970's, to set up R&D facilities in relatively early years in their business operations in Japan. Most of the foreign-affiliated companies which established their R&D facilities in the 1st period started as "business-type" companies; engaged mainly in importing and market development, and gradually expanded. Those established after the mid-1970's, companies of the 2nd period, are increasingly becoming "R&D- type" companies, opting for R&D activities from the start of their Japan presence.

Figure 1-7-2 Number of R&D Facilities of Japanese Affiliates Abroad



Ministry of International Trade and Industry, "Statistics on Foreign Investment"

Figure 1-7-3 Trends in the Number of R&D Facilities of Foreign-Affiliated Companies in Japan



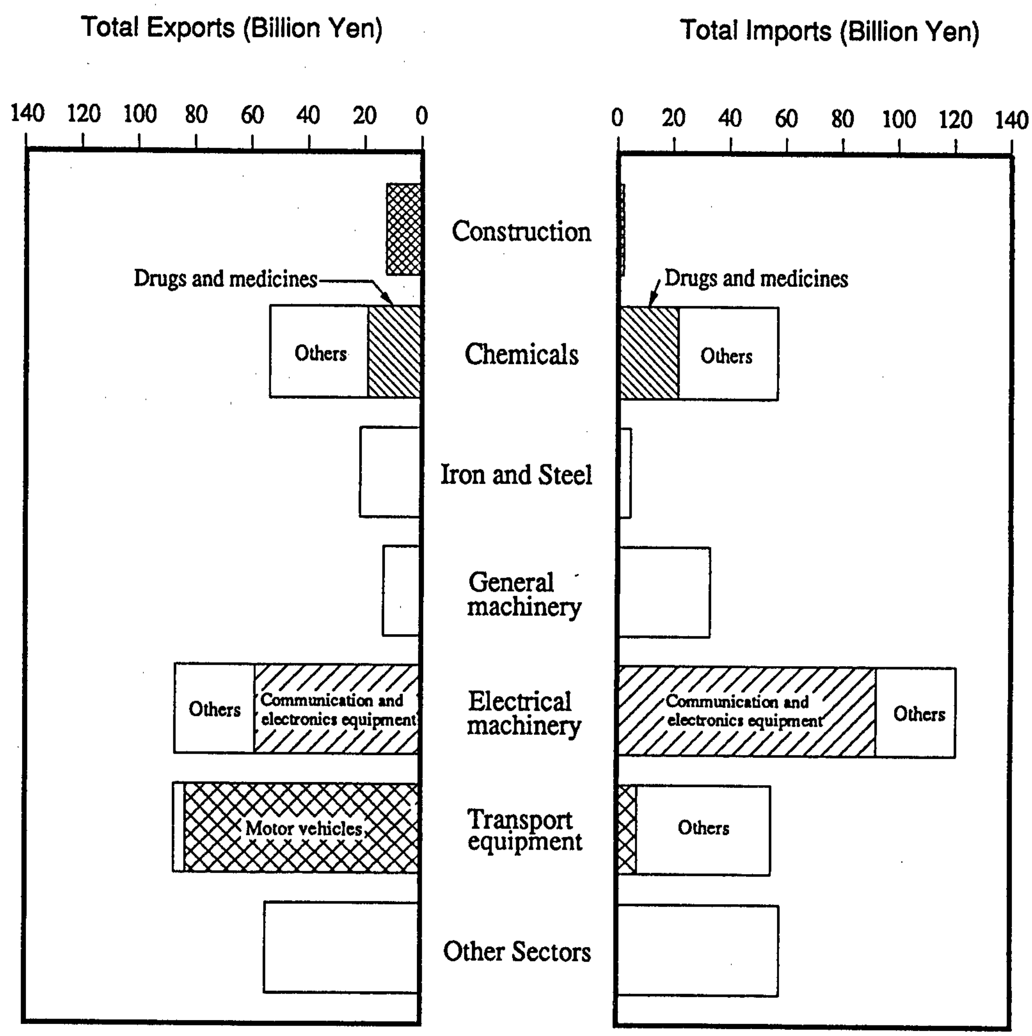
National Institute of Science and Technology Policy

Technology trade (international commercial transactions involving compensations for patents, utility models, know-how) is also an indicator of flows of R&D activities. The ratio of the total amount of trade in technology to the balance of total trade in Japan has been increasing, indicating that the growth of the former is exceeding the increase of the latter. According to the data calculated by the Bank of Japan, Japan's balance of trade ratio in technology (exports of technology divided by imports of technology) has gradually increased in the past 15 years, but still is at a lower level compared with that of the United States, the United Kingdom, France and Germany.

Looking at Japanese technology trade by industry, imports and exports of technology trade have approximately balanced in the drugs and medicines industry since the mid-1980's. It can therefore be said that competitiveness in technological development in this industry reached the international level at that time.

As far as the motor vehicle industry is concerned, after technology exports surpassed technology imports for the first time in the early 1980's, there has been a large trade surplus in this technology area, owing to a rapid increase in the exports since the mid-1980's. From the late 1970's to the early 1980's, 60-70 percent of the motor vehicle technology imports came from the United States. This tendency, however, was reversed in FY 1984, and Japan has been holding a large trade surplus in automobile technology with the United States. The increase in technology exports from Japan has been accompanied by the development of Japanese automobile production in the United States. The increase in the number of production facilities abroad as well as the improvement in the competitiveness in technological development are therefore considered to be main factors leading to a large trade surplus for the Japanese automobile industry.

Figure 1-7-4 Japanese Technology Trade by Industry (FY 1989)



Source: Statistics Bureau, Management and Coordination Agency,Japan,

"Report on the Survey of Research and Development"

1.8 Science, Technology and Society

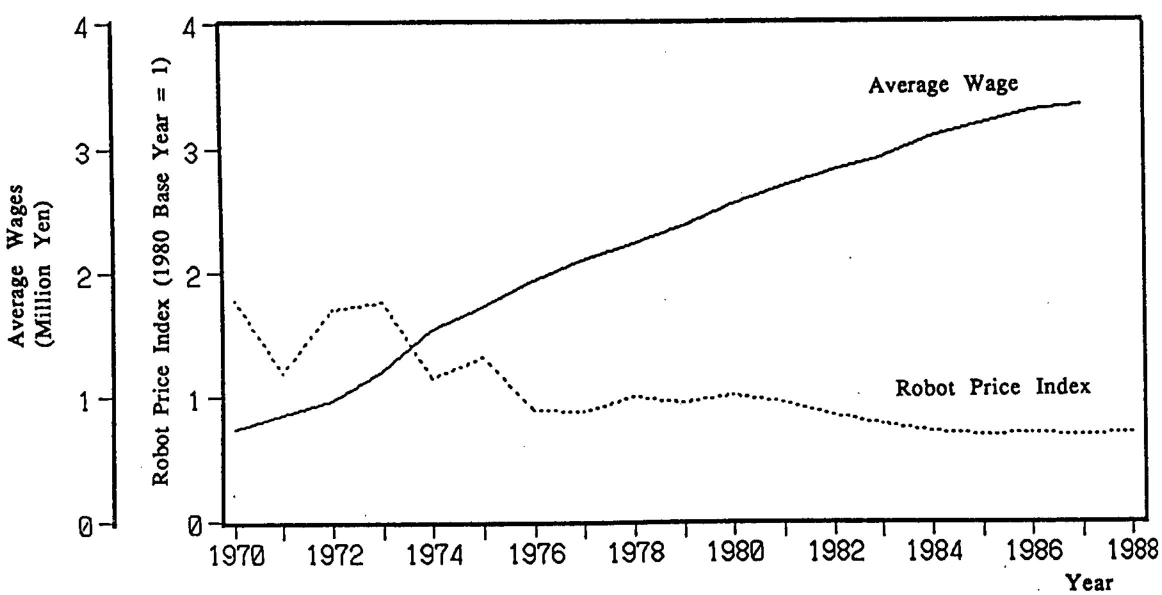
Industrial Robot Use and Corporate Technical Executives

According to data published by Japan Industrial Robot Manufacturers Association, the number of industrial robots in Japan has greatly increased since the late 1970's. In 1988, 55,900 industrial robots (5.5 times as many as in 1978) were shipped, for a total value of 324.5 billion yen (12.8 times the amount in 1978).

This remarkable growth has occurred against the backdrop of technological advancement which has subsequently led to reductions in robot prices. Figure 1-8-1, which shows the price index of robots (a weighted average of price indices by robot types according to their respective shipment value), clearly illustrates this situation. It is widely understood that in the past introduction of robots improved quality and technology development. But at present in Japan, introduction of robots by manufacturers is principally for their economic efficiency.

A much discussed question is whether robots in industry are attaining greater improvements in operational sophistication. According to our analysis, there certainly is such a tendency towards improvements, but the rate of improvements being observed at present are not as great as those in the past.

Figure 1-8-1 Wage Index and Robot Price Index



S. Mori, "Macroeconomic Effects of Robotization In Japan"

This section also classifies executives from 2,064 registered companies according to the undergraduate departments they graduated from and calculates the ratio of graduates from science and engineering related departments. This is used as an indicator for analyzing the level of corporate utilization of scientific and technical personnel. The analysis shows a relatively high ratio of scientific and technical personnel in the principal manufacturing industries in Japan, namely in the electrical and machinery, transport equipment and chemical industries.

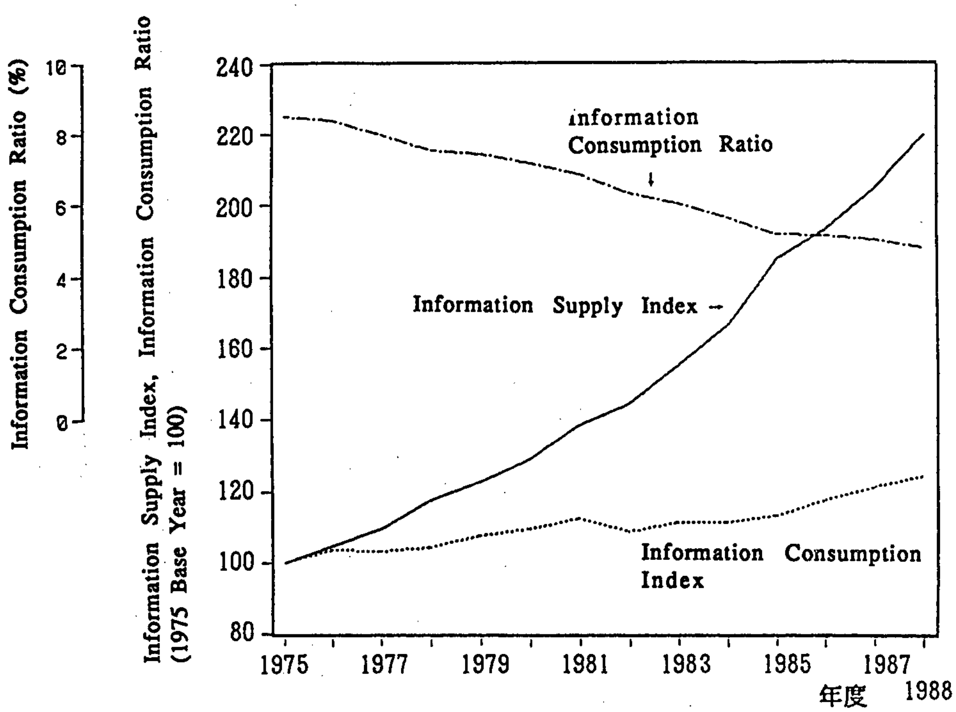
Impact on Life Styles

In recent years, significant developments in the field of communications have been considered to be contributing to the improvement of life styles. The relationship between achievements in science and technology on the one hand and life styles on the other can be measured by the level of information media use.

First examined is the total amount of information supplied in forms acceptable to receivers (consumers) and the amount of information actually consumed. The total amount of information supplied has grown considerably in the eighties due to a large increase in communications media such as facsimile and VAN/ data communications. The total amount of information consumed, however, has had a slight downward tendency, as a gradual decrease in the consumption of information from terrestrial TV broadcasting services, which still supply about 50 percent of the total information consumed, has not been fully offset by an increase in the consumption of information supplied by newspapers, magazines and books.

The impact of changes in the amount of information on social activities can be measured by the number of newspaper articles on science and technology. The number of specialized articles on science and technology increased rapidly in the mid-1980's, while those of general science and technology-related articles has stayed at the same level. This phenomenon reflects increasing demand for detailed explanations on scientific matters and an increased awareness by publishers of the need to supply detailed information to their readers. The results of surveys, along with public opinion polls conducted by the Prime Minister's Office, indicate increasing opportunities to obtain scientific and technological information.

Figure 1-8-2 Supply and Consumption of Science and Technology Information

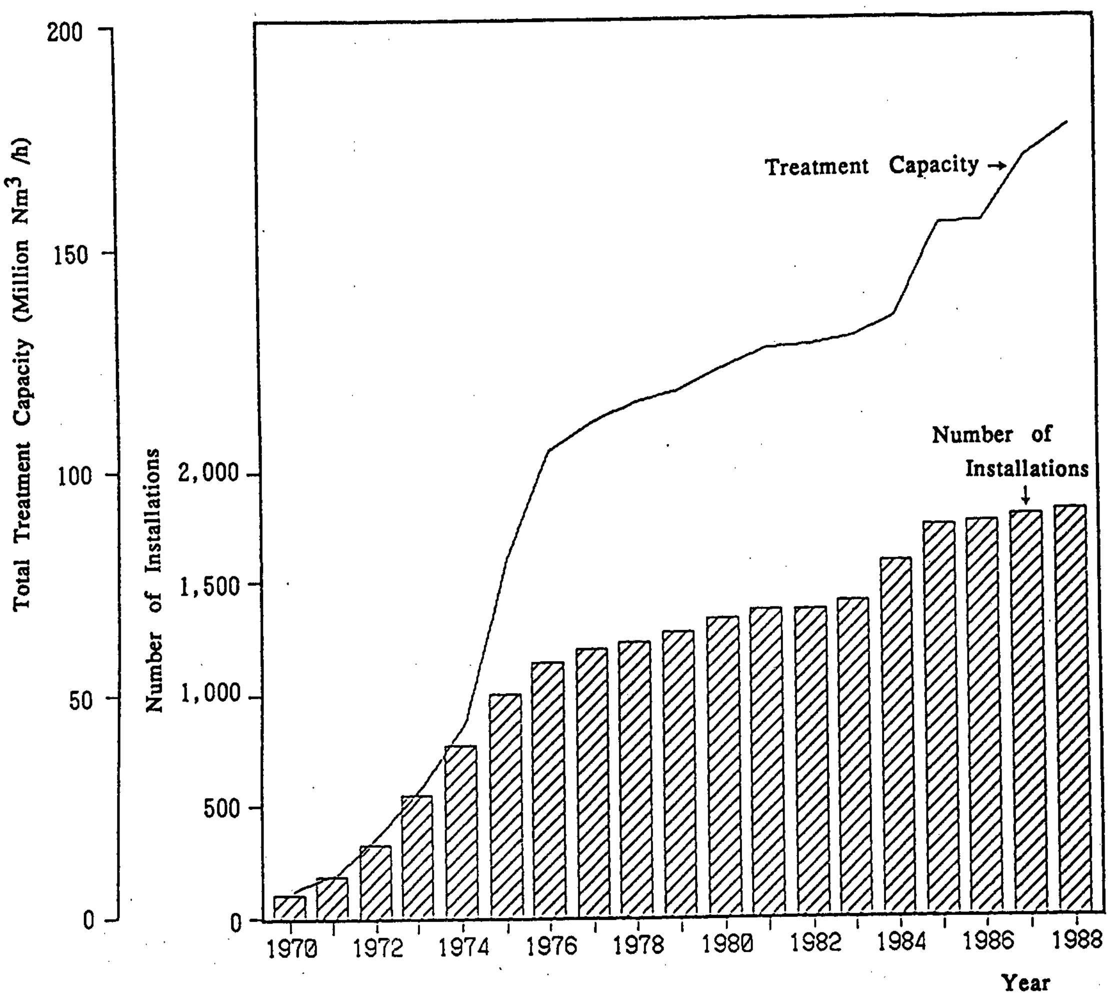


Ministry of Posts and Telecommunications, "Census on Information Flows 1988"

Contribution to Global Environmental Conservation

In Japan, consumption of petroleum increased rapidly in the 1960's, due to the expansion of industrial activities particularly in heavy industries such as mining and manufacturing. This industrial activity had also resulted in serious environmental pollution in the mid-1960's. The Japanese government has addressed the problem of environmental conservation by establishing relevant laws and regulations as well as by developing technologies for the prevention of environmental pollution through industrial technology development schemes.

Figure 1-8-3 Trends in the Number and Total Capacities of Fluegas Desulphurization Units

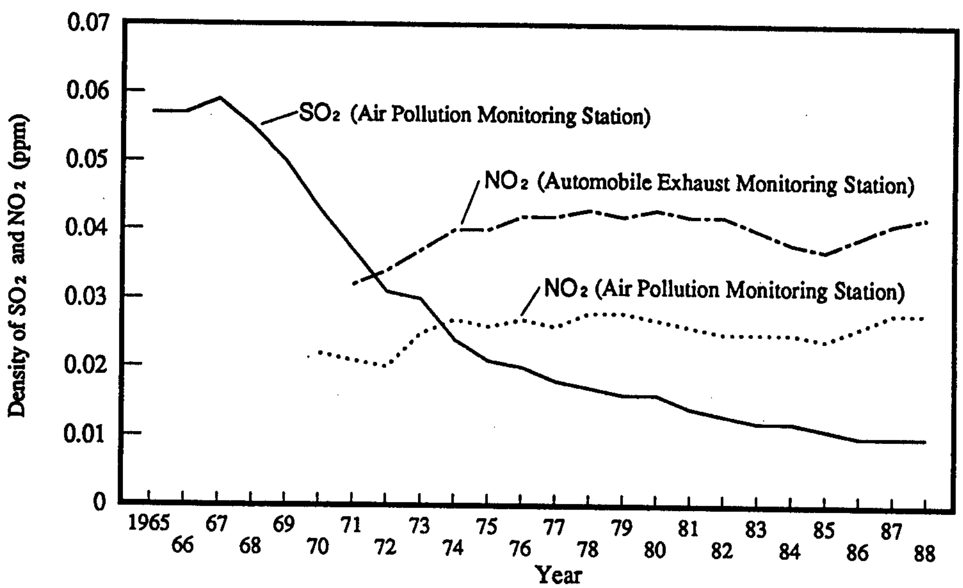


Environment Agency, "White Paper on the Environment 1990"

One such preventive technology is fluegas desulphurization. Figure 1-8-3 shows the progress in the installation of fluegas desulfurization units. This technique and other measures for environmental preservation such as use of low-sulphur crude oil have resulted in a lower level of SOx discharges (in proportion to primary energy) in comparison to other industrialized countries, as well as in the improvement in lower density of sulphur dioxide in the atmosphere (see Figure 1-8-4). NOx discharges from fixed origins such as factories have declined due to improvements in burning methods and denitrification of fluegas, but the increase in automobile traffic has caused a rise in NOx discharge levels, causing NOx density in the atmosphere to remain almost unchanged. As for water pollution, despite development of preventive methods in factories and establishments, households have increasingly become polluters of water in recent years.

An important global environmental issue is the phenomenon of global warming caused by rising discharge levels of carbon dioxide. Since the oil crisis, countries have promoted changes in their energy dependency structures (i.e. lowering dependence on petroleum) and have introduced energy saving measures. However, in Japan and other countries, the switch to non-fossil fuel is proceeding very slowly as is reflected in the discharge level of carbon dioxide (in proportion to primary energy). Energy conservation progressed for 10 years until the early 1980's, but has slowed down. This analysis shows how a reduction in carbon dioxide discharge could be made possible through changes in the energy supply structure, and concludes that a switch to non-fossil energy sources needs to be further encouraged as a preventative measure of global warming.

Figure 1-8-4 Changes in the Annual Average Concentration of SO_2 and NO_2



Source: Environment Agency, "White Paper on Environment" 1990

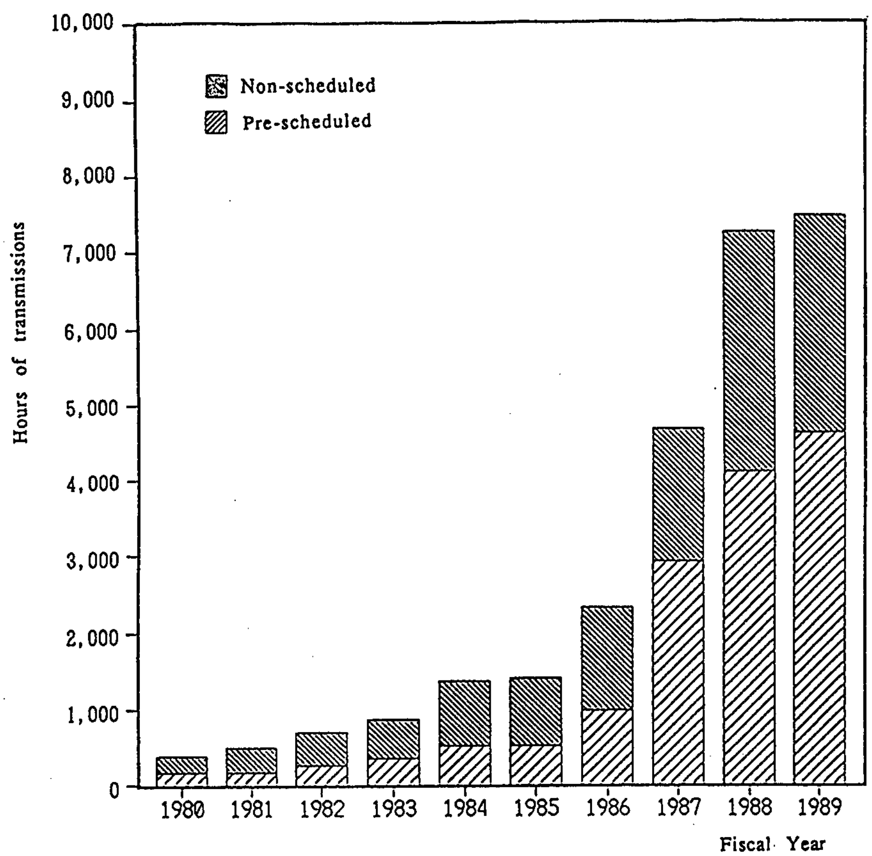
See Table 8-3-7

Science, Technology and Culture

The public is increasingly exposed to the changes in world events. Japanese newspaper publishing companies are now printing abroad through data transmission systems, using satellites, thus enabling a steady information supply without tarnishing news "freshness". In addition, broadcast images sent to Japan via satellite are seen daily in TV news programs, indicating large annual increases of images received (Figure 1-8-5). Japanese broadcasts are also being sent abroad and are functioning as excellent sources of information, especially for viewers in Asia who wish to have opportunities to get in touch with Japanese news and culture. This growth in transmission and reception of broadcast illustrates how science and technology contributes to international exchange of information and culture.

In artistic aspects, achievements in science and technology can be utilized to promote creative television viewer interpretations. In this sense, computer graphics (CG) when used in broadcasting programs, play an important role in aiding viewers comprehension and enabling individuals to understand how media design and illustration work.

Figure 1-8-5 International Transmission of Images via Satellite



Source: NIPPON HOSO KYOKAI (*Japan Broadcasting Corporation*), "NHK Yearly Report"

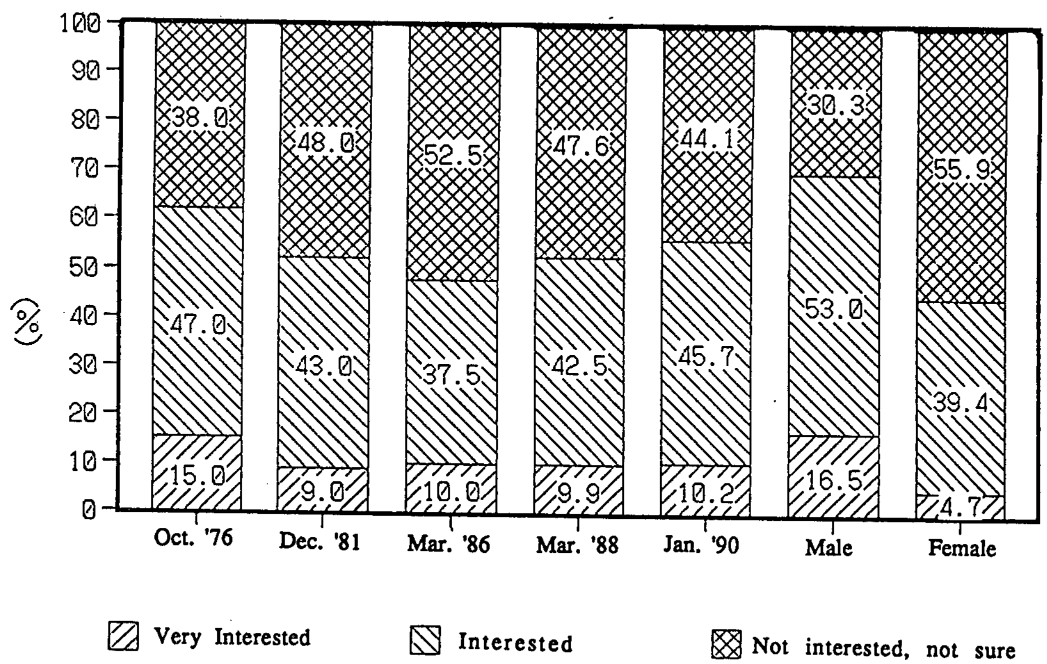
1.9 Public Opinion on Science and Technology

An important indicator reflecting scientific and technological activities is public perception of science and technology. Public opinion polls on science and technology are used to measure these perceptions. Many of these polls concern energy (atomic energy in particular), life sciences including organ transplants, and information sciences and the environment. Subjects in public opinion polls reflect particular social problems surrounding the polling period, as can be understood from the fact that a large number of these polls conducted after the 1985 Exposition of Science and Technology focused upon public perception of science and technology in general.

General Opinions on Science and Technology

Public perceptions of science and technology which are reflected in these opinion polls indicate public interest in science and technology has shifted in to U-shaped curve, and is recently showing an upward trend reflecting greater interest (Figure 1-9-1). According to a survey conducted in 1990, 10.2 percent of those interviewed are "very much interested" and 45.7 percent "somewhat interested" in science and technology, which means over half (55.9 percent) of those polled show an interest in S&T issues. Previous polls also indicate men tend to be more interested in science and technology issues than women.

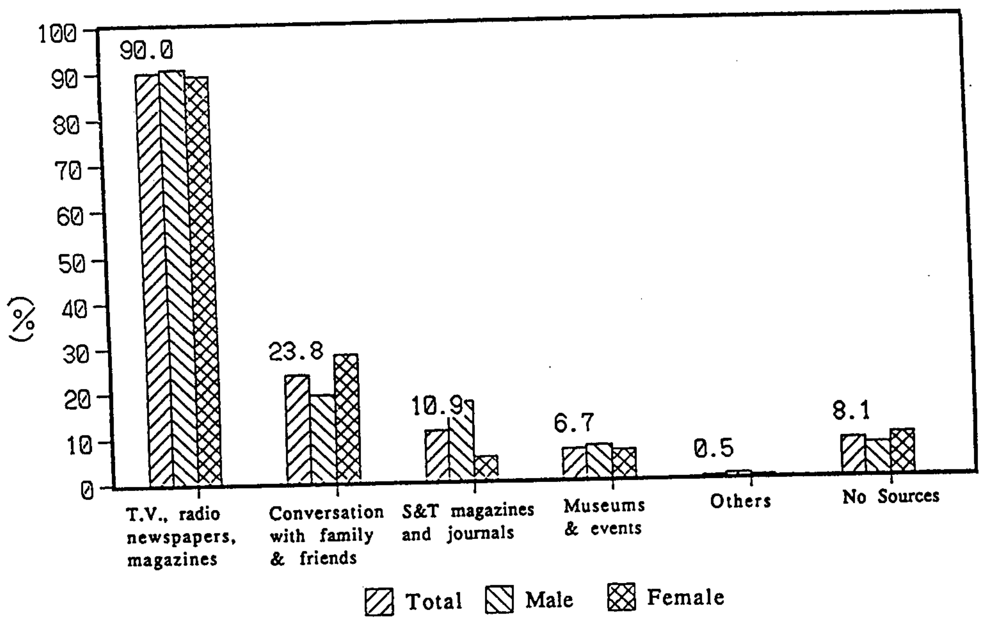
Figure 1-9-1 Interest in Science and Technology



Prime Minister's Office, "Opinion Survey on Science, Technology and Society" 1990

Interest in science and technology is deeply related with the collection and dissemination of information. Surveys indicate about 90 percent of those polled obtain information on science and technology from such mass-communication media as TV, radio, newspapers and general magazines (Figure 1-9-2).

Figure 1-9-2 Sources of Information on Science and Technology

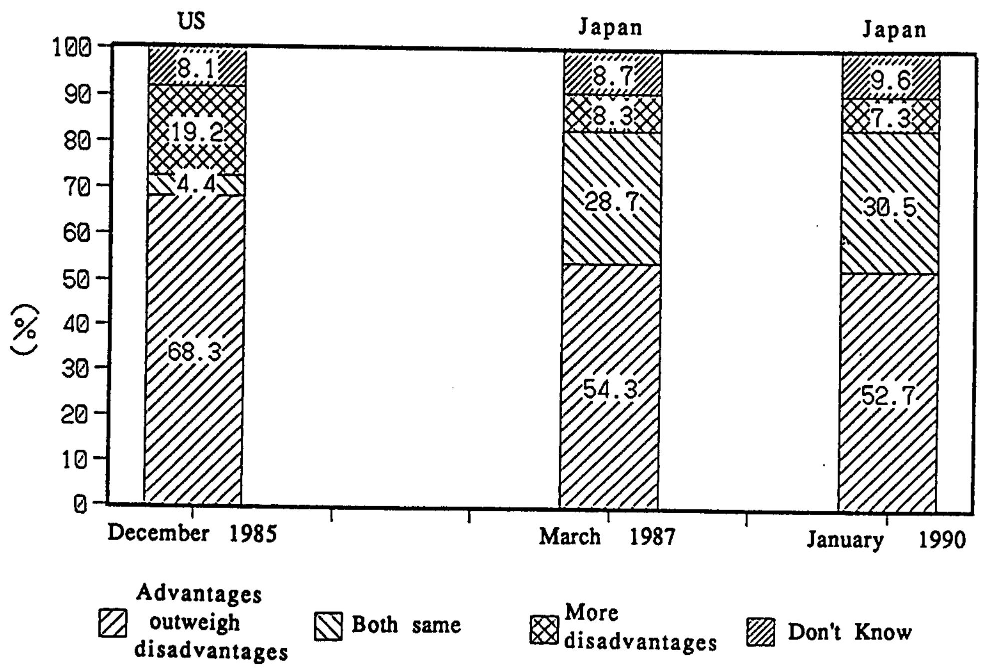


Prime Minister's Office, "Opinion Survey on Science, Technology and Society" 1990

According to a survey concerning recognition of terms related to science and technology, while terms such as GNP and computer software are well known by the public, only a small percentage of those polled recognize the word DNA. As far as knowledge of science and technology is concerned, more than 80 percent of those polled think that "continents are moving little by little in a span of thousands of years," while those who believe "an electron is smaller than an atom" represent less than 40 percent of the pollees. Results of these surveys depend on the level of education and newness of knowledge as well as the frequency of appearance in the media and level of specialization for each term.

More than half those polled reflect positive images of science and technology through expressed levels of interest and knowledge. However, the results of a survey on the relationship of the advancement of science and technology with human satisfaction and individual fulfillment suggests that more and more people have come to feel that the former does not necessarily lead to the latter (Figure 1-9-3). Furthermore, many of those polled in a survey on the contribution of S&T to working and living conditions see positive contributions resulting but concerns about negative impacts such as abuses and mistakes in the utilization of science and technology were concurrently expressed. It can be concluded that even though the public has positive opinions on science and technology in general, there is also a concern about some aspects of scientific and technological progress.

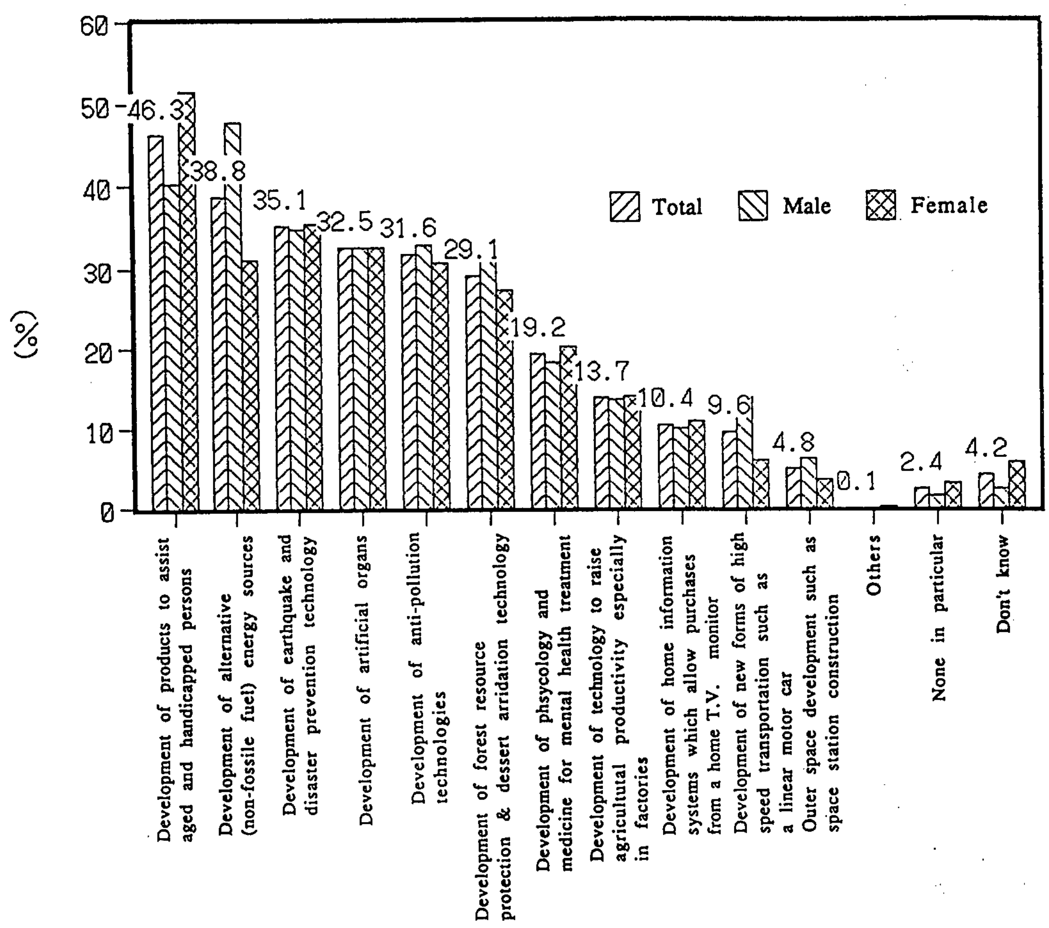
Figure 1-9-3 Public Perceptions on Achievements in Science and Technology



Prime Minister's Office, "Opinion Survey on Science,Technology and Society" 1990

Desired paths on the promotion of science and technology are reflected in the answers to the question about what sort of science and technology should be developed in the future. The result is that "development of products to assist elderly and handicapped persons" and "development of alternative energy sources" have broadest support among the public (Figure 1-9-4).

Figure 1-9-4 Categories of Science and Technology to be Developed



Prime Minister's Office, "Opinion Survey on Science,Technology and Society" 1990

Opinions on Individual Categories of Science and Technology

This section examines public opinion on four selected categories of science and technology: Information, Energy, Life Sciences and the Environment.

Information

The term "information society" (*joho shakai*) is now recognized by over 80 percent of the population, a figure which has increased by more than 10 points in the last 5 years. In addition, the idea that modern society is becoming an information society has come to be broadly shared among the public. However, those polled are divided on the perception of just what an information society is, as the number of positive opinions is matched by that of negative ones.

Development and spread of computers are major factors contributing to the progress towards an information society. According to a survey concerning the necessity of computers, approximately 80 percent of the respondents regard computers as indispensable in modern society. On the other hand, a public opinion poll on the use of computers suggests that many people feel that advantages and disadvantages of computers are not intrinsic to the technology itself but in the human beings who use them. However, the poll also indicates that a large number of people also agree with opinions which point out negative aspects of computers.

Invasion of individual privacy is one negative aspect pointed out in public opinion polls. More than 60 percent of those polled are interested in the protection of privacy, and this percentage is growing. Those who point out that the increase of privacy invasions are growing in number, and represent almost 50 percent of those polled. Furthermore, over 70 percent expect further increases in cases of privacy invasion in the future. If improvement and spread of computer systems lead to their use by more people, especially by the younger generation, there may be a sense of growing crisis among the population concerning invasions of privacy.

Energy

Many surveys have been conducted since the 1st oil crisis regarding energy conservation and other energy problems and their solutions. In general, most of those polled are of the opinion that energy conservation should proceed concurrently with an improvement in living standards, and that possible energy shortages in this process are expected to be compensated for by new energy developments.

Nuclear power generation is the most frequent theme in opinion polls on energy. According to surveys on the promotion of nuclear power generation, a gradual decrease in opinions supporting promotion since the late 1970's has resulted in a reversal of the situation in the 1986 poll, with against nuclear power promotion becoming the majority and the gap between the two opinions has been widening ever since (surveys conducted by Asahi Shimbun). It should be Noted here, however, that opinions against the promotion of nuclear power generation represent those who do not support the construction of new nuclear power plants, and include the opinion that the current level of nuclear power generation is acceptable. In fact, the same Asahi-Shimbun poll indicates that majority of those polled are of the opinion that nuclear power generation should remain at current levels.

Incidents such as the Chernobyl disaster seem to affect public opinions on the promotion of nuclear power generation. The same is true with the answers to questions concerning the safety of nuclear power generation.

Survey results on future desired methods of electric power generation are also important in determining the public image of nuclear power. The number of answers indicating nuclear power as a main source of electricity generation in the future has shifted in a U-shaped curve, turning upward after having bottomed out in 1980, and accounting for more than half of the total answers in recent years. According to results mentioned above, it can be concluded that the general public, despite opinions against the promotion of nuclear power generation, expect a careful development of nuclear energy, admitting the necessity for nuclear power generation to play a central part in light of the energy resource situation in Japan and global environmental problems.

Life Sciences

Survey results indicate that 80 percent of those polled recognize the term "life sciences." As for more concrete terms, "in-vitro fertilization" and "artificial heart implants" are recognized by more than 70 percent of the people.
80 percent of those polled have high expectations on advancement of life sciences, particularly for treatment of cancer and hereditary diseases. The medical aspects of the achievements in life sciences consist of contributions to prolonging human life. However, more than 60 percent advocated for a natural death with minimal artificial intervention, more than double those who advocate utilizing maximum means of science and technology to prolong human life.

Brain death and organ transplant issues are the most disputed subjects in the life sciences. More and more people have come to accept the condition of brain death as death of a human being (accounting for over 40 percent of the total responses in the 1985 survey), and those who do not define real death at brain death are in the minority.

Concerning R&D in life sciences, which is also seeing broad interest, less than 1 percent of those polled believe in the total freedom of R&D and use of technology. The majority of those polled would require broad consensus in the R&D process concerning life sciences and in the effect these achievements have on society.

Environment

Global environment issues are also of increasing public concern in recent years. There are thus increasing expectations for science and technology to help make greater contributions to the preservation of the environment.

About half those polled are of the opinion that we should seek a symbiosis between human beings and nature, subjecting ourselves to the principles regulating life and nature but at the same time using nature for the benefit of all. On the relationship between technological progress and environmental problems, those polled are divided among three opinions; those who are concerned about possible environmental problems resulting from technological progress, those who believe in the "cleanliness" of new technology, and those who feel obliged to pay a certain price in exchange for the benefits from advancement in science and technology. This situation, plus a considerable number of "don't know" responses illustrate lack of consensus regarding the proper relationship between technological progress and the environment.

CHAPTER 2

HUMAN RESOURCE DEVELOPMENT FOR SCIENCE AND TECHNOLOGY

CHAPTER 2

HUMAN RESOURCE DEVELOPMENT FOR SCIENCE AND TECHNOLOGY

Human resource development is one of the most important fundamentals in scientific and technological activities. Educational infrastructure is stratified according to the age of students into primary, secondary and higher education. It starts with elementary education, at which point the human resource development related to science and technology is considered to have already commenced, and ends with such institutions as high schools, colleges, universities and post-graduate schools, which provide personnel for R&D in the industrial, academic and public sectors.

This chapter discusses the indicators of educational infrastructure, which plays an important role in scientific and technological activities, in order of age of students. As indicated in the introductory chapter, the indicators were chosen on the basis of a solid system called cascade structure. Thus, these choices were made systematically though subject to the availability of statistical data.

The chapter is composed of three sections; educational achievement in primary and secondary education, higher education resource trends and employment graduates from higher education. Concerning the primary and secondary level, an international comparison of performance in science and mathematics, diffusion level of personal computers and technical courses in senior high schools among others are provided as indicators related to science and technology education in elementary schools and high schools. In higher education, such factors as number of applicants for admission and enrollment and expenditures for education are adopted as indicators of science and technology in colleges and universities. The section concerns employment of higher education graduates and discusses employment of college and university graduates, enrollment in post-graduate schools, and number of master's and doctorate degrees conferred.

2. 1 Primary and Secondary Education

The total number of students at the primary and secondary levels (elementary schools and high schools) is currently showing a downward trend. At the peak of the second baby-boom period, almost 2 million babies were born each year, but since then, the drop in the number of newly born children has been accelerating. For example, only 1.2 million children were estimated to be born in 1990.

Thus, enrollment at the primary and secondary levels has been decreasing. At these levels, mathematics and science are considered to be the subjects having a close relationship with science and technology. The number of lessons in these subjects is supervised in accordance with the study guidelines established by the Ministry of Education. These guidelines seem to be well observed though slight differences may exist according to educational policies in each school. The standard teaching hours specified in the course of study have changed very little in the past as far as these two subjects are concerned. Lessons in mathematics account for 175 unit hours (see Note) from the 3rd through 6th grade in elementary schools and 105-140 unit hours in junior high schools. Situations in senior high schools vary from 350 to 560 unit hours according to whether they are general or technical schools.

Lessons in science, on the other hand, account for 105 unit hours in elementary schools and 105-140 unit hours in junior high schools. In senior high schools, the total lessons in optional scientific subjects such as physics, chemistry and earth science account for 210-350 hours in the three years.

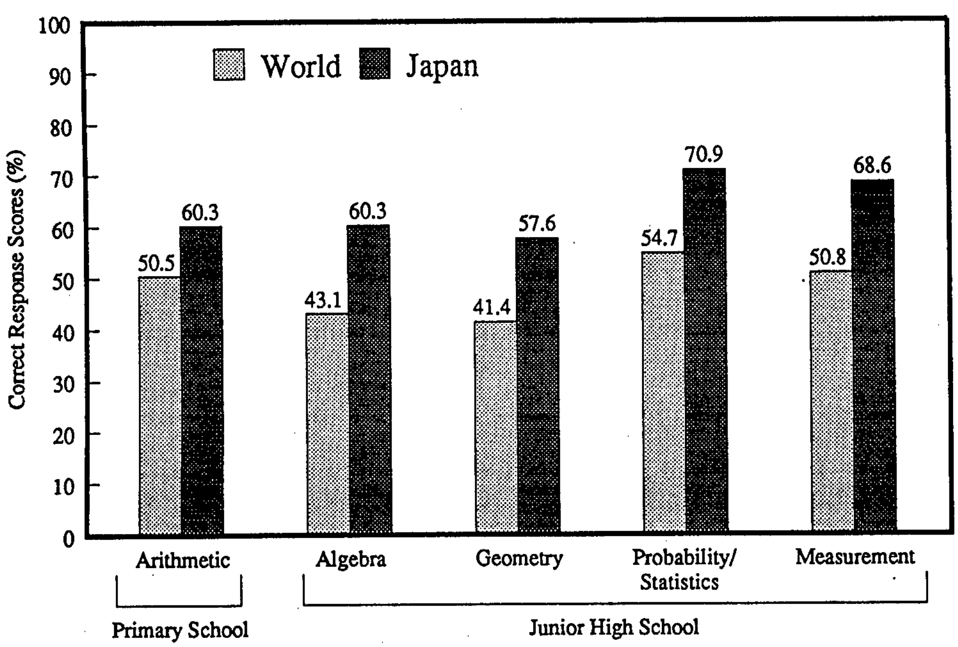
Note: A standard unit hour at the primary and secondary levels corresponds to 45 minutes in elementary schools and 50 minutes in high schools.

2. 1. 1 Student Performance in Mathematics and Science

What is the performance of Japanese elementary and high school students in mathematics and science? An international comparison of performance at the primary and secondary levels is difficult due to the differences of educational systems and policies among nations. The IEA (see Note (1)) makes comparisons in mathematics and science education. This international comparative research indicates that Japanese students have relatively good marks in both subjects.

In mathematics, Japanese junior high students have the highest scores in every category (Source 1, Figure 2-1-1). Compared with the international median score (which can be considered as the international average), Japanese students have high correct answer percentages in algebra, geometry, probability/ statistics and measurement. Japan leads the country ranked second by a very comfortable margin in each of these categories. Therefore, Japanese junior high students can be considered internationally to have excellent performance in algebra, geometry, probability/ statistics and measurement. Incidentally, Dutch students are in second place in mathematics.

Figure 2-1-1 Performance of Elementary and Junior High School Students in Mathematics: International Comparison

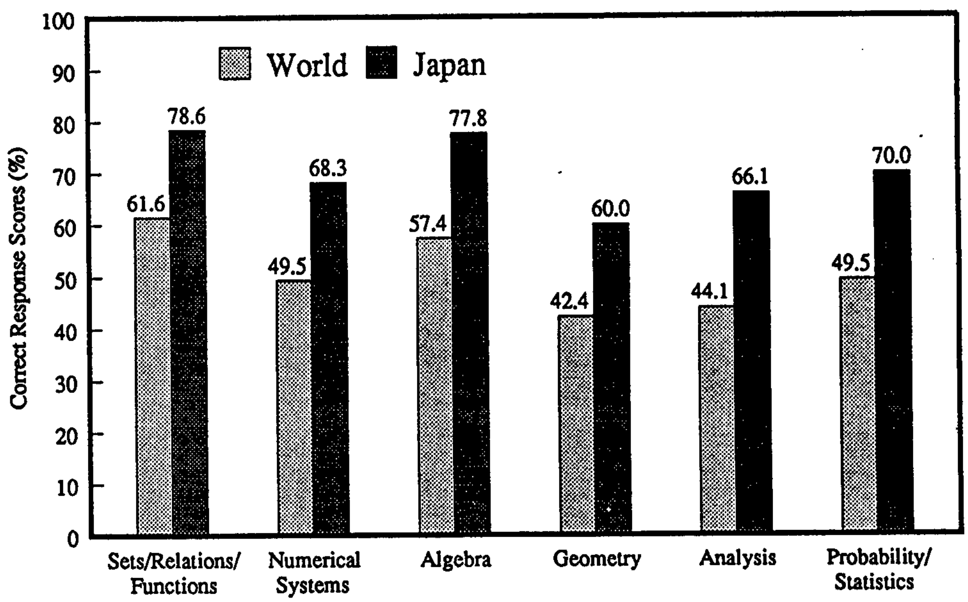


Source: National Institute of Educational Research, "IEA International Mathematics and Science Education Survey, Midterm Report", 1988

See Table 2-1-1

As far as senior high school students are concerned, Japanese students are ranked second in each category (Source 1, Figure 2-1-2). However, it cannot necessarily be conclude from this fact that the performance of Japanese students declines relatively as they move from junior high to senior high schools. In fact, Japanese student performance exceeds the international standard in each category, even though it is only in second place. Furthermore, Japanese students are close to Hong Kong students, ranked first, in all categories but numerical systems and analysis. In making such comparisons, differences in curricula need consideration. If you allow for such differences to be represented by the percentage of students studying each category of subject, countries with large number of students studying algebra and analysis tend to have good performances as regards these two respective categories (Source 1).

Figure 2-1-2 Performance of Senior High School Students in Mathematics: International Comparison



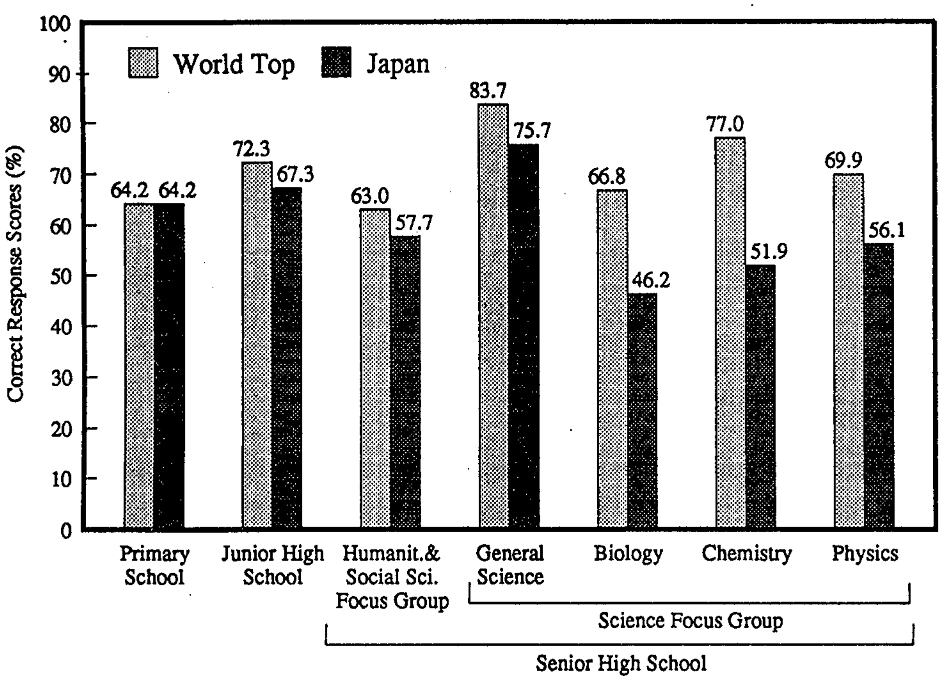
Source: National Institute of Educational Research, "IEA International Mathematics and Science Education Survey, Midterm Report", 1988

See Table 2-1-2

Concerning performance in science (Source 1, Figure 2-1-3), Japan is ranked first at the primary level along with South Korea, and second at the junior high level, with Hungary holding a small edge. At the senior high level, Japanese students in the Social Science and Humanities-Focus group are in third position in required science, whereas the Natural Science-focused group students are ranked between 5th and 11th. No international scores are available in science. Compared with the correct answer percentage of the country at the top, Japan trails by more than 10 points in all categories but total science subjects, and in biology and chemistry, the margins exceed 20 points. These facts suggest that the performance of Japanese students is relatively lower in science at higher educational levels. Students in the U.K., Singapore and Hong Kong, on the contrary, show top-level performance at the end of their secondary education, notwithstanding fairly mediocre scores in elementary and junior high school (Source 1).

It is currently pointed out that the performance of Japanese students declines relatively as they grow older, and that their correct answer percentages are considerably lower in subjects calling for much thinking than in subjects focusing on calculation. It is true that the performance of Japanese students is generally at a high level, but problems remain in maintaining that performance at higher educational levels and in nurturing in students a more creative ability.

Figure 2-1-3 Performance of Primary and Secondary School Students in Science: International Comparison



Source: National Institute of Educational Research, "IEA International Mathematics and Science Education Survey, Midterm Report", 1988
See Table 2-1-3

Note:

(1) The IEA (International Association for the Evaluation of Educational Achievement) is an international academic research body established in 1960, composed of educational R&D organizations representing member countries and specially recognized individuals. Currently, 31 organizations in 28 countries are members of this academic society with its headquarter located at Stockholm University in Sweden.

(2) Outline of research conducted by the IEA is as follows;

In Mathematics:

20 countries including Japan, the U.S. and France participated in this research concerning the following two groups of students.

(a) Students in a grade composed for the most part of 13 year-olds (corresponding to junior high school students).

(b) Students directly before entrance into colleges and universities who regularly receive lessons of at least 5 unit hours per week in mathematics (corresponding to junior high school students).

The research was conducted from 1980 to 1982 (in FY 1980 in Japan). The number of students subject to the research differs by country. In the case of Japan, 8,091 junior high school students and 7,954 senior high school students participated in the research. The total number of participants was about 80,000 in junior high schools and about 45,000 in senior high schools.

In Science:

22 countries including Japan, the U.S., the U.K. and Canada participated in the research concerning the following three groups of students:

(a) Students in a grade composed for the most part of 10 year-olds (elementary school pupils).

(b) Students in a grade composed for the most part of 14 year-olds (junior high school students).

(c) Students in the final grade of the secondary education (senior high school students).

The research was conducted from 1983 to 1986 (in FY 1983 in Japan). The number of students subject to the research differs by country. In the case of Japan, 7,924 elementary school pupils, 7,610 junior high school students and 6,500 senior high school students participated in the research. The total number of participants was about 72,000 in elementary schools, 73,000 in junior high schools and 54,000 in senior high schools. All of the above data were adopted from Source 1.

2. 1. 2 Diffusion of Personal Computers in Primary and Secondary Education

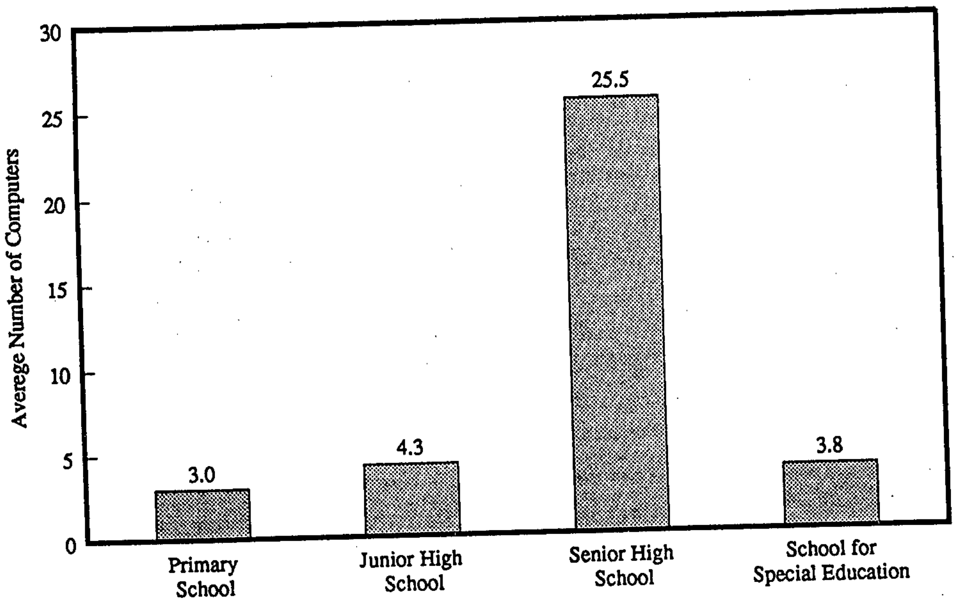
The installation of personal computers for pedagogic purposes at the primary and secondary levels is expected to enhance student interest in and familiarization with computers and consequently to strengthen their interest and knowledge in science and technology. It is also useful in developing professional skills from an early stage in order to meet the increasing social demand for information engineers.

It has only been several years since the Ministry of Education adopted the diffusion of computer related education at the primary and secondary levels as a national policy with budget allocation. Actually, governmental subsidies for the installation of computers in public elementary and junior high schools started in FY 1985. Therefore, as of March 1989, 21.6 percent of the elementary schools and 44.8 percent of the junior high schools are equipped with computers for pedagogic purposes. However, the average number of computers per school is only 3.0 for elementary schools and 4.3 for junior high schools (Source 2, Figure 2-1-4).

Introduction of computers for pedagogic purposes in commercial and technical courses at the senior high schools is growing.The above-mentioned support activities for public schools started in FY 1983 for vocational senior high schools, and in FY 1985 for other high schools. These support activities were extended to private vocational high schools in FY 1985. As a result, 96.3 percent of the schools are equipped with computers for pedagogic purposes, but their number remains at a modest level of 25.5 per school.

With the expectation of further expansion of computer use for pedagogic purposes, the improvement of in-service training has been in progress in order to develop computer related abilities of teachers.

Figure 2-1-4 Installation of Computers for Pedagogic Purposes in Primary and Secondary Schools



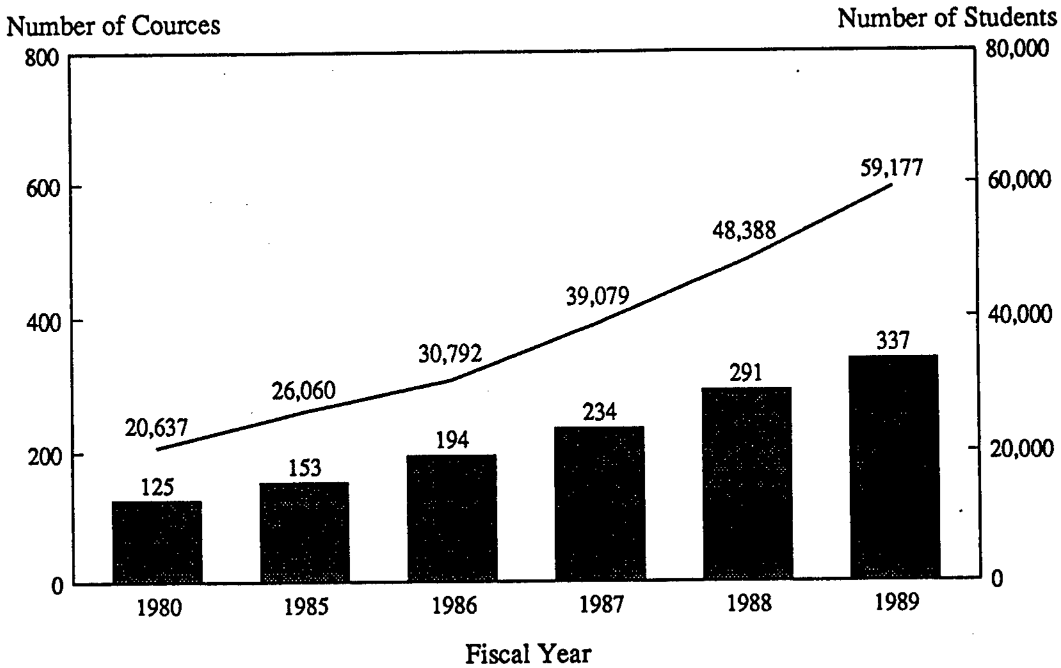
Source: Ministry of Education,
See Table 2-1-4

2. 1. 3 Information-Related Courses in Senior High Schools

As a form of vocational education in senior high schools, expansion of information science related courses has been promoted to meet social needs. The numbers of courses related to information technology and data processing and of high school students in these courses have both increased by almost 3 times from FY 1980 to 1989 (Source 2, figure 2-1-5).

Social needs for engineers in information science related sectors are expected to increase further in the future. Because of the expansion of these information science and data processing subjects, the focus of human resource development in vocational education is expected to change.

Figure 2-1-5 Numbers of Information Science Courses and Students in High Schools



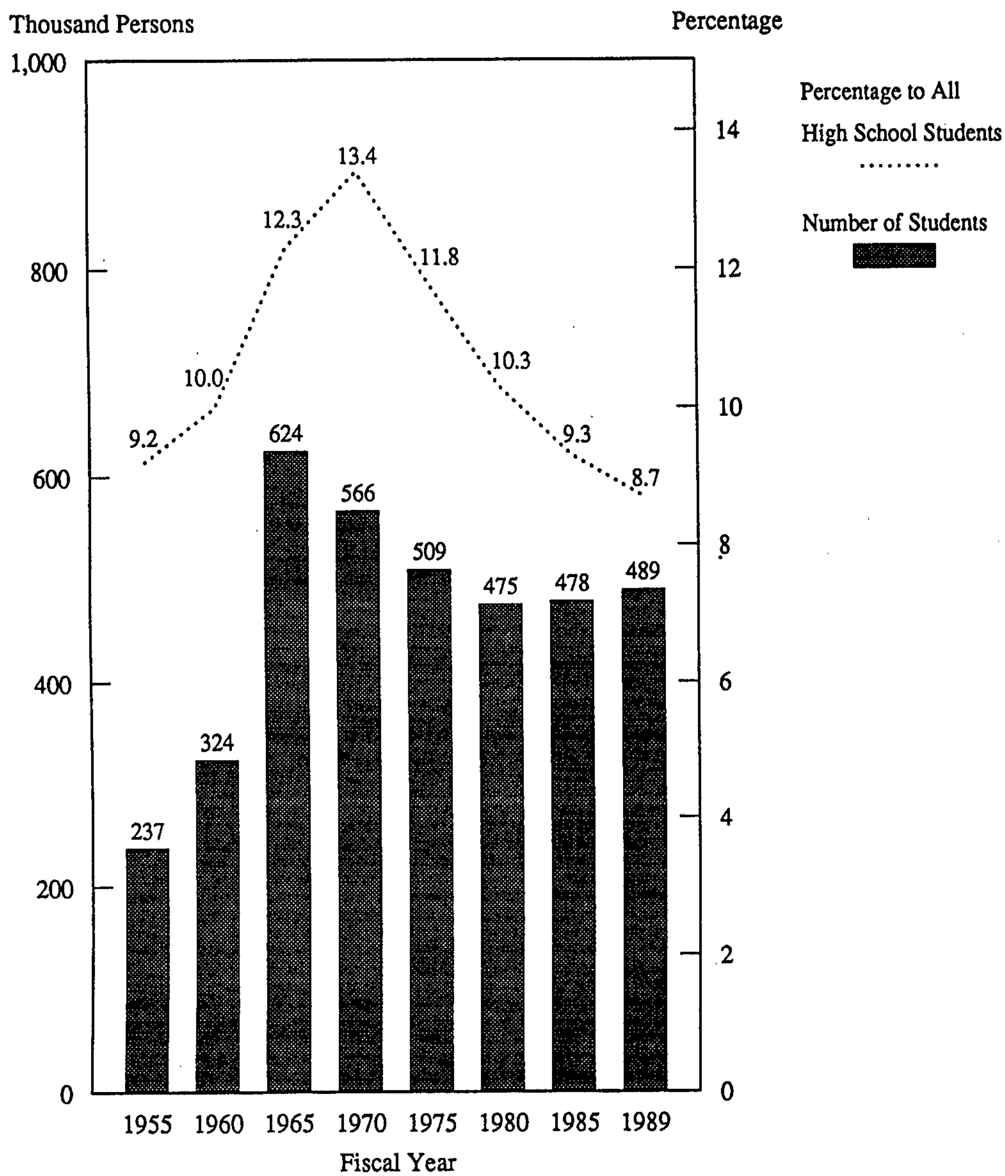
Source: Ministry of Education, "Report of Basic Survey on Schools", various editions
See Table 2-1-5

2. 1. 4 Technical Courses in Senior High Schools

One of the educational bases for science and technology is engineer development course, particularly technical courses in senior high schools. Figure 2-1-6 (Source 2) shows us changes in the number of students in technical courses and their share in the total number of high school students. The number of high school students in industrial courses hit a peak in 1965 at over 620,000. At this time, those who had been born in the baby-boom period just after World War II were in high schools. In addition, the number and rate of enrollment in high schools both recorded sharp increases in the 1960's. The peak reflects such social background at that time. The ratio of technical high school students to the total number of high school students increased until 1970, when it hit a peak, and has been declining ever since. This 5-year lag between the two peaks can be explained by the remaining attractiveness of technical courses in that period.

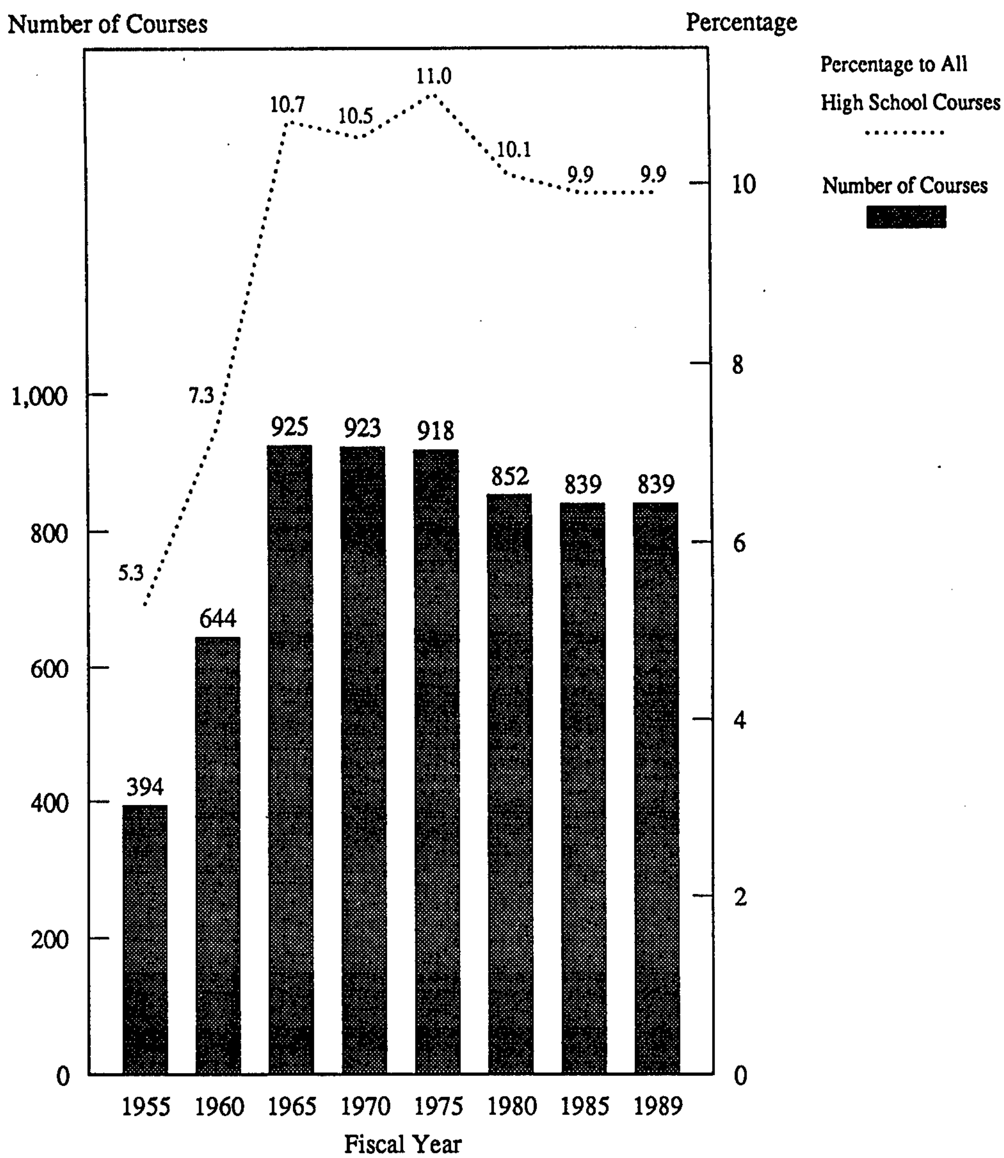
As the Japanese economy grew rapidly a large-scale demand in industry for engineers and technicians followed. In order to respond to these needs, a large number of technical courses were newly established at that same time (Source 2, Figure 2-1-7). The peak in the establishment corresponds to that of enrollment, at which point the number of technical high school courses exceeded 925, accounting for 10.7 percent of the total high schools. This percentage continued to climb even after that, hitting a peak at 11.0 percent in 1975. Personnel thus provided by technical courses can be said to have played an important role, filling societal needs.

Figure 2-1-6 Number of High School Students in Industrial Courses



Source: Ministry of Education, "Report of Basic Survey on Schools", various editions
See Table 2-1-6

Figure 2-1-7 Number of Technical Courses in Senior High Schools



Source: Ministry of Education, "Report of Basic Survey on Schools", various editions
See Table 2-1-6

The situation in the 1960's is represented by the "7:3 educational policy" adopted by certain prefectures. The 7:3 policy meant placing 7 students in technical courses for every 3 students in general courses and is a clear reflection of strong emphasis on vocational education in this period. However, as the enrollment rate in colleges and universities increased, a higher percentage of students came to seek entrance to general high schools. Consequently, as mentioned above, the number of students in technical courses has been declining, causing a drop in their share of the total number of high school students.

The decline in the number of courses and students has come to a temporary halt, as the second baby-boom generation is currently of high school age. However, a sharp drop in the number of high school age students after 1995 is expected to bring about a rapid reduction of students in technical high schools, which in turn will bring a severe shortage of engineers and technicians to meet futures demand in industry.

2. 2 Higher Education

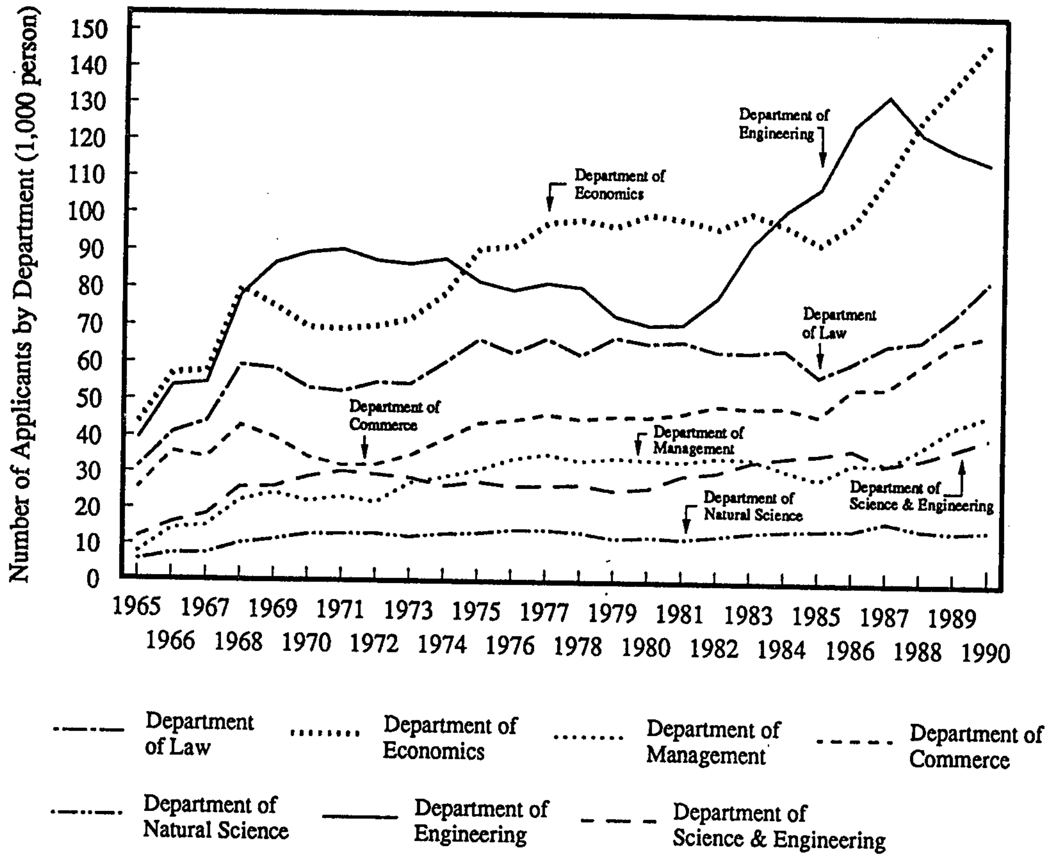
2. 2. 1 Number of Applicants for University Admission

This section examines choice of academic department (see Note) made by those seeking entrance to higher educational institutions (Reference 2, Source 2, Figure 2-2-1). Application for departments related to science and engineering is an indicator of commitment to scientific and technological fields. Figure 2-2-1 shows fluctuations in the number of applicants for engineering departments from 1965 to 1989, increasing in the late 1960's, gradually decreasing until the late 1970's, sharply rising until the late 1980's, and declining after hitting a peak in 1988. The increase in the late 1960's can be explained by an economic boom and expansion, the constant decline from the early 1970's by a recession in the manufacturing industry due to the oil crisis, and the upward trend in the early 1980's during a period of economic prosperity. However, in 1988 and 1989, despite favorable conditions for manufacturers and consequently for graduates from engineering departments, fewer students have applied to these departments. Similar tendencies can be Noted for applicants of natural science departments. Applicants for engineering departments are estimated to decrease from 133,000 in 1987 to 118,000 in 1989, down by 11 percent. As far as new high school graduates are concerned, applicants declined by 13 percent, down from 93,000 to 81,000. Applicants for physical science departments are also estimated to decrease from 17,000 in 1987 to 14,000 in 1989, down by 15 percent. The move away from science and engineering therefor begins as early application for entrance to colleges and universities.

The share of applicants for economics, law and commerce departments in the total number of applicants for colleges and universities showed an upward trend in the recession period from the mid-1960's to the late 1970's, but it remained flat or even declined slightly after the early 1980's. Recently however, applicants for these departments have been increasing again since 1986, contrary to the case of science and engineering departments.

Note: Numbers of applicants for selected departments were estimated based on the statistics on the number of submitted applications reported in the "Report on Basic Survey on Schools." The estimation concerns engineering, physical science and science and engineering for scientific departments, and law, economics, commerce and management for social science and humanities departments.

Figure 2-2-1 Applicants for Colleges and Universities by Departments



National Institute of Science and Technology Policy, "Choice of Fields of Study among University Applicants" (NISTEP Report No.12), 1990
See Table 2-2-1

2. 2. 2 Higher Education Enrollment

Enrollment statistics for colleges and universities (Source 2, Figure 2-2-2) show an upward trend in the late 1970's, a remaining static trend after a peak in 1978, and a rapid increase since 1985. The upward trend in the late 1970's can be attributed to expansion of capacities in colleges and universities to cope with the rising enrollment rates, whereas the increase in the late 1980's is mainly due to higher educational achievement especially of women and of improved conditions for receiving students in colleges and universities. In fact, the total number of students in FY 1985 was 11.5 percent larger than in FY 1980, with women recording a sharper increase (25.1 percent) than men (6.9 percent).

In examining the trend by department, there are 7 groups; 6 department groups and others (see Note). Figure 2-2-3 (Source 2) indicates numbers of students calculated in this way. The social science group has the largest number of students followed by engineering, humanities, health science, agriculture and physical sciences. It is characteristic in Japan that the enrollment in social science departments is twice as large as in engineering departments which rank second. Statistics also suggest that the number of students in social sciences and humanities have recorded an increase similar to the increase in the total number of college and university students in the late 1980's. In other words, the increment in the total number of students in this period is mostly produced by increases in social sciences and humanities. In the same period, enrollments in engineering and physical sciences have recorded relatively small increases. This trend becomes clearer when we look at the changes in enrollment from FY 1985 to 1989. Total enrollment rose by 11.2 percent in this period. By department, the number of students increased by 17.6 percent in humanities, 13.2 percent in social sciences; both exceeding the average rate of growth. Enrollments rose by 10.2 percent in engineering, 8.2 percent in agriculture and 7.2 percent in physical science, which are all below the average. In the case of health science departments, enrollment dropped by 0.1 percent. This tendency seems to reflect the capacity of each college or university.

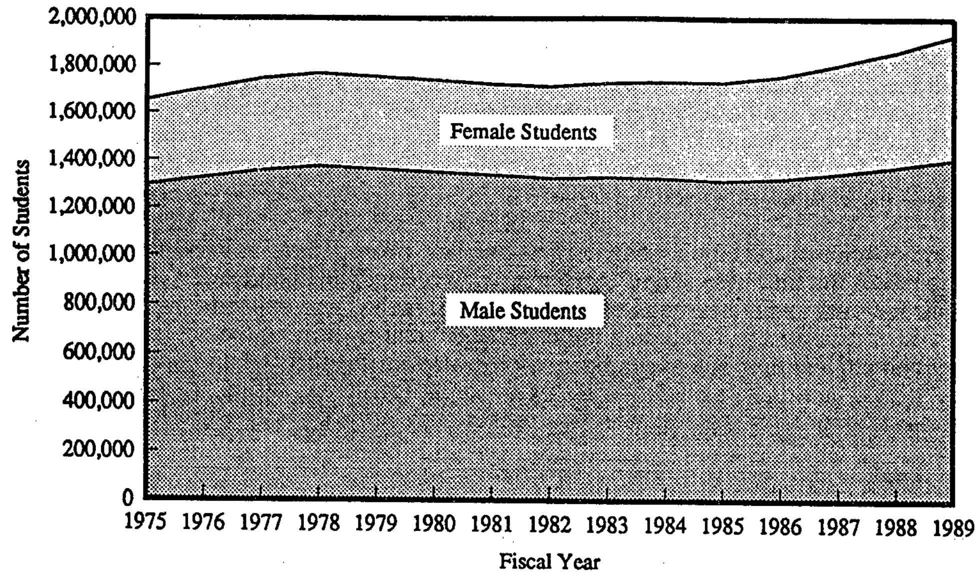
Note: Departments are divided into the following groups.
Humanities group: literature, history, philosophy etc.
Social sciences group: law and politics, commerce and economics, sociology etc.
Natural sciences group: mathematics, physics, chemistry, biology, earth science etc.
Engineering group: mechanical engineering, electrical and telecommunication engineering, civil and construction engineering, applied chemistry, applied mathematics, applied science, atomic engineering, mineralogy, metal engineering, fiber engineering, ship engineering, aviation engineering, business engineering, technical art etc.
Agriculture group: agriculture, agricultural chemistry, agricultural engineering, agricultural economics, forestry, woodcraft, veterinary and stock breeding science, fishery etc.
Health sciences group: medical science, dentistry, pharmacology, nursing science, specialized medical sciences etc.
Others: mercantile marine, housekeeping (domestic science, food science, clothing, housing, child science etc.), education, art etc.

2. 2. 3 Expenditure for Education and Research in Colleges and Universities

Educational infrastructure can be assessed in terms of expenditures for education and R&D. The expansion of higher education in national and public colleges and universities is reflected in rising expenditures for education and research. As shown in Figure 2-2-4 (Source 2), such expenditures have increased most significantly from 1975 to 1980, up by almost 550 billion yen in nominal terms. From 1970 to 1987, the period in which data have been collected, expenditures for education and research rose by 5.1 times. In nominal terms (Note 2, Figure 2-2-5), however, it has increased by 2.2 times, due mainly to the inflation which accompanied the oil crises. In light of the rise in enrollment by 1.5 times, expenditures per student have increased by about 1.5 times.

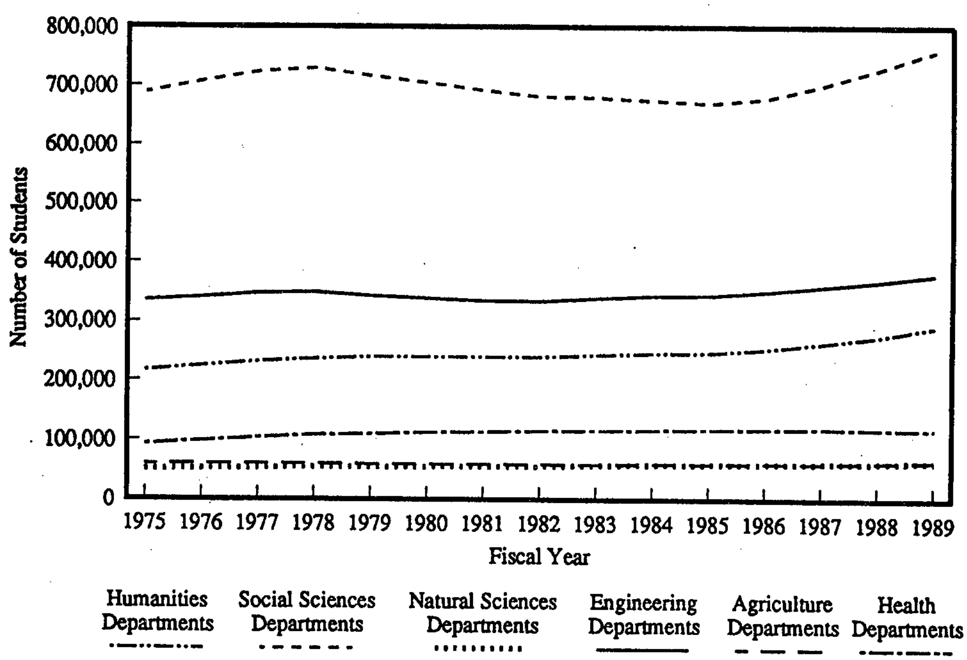
Looking at expenditure by department (Note 3, Figure 2-2-5), hospitals attached to universities not only spend an increasing amount of resources but their share in the total expenditure is larger than that of the other departments. This is because funding for national colleges and universities comes from the Special Account for National Schools which is operated in principle on the basis of self-supporting accounting, and that increasing amount of resources are being mobilized for activities to obtain more income. Elsewhere, departments related to natural sciences including

Figure 2-2-2 Number of Students in Colleges and Universities



Source: Ministry of Education, "Report of Basic Survey on Schools", various editions
See Table 2-2-2

Figure 2-2-3 Enrollment by Department Groups



Source: Ministry of Education, "Report of Basic Survey on Schools", various editions
See Table 2-2-2

science and engineering have steadily increased their share in expenditures for research and education since 1980, reflecting the emphasis attached to education and research in this domain. On the other hand, the share for research institutes attached to colleges and universities has remained small and static.

Expenditures for education and research in private colleges and universities indicates that such private institutions are no less important than national and public colleges and universities in higher education in Japan. In fact, they have been spending larger amount of resources for education and research than national and public colleges and universities since around 1980 (Source 2, see Figures 2-2-6 and 2-2-7).

The share of science and engineering departments and other natural-science-related departments in expenditures for education and research in private colleges and universities is not much smaller than their national and public counterparts. Rather, it is the large expenditures in amount and in share in other departments (including junior colleges) that constitutes the characteristic of private colleges and universities. The expenditures in research institutes attached to private colleges and universities and in private technical colleges are significantly smaller than in national and public institutions.

Note:
(1) The notion of expenditures for education and research is adopted as it is difficult to distinguish between expenditures for education and expenditures for research in the Report of Basic Survey on Schools (Source 2). As for higher education, only expenditures in the Special Account for National Schools are taken into consideration. As a result, Grant-in-Aid for Scientific Research, scholarships and reimbursement of debts are not included in expenditures in higher education. For research expenditures in colleges and universities, see Chapter 4.

The classification standard for 1970 is different from that of other years. Consequently, the classified results for 1970 cannot be compared with data for other years. This also applies to Figures 2-2-6 and 2-2-7.

(2) GDP deflators are used according to Economic Planning Agency reports(based upon the 1980 level, Reference 3).

(3) In calculating expenditures for education and research, it is impossible to make a strict classification of departments, for many of them concern two or more subjects. In the case of national and public institutions, departments are classified as follows:
Science and engineering group: physical science, humanities and sciences, engineering, basic engineering, technical art, art engineering, electrical engineering, mineralogy, fiber, mercantile marine, science and engineering, information engineering.

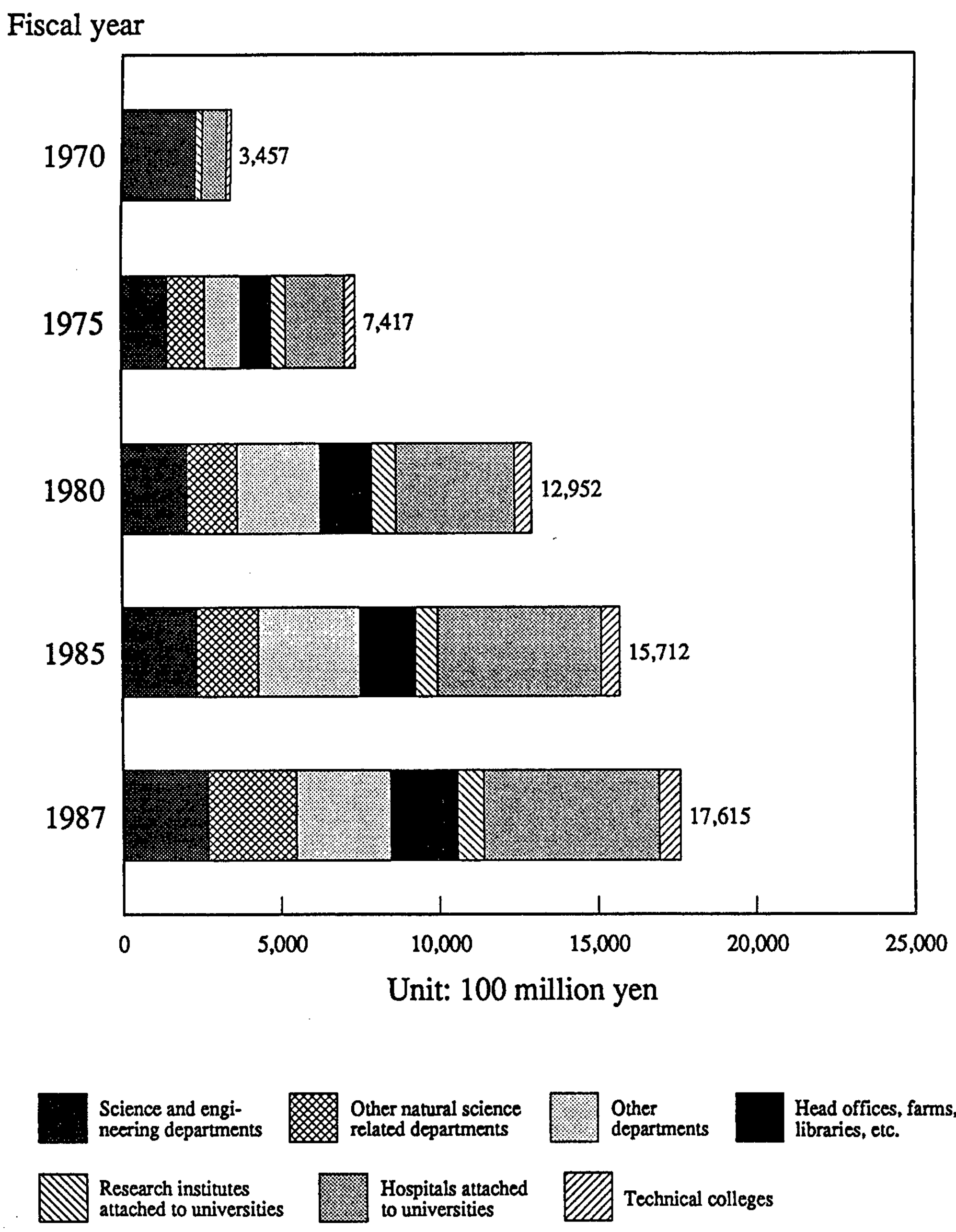
Other natural sciences group: agriculture, horticulture, veterinary science, stock breeding, fishery, life production, life resources, medical science, dentistry, pharmacology, nursing-related sciences.
Others: all the other departments and departments in junior colleges.

Expenditures are not classified according to their components in each department groups at the University of Tsukuba. Therefore expenditures for education and research from the department and enrollment in each of the groups is estimated. As a result, 38 percent of total expenditures goes to the science and engineering group, 28 to the other natural sciences group, and 34 percent to other departments.

(4) Reimbursement of debts is included in the expenditures of private colleges and universities, but not in that of national and public institutions. In the case of private colleges and universities, departments are classified as follows.
Science and engineering group: humanities and sciences, physical science, science and engineering, engineering, production engineering, art engineering.

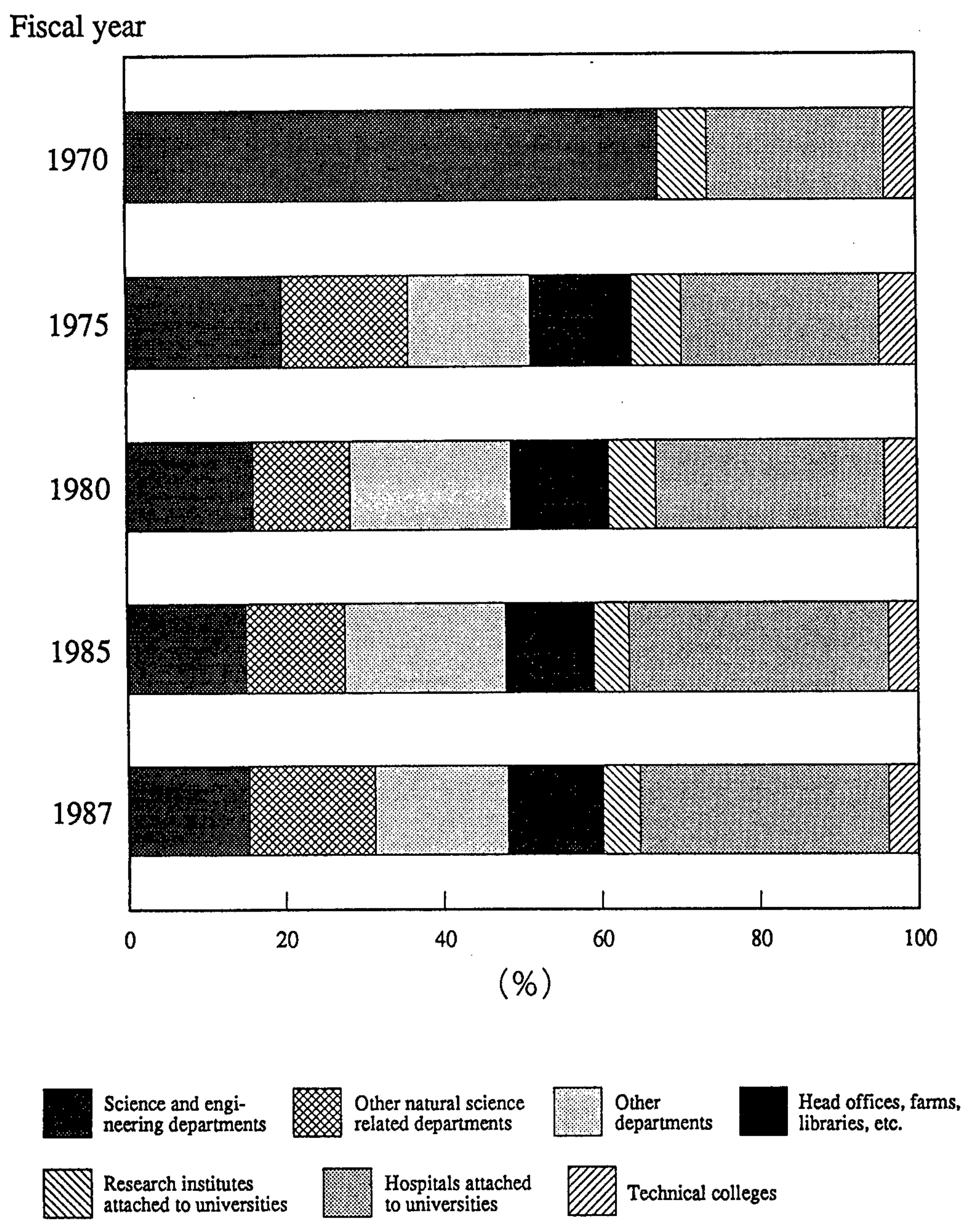
Other natural sciences group: hygienic, agriculture, horticulture, dairy farming, veterinary and stock breeding science, veterinary science, agricultural and veterinary science, fishery, oceanography, medical science, dentistry, health, pharmacology, nursing, environment and health, acupuncture and moxa cautery.
Others: all the other departments and departments in junior colleges.

Figure 2-2-4 Expenditures for Education and Research in National and Colleges and Universities by Department (nominal terms)



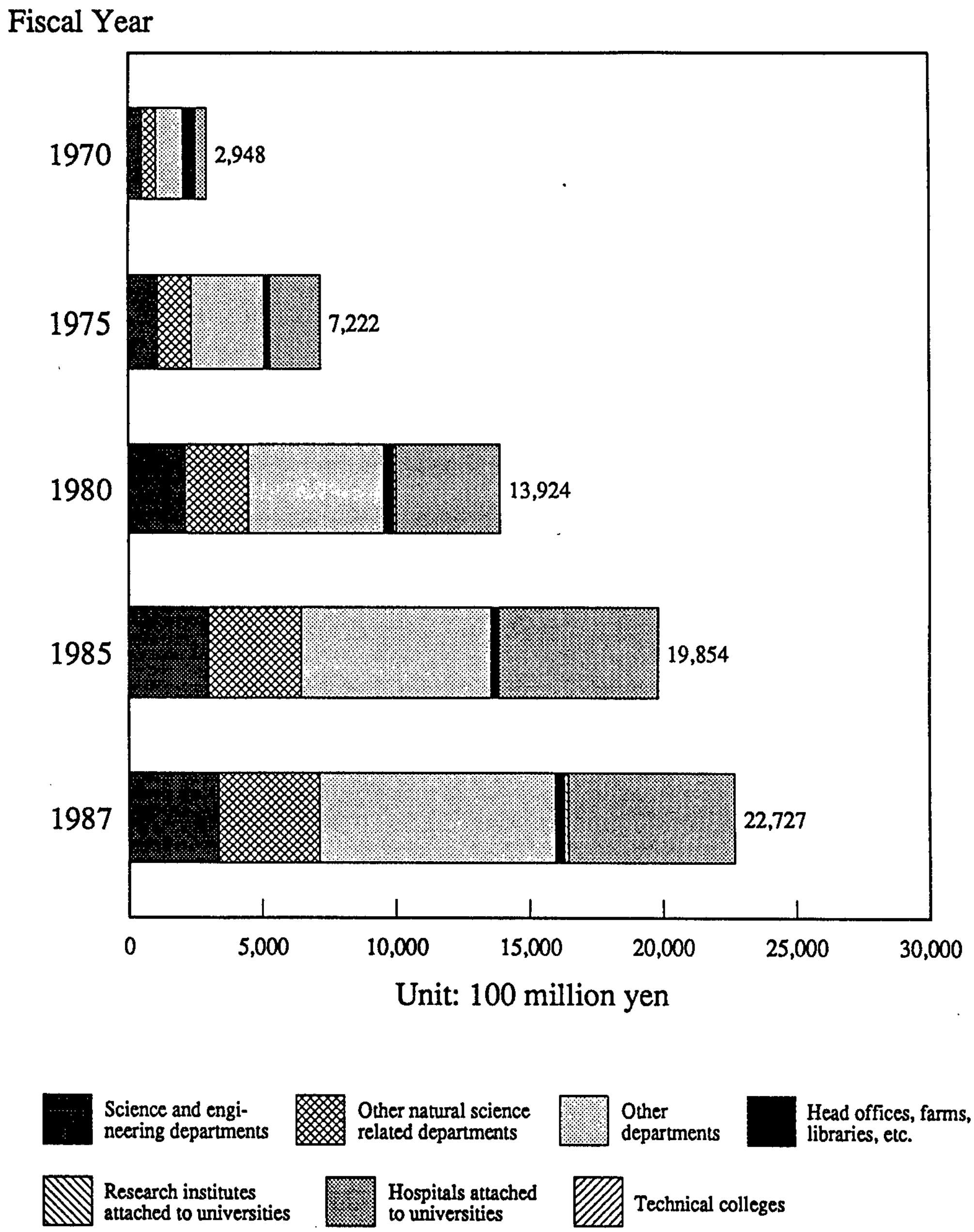
Source: Ministry of Education, "Report of Basic Survey on Schools", various editions
See Table 2-2-3

Figure 2-2-5 Expenditures for Education and Research in National and Public Colleges and Universities by Department (share)



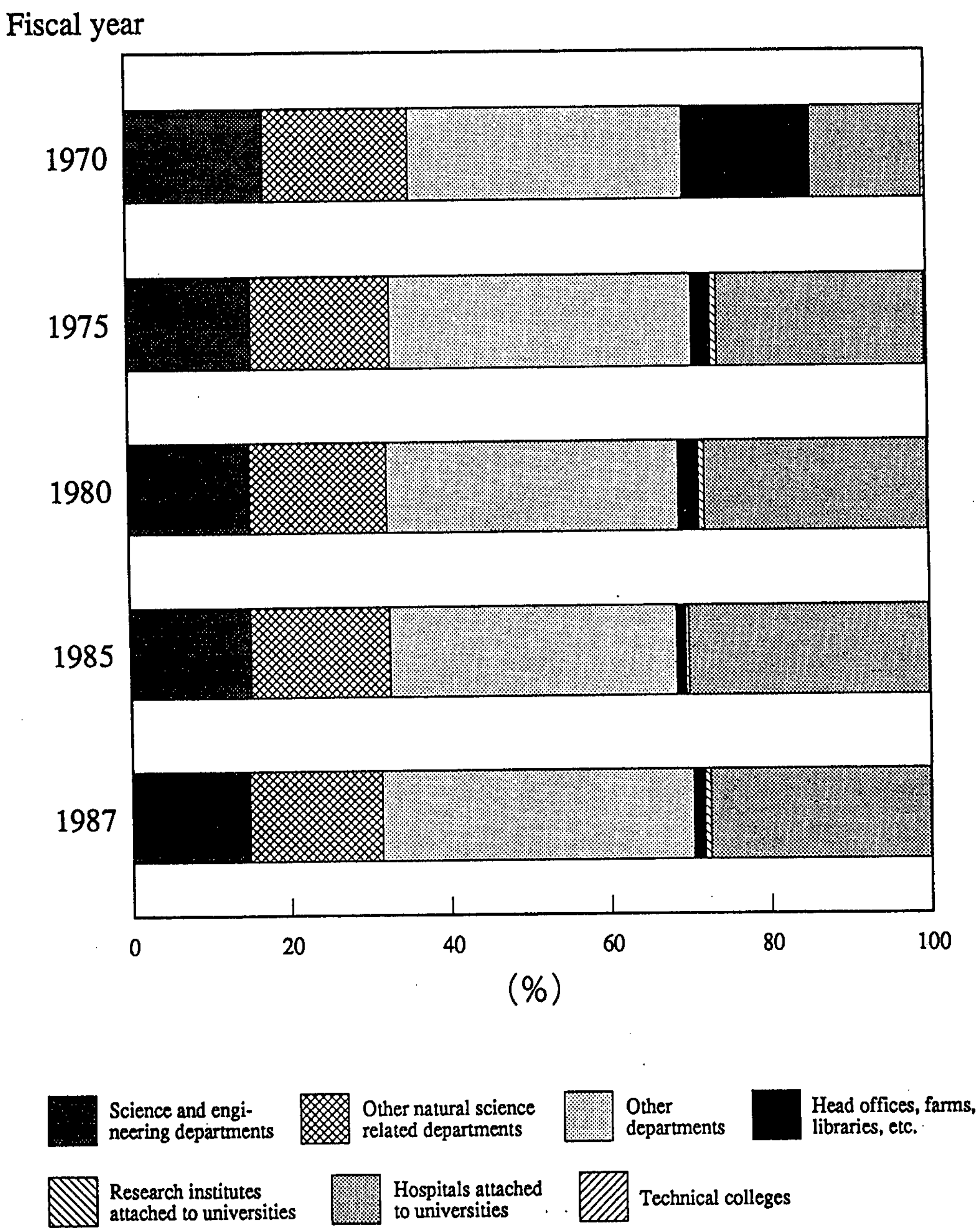
Source: Ministry of Education, "Report of Basic Survey on Schools", various editions
Reference: Economic Planning Agency, "Annual Report on National Accounts"
See Table 2-2-3

Figure 2-2-6 Expenditures for Education and Research in Private Colleges and Universities by Department (nominal terms)



Source: Ministry of Education, "Report of Basic Survey on Schools", various editions
See Table 2-2-4

Figure 2-2-7 Expenditures for Education and Research in Private Colleges and Universities by Department (share)



Source: Ministry of Education, "Report of Basic Survey on Schools", various editions
See Table 2-2-4

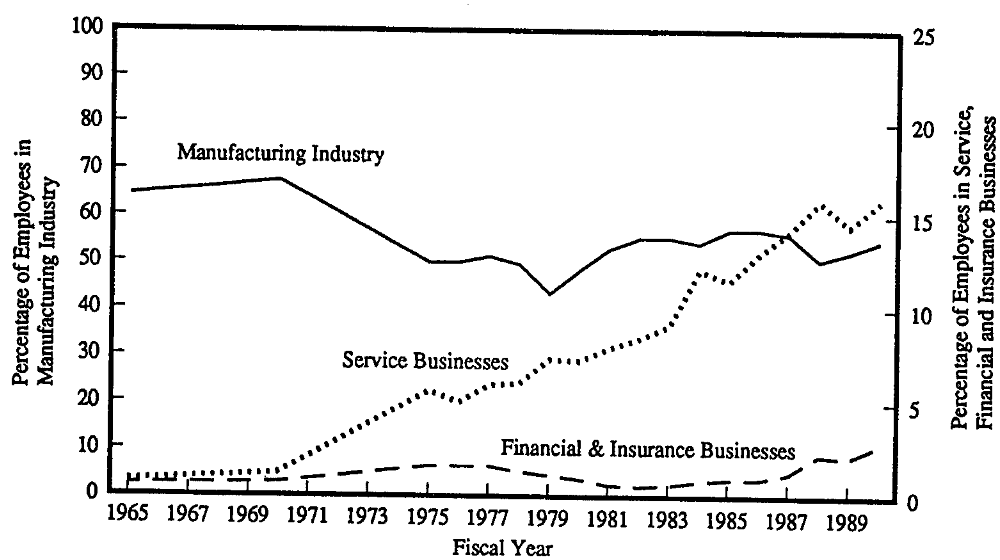
2. 3 Employment of Higher Education Graduates

2. 3. 1 Employment of University Graduates

Education in colleges and universities can be evaluated by looking at employment trends of graduates. According to research on the employment of graduates from science and engineering departments conducted from 1965 through 1988, 68 percent of graduates were employed in the manufacturing sector in 1970. This percentage dropped to 43 percent in 1979, recovered to 57 percent in 1985, but declined to 51 percent in 1988.

Recent trends indicate that relatively smaller number of graduates from science and engineering departments are employed in the manufacturing sector, compared to those employed in the banking and insurance sector.This tendency also emerged at the time of the oil crisis and the ensuing period of economic recession, for manufacturers were obliged to reduce the recruitment activities. However, it is typical in recent years that the increase in employment of those graduates in banking and insurance sectors is taking place against the backdrop of active recruitment in the manufacturing sector. This reflects a tendency of alienation of science and engineering graduates from manufacturing sector towards service sector employment.

Figure 2-3-1 Employment of Science and Engineering Graduates



National Institute of Science and Technology Policy, "Employment Trends of Science and Engineering Students" (NISTEP Report No.1), 1989
See Table 2-3-1

2. 3. 2 Enrollment in Graduate Schools

Enrollment in master's degree courses (Source 2, Figure 2-3-2) has been increasing since 1979 to 58,200 in 1989, up by 1,600 from the previous year. Enrollment of foreign students and previously employed students is mainly responsible for the increase. By department group (NOTE, Source 2, Figure 2-3-3), students in engineering departments have increased since 1979 to 26,800 in 1989, accounting for 46 percent of the total students. Unlike the case of undergraduates, this trend apparently reflects favorable conditions in the manufacturing sector and the rising demand for students with sophisticated professional knowledge.

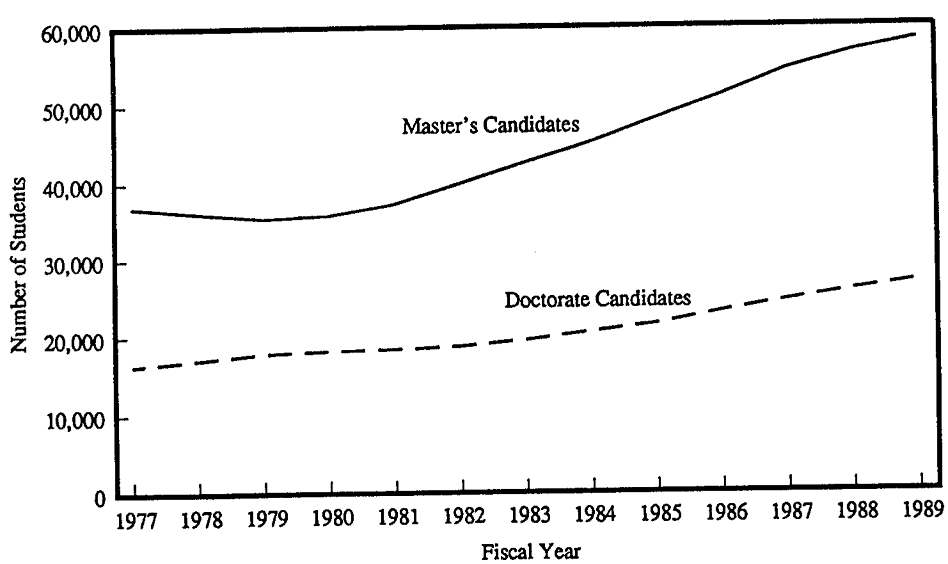
Elsewhere, the number of students in agricultural departments has fluctuated considerably; it had been growing after 1980, but after peaking at 5,500 in 1987, has declined to 3,800 in 1989. This seems to be due to the adoption of 6-year undergraduate courses in veterinary departments. In other faculties, the number of students has remained nearly steady.

The number of students in doctorate courses (Source 2) has increased yearly, reaching the 27,000 mark in 1989, up by 1,200 from the previous year.

By department groups (NOTE, Source 2, Figure 2-3-4), students in health-related departments not only have a large share (43 percent in 1989) in the total number of students, but are also increasing steadily (1,500 in 1989). Within these departments, medical science takes up the largest proportion (79 percent in 1989).

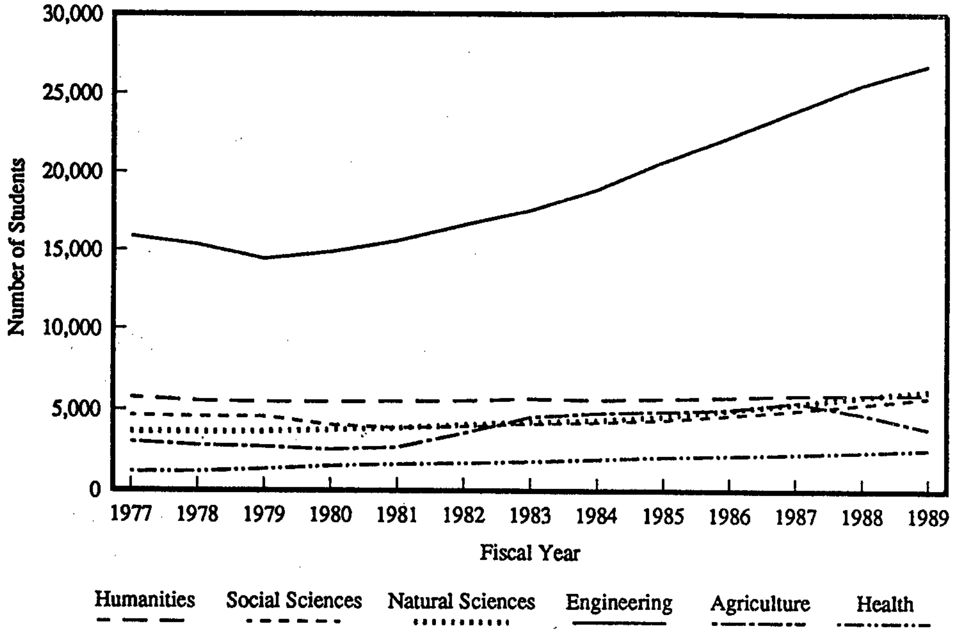
In other department groups, engineering and physical science departments have experienced slight fluctuations. In the case of engineering departments, the number of students had dropped from 2,600 in 1977 to 2,200 in 1987, but has regained its upward trend and reached 3,900 in 1989. These trends in doctorate courses, as in the case of masters courses, seem to reflect favorable conditions in the manufacturing sector and the rising demand for students with sophisticated professional knowledge. As for the other groups of departments, there has not been significant changes in enrollment.

Figure 2-3-2 Number of Students in Graduate Courses



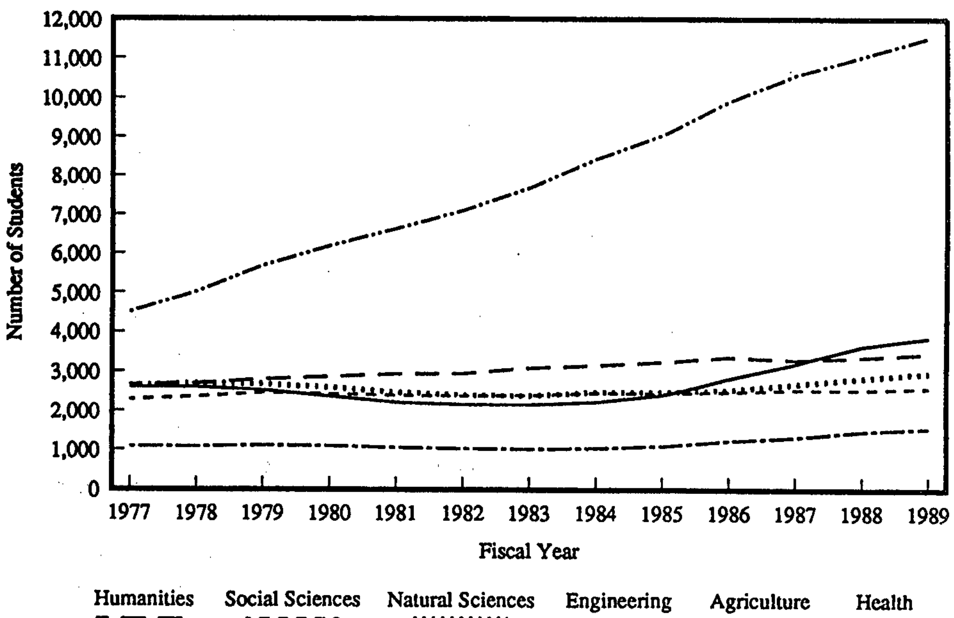
Source: Ministry of Education, "Report of Basic Survey on Schools", various editions
See Table 2-3-2

Figure 2-3-3 Number of Students in Master's Courses



Source: Ministry of Education, "Report of Basic Survey on Schools", various editions
See Table 2-3-2

Figure 2-3-4 Number of Students in Doctorate Courses



Source: Ministry of Education, "Report of Basic Survey on Schools", various editions
See Table 2-3-2

Note: Considering actual industrial structure, graduate course departments are classified into the following groups;

Humanities: literature, history, philosophy etc.
Social sciences: law and politics, commerce and economics etc.
Physical sciences: mathematics, physics, chemistry, biology, earth science, atomistics.
Engineering: mechanical engineering, electrical and telecommunication engineering, civil and construction engineering, applied chemistry, atomistic engineering, mineralogy, metallography, fiber engineering, ship engineering, aviation engineering, business engineering, technical art etc.
Agricultural sciences: agriculture, agricultural chemistry, agricultural engineering, agricultural economics, forestry, woodcraft, veterinary and stock breeding science, fishery etc.
Health sciences: medical science, dentistry, pharmacology etc.
Others: mercantile marine, housekeeping, food science, clothing, housing, child science, pedagogy, teacher development, athletics, art, design, music, social and natural sciences, humanities and social sciences etc.

2. 3. 3 Number of Degrees Conferred

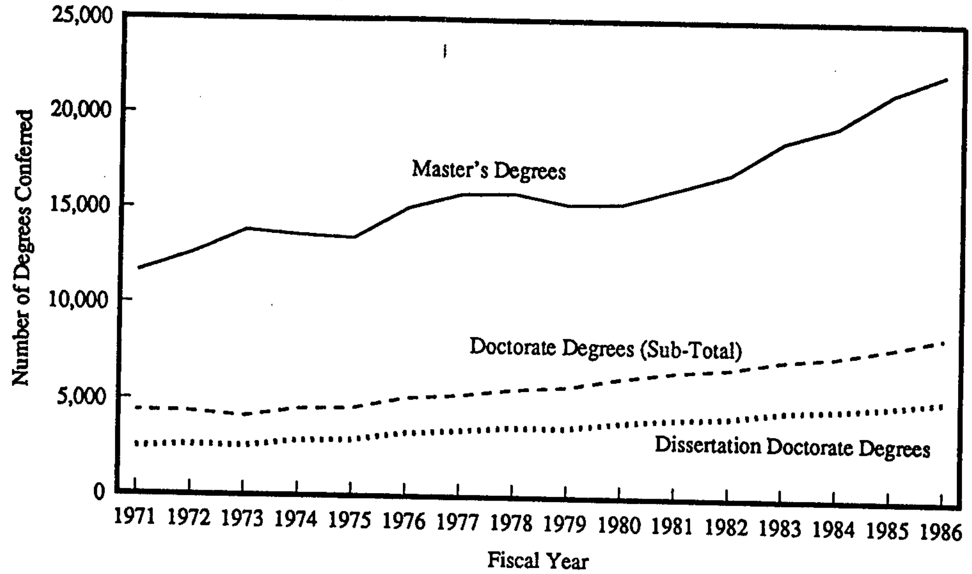
The number of degrees conferred to students not only shows the extent of success in education but is also an indicator of human resource development for science and technology. Furthermore, the number of doctorate degrees conferred is an indicator of scientific and technological activities in that they are conferred as recognition for achievements of sophisticated research.

22,354 master's degrees were conferred in 1986 (Source 3, Figure 2-3-5), up from 11,605 in 1971, which means that the number has doubled in 15 years. Engineering departments conferred the largest number of master's degrees (10,361) in 1986, followed by humanities and social sciences, physical science, agriculture, pharmacology and health science, and art and science (Figure 2-3-6). The order has not changed since 1971, but the share of engineering departments has increased from 43 percent in 1971 to 46 percent in 1986, reflecting a change in enrollment. The increase in the number of master's degrees conferred in engineering was reversed in 1973 and in 1979, probably as a result of the oil crises.

8,533 doctorates degrees were conferred in 1986 (Source 3). Doctorate degrees in medical sciences take up the largest share (49 percent) in the total number of conferred degrees with 4,215, followed by engineering, physical science, dentistry, agriculture, pharmacology and health science, and humanities and social sciences (Figure 2-3-7). As in the case of master's degrees, the number of doctorate degrees has almost doubled in 15 years, from 4,407 in 1971.The share for medical sciences has increased from 41 percent in 1971 to 49 percent in 1986. A smaller share for humanities and social sciences may be explained by difference in social needs and in the practice of conferring degrees.

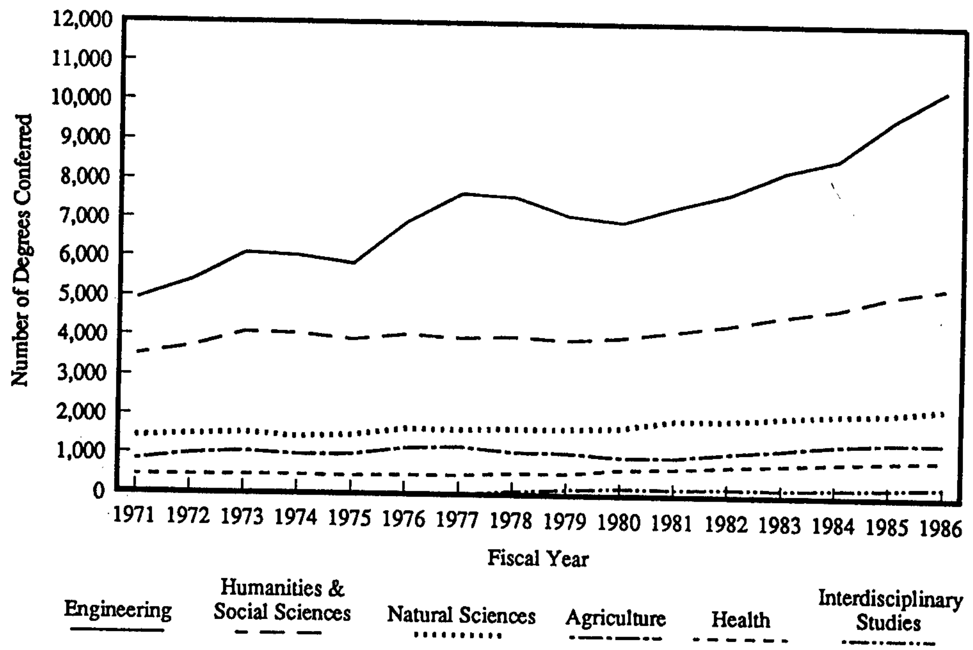
5,281 dissertation doctorate degrees in 1986 (61.9 percent of the total) were conferred through submission of a doctorate theses (Source 3, Figure 2-3-8), representing 1.5 times as many degrees conferred through actual completion of courses. Medical sciences has the largest share (51 percent) in the total number of dissertation doctorate degrees with 2,713, followed by engineering, agriculture, dentistry, pharmacology and health science, and humanities and social sciences. The share of medical science rose by 6 points in 15 years, from 45 percent in 1971.

Figure 2-3-5 Number of Degrees Conferred



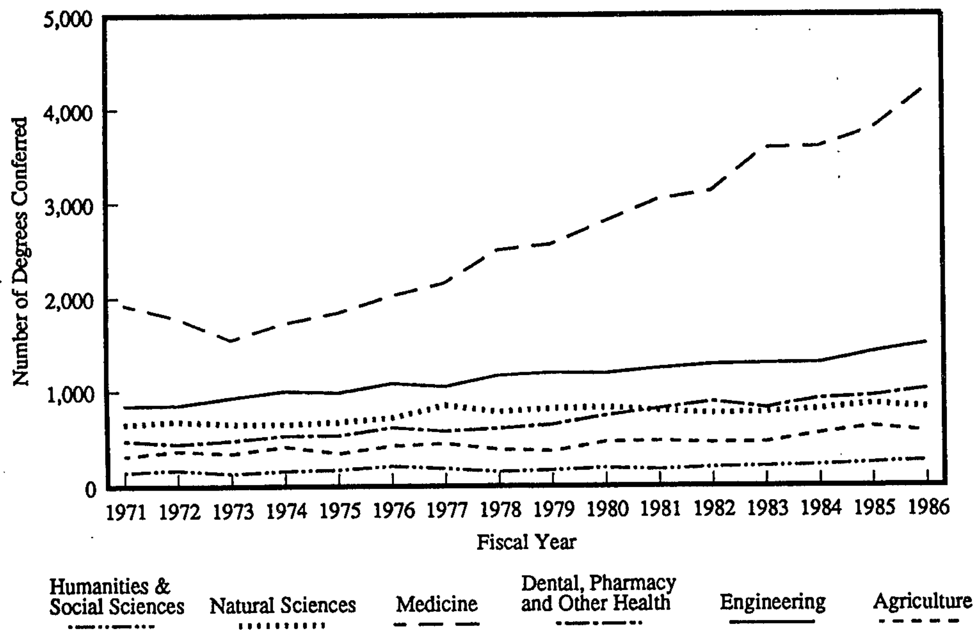
Source: Hiroshima University - University Education Center, "Compilation of Higher Education Statistical Data", 1989
See Table 2-3-3 and Table 2-3-4

Figure 2-3-6 Number of Master's Degrees Conferred



Source: Hiroshima University - University Education Center, "Compilation of Higher Education Statistical Data", 1989
See Table 2-3-3

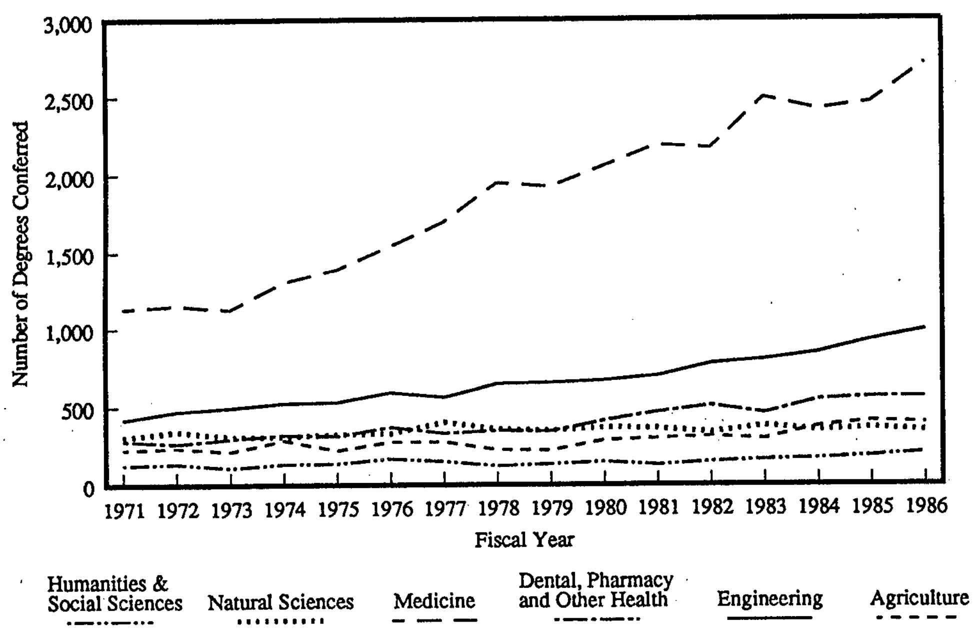
Figure 2-3-7 Number of Doctorate Degrees Conferred



Source: Hiroshima University - University Education Center, "Compilation of Higher Education Statistical Data", 1989

See Table 2-3-4

Figure 2-3-8 Number of Dissertation Doctorate Degrees Conferred



Source: Hiroshima University - University Education Center, "Compilation of Higher Education Statistical Data", 1989

See Table 2-3-4

Sources:

(1) National Institute for Educational Research, "Interim Report on the IEA International Survey on Eduction in Mathematics and Science," 1988.
(2) Ministry of Education, "Basic Research Report on Schools (Higher Education Institutions), "1965-1990.
(3) Research Center for University Education, Hiroshima University, "Compilation of Higher Education Statistical Data," 1989.

References:

(1) Ministry of Education, "Education Policies in Japan, FY 1990," 1991.
(2) National Institute of Science and Technology Policy, "On Choices of High School Graduates Seeking Entrance to Colleges and Universities" (NISTEP REPORT No.12), 1990.
(3) Economic Research Institute, Economic Planning Agency, "Report on National Accounts."
(4) National Institute of Science and Technology Policy, "On Employment of Science and Engineering Graduates" (NISTEP REPORT No.1), 1990.

CHAPTER 3

SUPPORTS FOR R&D

CHAPTER 3

SUPPORTS FOR R&D

Supports for R&D refer mainly to financial support provided to institutions engaged in R&D activities. A characteristic of R&D activities in Japan shows the private sector conducts R&D activities using mostly industrial resources with little help from other sectors. In fact, R&D resources provided by the government for the private sector represent less than 2 percent of the total budget for science and technology in Japan. By contrast, in colleges and universities and national research institutes, R&d activities are financed by governmental R&D expenditures, secured in the budget for science and technology. Most R&D activities in these academic institutions are not directly regulated by market economy principles. Promoting this type of academic research therefore calls for public support. In addition, financial support from foundations and the activities of academic organizations such as learned societies also constitute social supports for science and technology, specifically for academic research. In the context of non-financial support form the public, learned societies are important in that they provide a forum for research exchange among scientists and engineers. These functions are considered to supplement public support for academic research. In this chapter, Section 1 covers the budget for science and technology, while Section 2 discusses financial supports for R&D activities from various foundations.

3. 1 Governmental Budget for Science and Technology

In Japan, the budget for science and technology consists of the General Account and Special Accounts. The budget for science and technology included in the General Account is divided into Expenditures for the Promotion of Science and Technology, R&D Expenditures included in the Energy-Related Expenditures, and other R&D Related Expenditures. The following are descriptive details of the science and technology budget.

(1) The Budget for the Promotion of Science and Technology consists of expenditures for national R&D facilities and various subsidies.

(2) The Energy Budget for R&D includes expenditures for the promotion of research on atomic energy for peaceful purposes, and of the R&D expenditures for new energy technology and energy conservation technology. This budget item had been part of the Expenditures for the Promotion of Science and Technology until 1978, after which it was established as a new budget item.

(3) The category of Other R&D-related expenditures include the expenditure for educational support, for economic assistance and for small-to-medium-sized enterprises, among others.

(4) Science and Technology Related Expenditures in the Special Accounts consist of the Special Account for National Schools, for the Promotion of Power Resource Development, and for Coal and Oil and Alternative Energy, as well as the Expenditures for R&D included in the Special Account for Industrial Investment.

In Japan, the budget for science and technology represents about 3 percent of the General Account in the national budget, a percentage which has changed very little in the past decade. Its ratio to GNP is 0.4-0.5 percent. On the other hand, in the United States, Germany, France and the United Kingdom, the ratio of science and technology budget to GNP is between 1.0 percent and 1.2 percent. A simple international comparison on budgets for science and technology is difficult to make as each country has its own budget system. However, it can be safely said that in Japan, the ratio of the S&T budget to GNP is less than half the level of other Western countries, which leads us to believe that science and technology is severely underrepresented in the national budget (Note 1).

In Japan, implementation of large scale projects such as energy development and space development takes up a large part of the budget for science and technology. R&D expenditures of national research facilities and colleges and universities are completely dependent on the governmental budget, and the expenditures set aside for the R&D activities in these institutions represents about 50 percent of the total budget for science and technology. Colleges and universities are engaged in academic R&D in the field of basic science, as well as in higher education, while the principal task of national research institutes is to conduct experimental research in line with administrative needs. R&D activities in these academic institutions are not directly regulated by market mechanisms and have different characteristics from industrial R&D activities. Therefore, the promotion of academic research calls above all for public support.

In recent years, one of the major preoccupations in science and technology policies in Japan has been the need to strengthen basic research. Colleges and universities are expected to take a major role in basic research, whereas national research institutes have been reorganized for greater emphasis towards basic research. On the assumption that the budget of national colleges, universities and R&D institutes represent a direct support for basic research by the central government (Note 2), about 50 percent of the total budget for science and technology is estimated to be spent for basic research. In FY 1989, it amounted to about 910 billion yen, representing only 8 percent of the total R&D expenditures in Japan.

Note:

(1) The Budget for science and technology in total accounts for 15 percent of R&D expenditures in Japan. According to Recommendation No.11 of the Council for Science and Technology (November, 1984), research investment should represent 3.5 percent of national income.

The relation between national income (NI) and gross national product (GNP) can be expressed as follows.

NI = GNP - (capital consumption) - (indirect tax - subsidy)

The comparison of the scale of the budget for science and technology with NI follows the examples of the past. However, capital consumption, indirect taxes and subsidies are also related to economic activities, and it is difficult to consider NI, which leaves out those factors, as precisely reflecting national economic activities. In this sense, it is better to determine the scale of the budget in comparison with GNP, a method used internationally. For FY 1989 Total R&D expenditures were 11, 815.5 billion yen, the budget for S&T was 1,815.6 billion yen, NI was 318,342.4 billion yen and GNP was 406,244.9 billion yen. Research investment accounts for 3.7 percent of NI, achieving the goal set by the council, but most of the investment comes from the private sector.

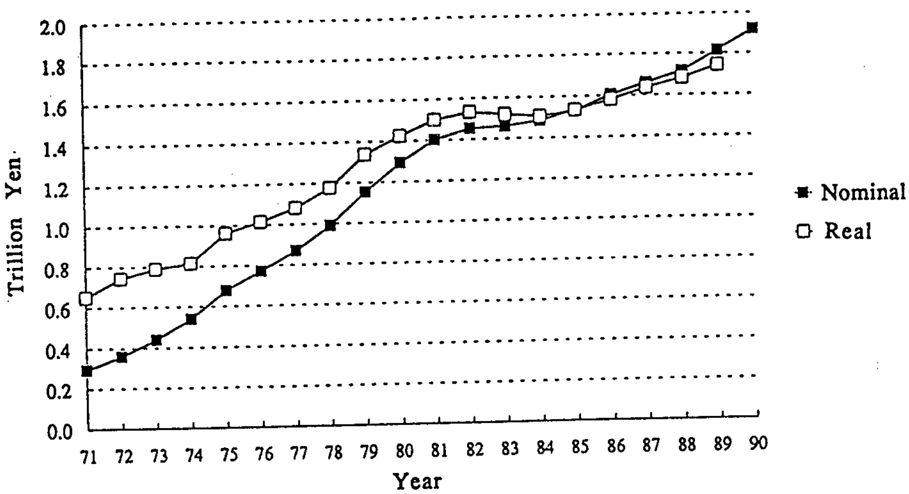
(2) The Budget for science and technology is not classified into categories of basic research, applied research and development. The budget for national colleges and universities includes the Research Grant Program and Other R&D Expenditures, while such expenditures as Subsidies for Current Expenditures in Private Colleges and Universities are not clearly delineated in terms of characteristic of R&D activity.

3. 1. 1 General Trends in the Budget for Science and Technology

In the past two decades from FY 1971 to 1990, the budget for science and technology (in the General and Special Accounts) has increased over 6 fold in nominal terms, up from 300 billion yen in FY 1971 to 1.9 trillion yen in FY 1990 (Figure 3-1-1). Considering inflation in this period and calculating expenditures in real terms by using GNP deflators (benchmark: 1980 figures), the growth rate falls dramatically. The increase in the budget has slowed down in both nominal and real terms in last 10 years compared to the decade preceding FY 1981. This is mainly due to the zero-ceiling policy adopted to balance the budget, the effects of which were most remarkable from FY 1982 to 1984.

In the past five years from FY 1985 to 1990, the share of each component in the total budget for science and technology has been as follows; 14-15 percent for national R&D facilities, 35 - 36 percent for national colleges and universities (including subsidies for private and public schools), 47 - 49 percent for various subsidies and governmental investment, and 1 percent for administration cost and others (Figure 3-1-2). These shares have changed very little in last five years. Subsidies and governmental investment are provided for corporations having special status and for R&D activities related to science and technology, and hold the largest share in the budget

Figure 3-1-1 Budget for Science and Technology in Japan

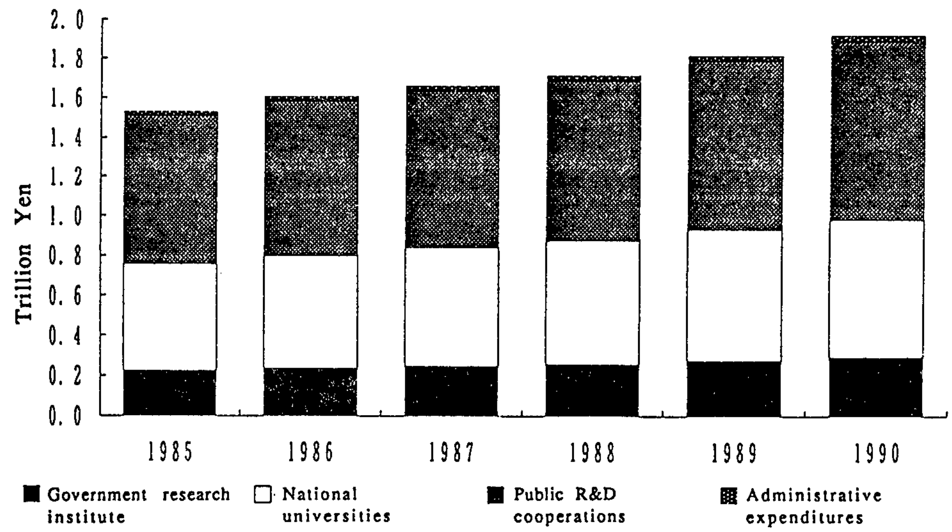


Science and Technology Agency, "Indicators of Science and Technology"

for science and technology. In the last five years, expenditures for national research institutes and for national colleges and universities have both increased slightly in nominal terms, by about 1 percent and by 2 percent respectively. But in light of inflation, these two expenditures have decreased in real terms.

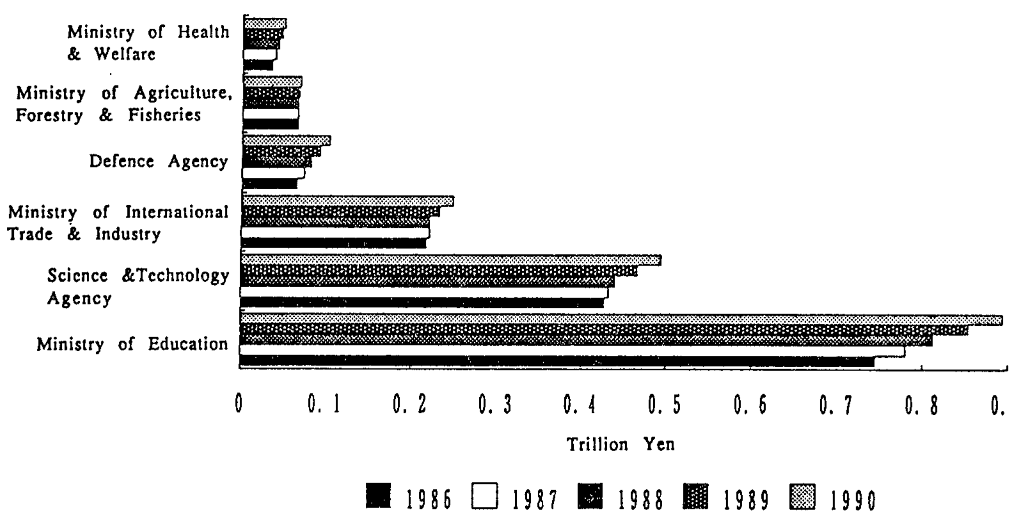
As regards the allocation of the science and technology budget among ministries and agencies in FY 1990, the Ministry of Education has the largest share with 47 percent, followed by Science and Technology Agency with 26 percent, and the Ministry of International Trade and Industry with 13 percent (Figure 3-1-3). Expenditures for these three governmental agencies represent over 80 percent of the total budget for science and technology in Japan. Each of the other ministries and agencies uses no more than 5 percent of the total budget for science and technology; the Defense Agency with 5 percent, the Ministry of Health and Welfare with 3 percent, the Ministry of Agriculture, Forestry and Fisheries with 4 percent, the Ministry of Posts and Telecommunications with 2 percent and the Ministry of Transportation with 1 percent. These figures have remained almost unchanged in the past five years.

Figure 3-1-2 Budget for Science and Technology by Item



Source: Science and Technology Agency
See Table 3-1-2

Figure 3-1-3 Budget for Science and Technology by Governmental Agency



Source: Science and Technology Agency
See Table 3-1-3
Note: indicates only top six Ministries/Agencies in S&T Budget.

3. 1. 2 Budget for Science and Technology in Japan and OECD Classifications

For the purpose of international comparisons, the Organization for Economic Cooperation and Development (OECD), classifies budget for science and technology in the national budget into the 12 items shown in Table 3-A.

Table 3-A OECD Budget Classifications for Science and Technology by Socioeconomic Objectives

1	Development of agriculture, forestry and fishing
2	Promotion of industrial development
3	Production and rational use of energy
4	Transport and telecommunications
5	Urban and rural planning
6	Protection of the environment
7	Health
8	Social development and services
9	Exploration and exploitation of earth and atmosphere
10 A	Advancement of research
10 B	General university funds
11	Civil space
12	Defence

Table 3-B Correspondence of Japanese Budget for Science and Technology by Governmental Agency to OECD Socioeconomic Classifications

	1	2	3	4	5	6	7	8	9	10A	10B	11	12
Diet										■			
Science Council										■			
National Police Agency								■					
Hokkaido Develop. Agency					■								
Defence Agency													■
Economic Planning Agency								■					
Science & Technology Agency			■						■	■		■	
Environment Agency						■							
National Land Agency	■												
Ministry of Justice								■					
Ministry of Foreigh Affairs			■					■					
Ministry of Finance		■						■					
Ministry of Education								■	■	■	■		
Ministry of Health & Welfare							■						
Ministry of Agri., F.& F. (*)	■												
MITI (**)		■	■									■	
Ministry of Transport.				■					■			■	
Ministry of Posts & Telecom.				■								■	
Ministry of Labour								■					
Ministry of Construction					■								
Ministry of Home Affairs					■								

(*) : Ministry of Agriculture, Forestry & Fisheries

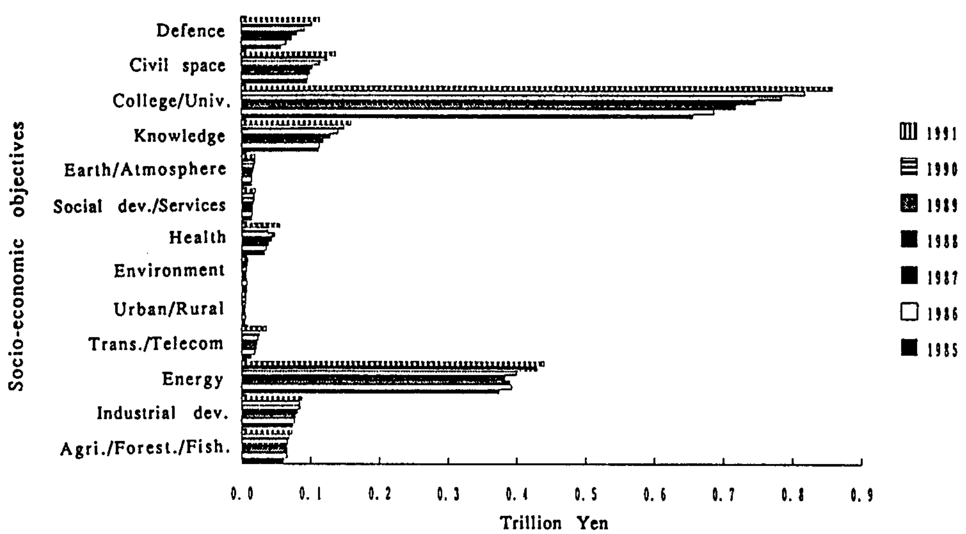
(**) : Ministry of International Trade and Industry

Adjustments are made by budget item in order to make Japanese governmental agency budgets correspond to OECD classifications shown in Table 3-A. This recalculation is needed because the items in each governmental agency budget are not necessarily the same for each fiscal year. Table 3-B shows the relation between the budget of each governmental agency and OECD classifications. (For an explanation of the classification method in the case where a ministry or agency budget for science and technology corresponds to multiple items see Note, References 4, 5).

Figure 3-1-4 classifies the Japanese budget for science and technology from FY 1985 to 1991, according to socioeconomic purposes. General expenditures for colleges and universities hold the largest share in the total budget for science and technology with about 50 percent, followed by energy with about 30 percent. This tendency has remained almost the same in the last five years.

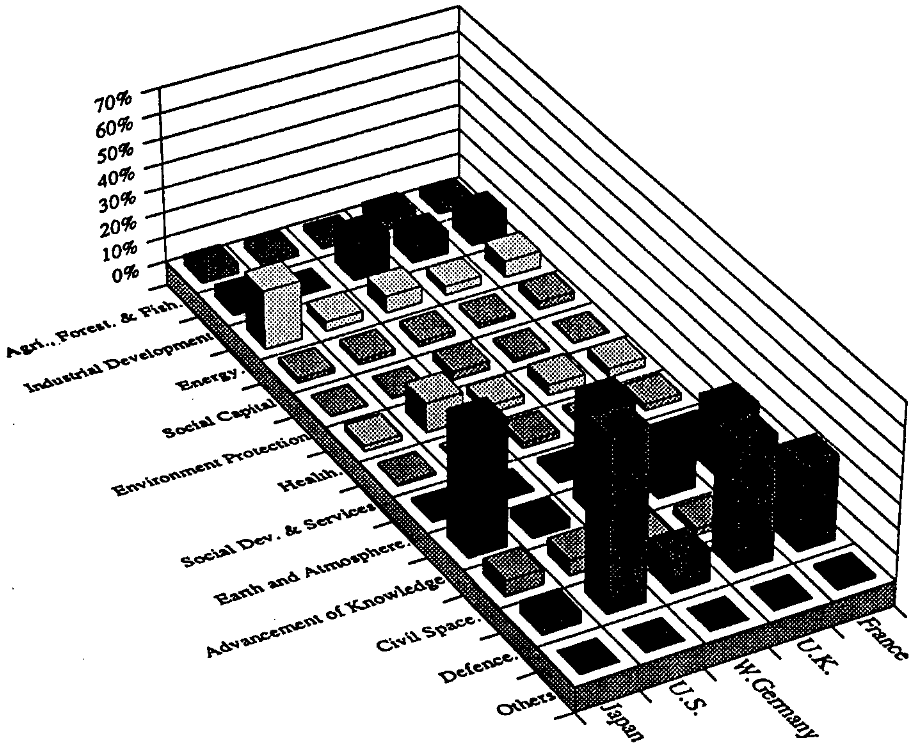
Figure 3-1-5 compares budgets for science and technology in OECD member countries (according to 1985 data). Each country's budget for science and technology cannot be compared directly because of differences in financial systems. Therefore, comparison is for each component in the science and technology budget. It is notable that the share of energy in the Japanese budget is the largest among major countries and that a large percentage of the budget is also spent for promotion of research. Here, promotion of research means items 10A (promotion of research) and 10B (general expenditure for colleges and universities) in Table 3-B combined. Promotion of research has the smallest share among major countries in the U.S., where the category of general expenditures for colleges and universities does not exist. National defense has the largest shares in the U.S., the U.K. and France, and Japan is ranked last among major countries in this category.

Figure 3-1-4 Budget for Science and Technology by Socioeconomic Purpose



Source: Science and Technology Agency
See Table 3-1-4

Figure 3-1-5 Budget for Science and Technology in Major Countries by Socioeconomic Purpose



Note:
The Budget for science and technology is reclassified as follows.

(1) Science and Technology Agency

The total of Energy-Related Expenditures included in Expenditures for the Promotion of Science and Technology and Special Account for the Promotion of Power Resource Development ---> Energy

Sea-Related Expenditures and Expenditures for National Research Institute for Earth Science and Disaster Prevention, included in Expenditures for the Promotion of Science and Technology ---> Earth and Air

Space-Related Expenditures included in Expenditures for the Promotion of Science and Technology ---> Exploration and Development of Space for Civilian Purposes

Remaining Items ---> Promotion of Research

(2) Ministry of Foreign Affairs

Energy-Related Expenditure ---> Energy

Remaining Items ---> Social Development and Services

(3) Ministry of Finance

Expenditure for Research Institute of Brewing ---> Promotion of Industrial Development

Research Institute of Printing Bureau (Special Account of Printing Bureau) ---> Social Development and Services
(4) Ministry of Education

National Institutes (Expenditure for the Promotion of Science and Technology) ---> Social Development and Services

Contribution to International Deep-Sea Excavation Programme and Expenditures for Observation Activities in the Antarctic Area ---> Earth and Air

Special Accounts for Private, Public and National Schools ---> General Expenditures for Colleges and Universities

Remaining Items ---> Promotion of Research

(5) Ministry of International Trade and Industry

The total of Special Accounts except for Special Accounts for Alcohol and for Industrial Investment ---> Energy

Special Research (space) included in Expenditures for the Promotion of Science and Technology ---> Exploration and Development of Space for Civilian Purposes

Remaining items minus the half of the Expenditures for The Japan Key Technology Center ---> Promotion of Industrial Development

(6) Ministry of Transportation

Space-Related Expenditures included in Expenditures for the Promotion of Science and Technology ---> Exploration and Development of Space for Civilian Purposes

Expenditures for Meteorological Research Institute ---> Earth and Air

Remaining items ---> Transportation and Electrical Telecommunication

(7) Ministry of Posts and Telecommunications

Space-Related Expenditures included in Expenditures for the Promotion of Science and Technology ---> Exploration and Development of Space for Civilian Purposes

Remaining items minus half of the Expenditures for The Japan Key Technology Center ---> Transportation and Electrical Telecommunication

3.2 Promotion of R&D by Foundations, Learned Societies

Direct financial support from various foundations and indirect support from learned societies and other academic communities, which provide a forum for research exchange among scientists and engineers, are considered as social supports for science and technology. These kind of supports have functions complementary to public support for basic research related to science and technology.

It has only been about 130 years Japan first introduced the Western-style academic system. This relatively short period is partly responsible for the insufficient public support and understanding in Japan concerning academic research. International contributions through science and technology call for adequate social supports in addition to governmental support. This section analyzes the activities of foundations related to science and technology, whose principal task are to provide financial support, and of learned societies, which provide a forum for exchange of opinions on scientific activities.

3.2.1 Foundations Related to Science and Technology

Support for R&D activities from various foundations is considered functions complementarily to public support for basic research related to science and technology. The history of Japanese foundations starts in 1914. However, those foundations in the early years were principally engaged in social and cultural activities and their support for science and technology had not been very active until World War II. Support from foundations for science and technology was active in the 1960's, and many large foundations were established by private companies in the 1970's.

In Japan, non-profit corporate bodies are classified into non-profit foundations, social welfare corporations, medical corporations, educational foundations, religious corporations and others. Non-profit foundations are usually formed as aggregate corporations or incorporated foundations. Incorporated foundations are largely divided into supportive foundations and activity-oriented foundations. The former provide support for non-profit activities and are not themselves engaged in activities. In Japan, most of the supportive foundations provide support for research, but those engaged in subsidizing cultural activities are springing up recently. Activity-oriented foundations conduct activities by themselves and can be divided into research foundations and general activity foundations. The former correspond to the so-called non-profit research institutes, while the latter are involved in activities other than research. However, the situation becomes complicated as certain foundations are involved in multiple types of activities. Therefore, adopted is data collected and analyzed by the Foundation Center Library of Japan. Recent trends indicate that more foundations are being established through financing from local governments. Such foundations sometimes provide support for research in order to promote local activities related to science and technology. This sort of support, however, is not included in the Center's data, rendering it currently difficult to grasp the whole picture of research supporting foundations.

The following non-profit bodies are considered to conduct activities related with science and technology.

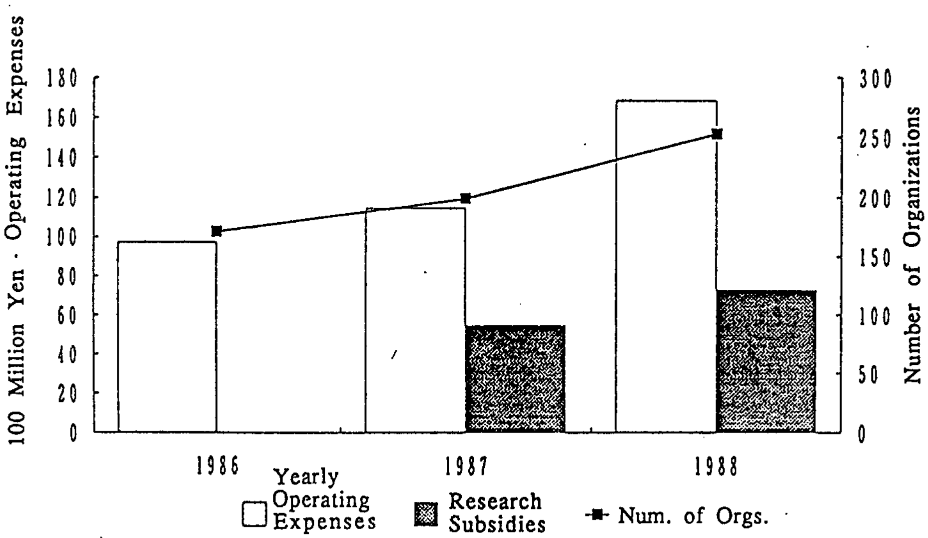
(1) Private higher education institutions (established as educational foundations).
(2) Learned societies (established as aggregate corporations or corporate foundations as well as voluntary corporations).
(3) Non-profit research institutes (mostly established as incorporated foundations).
(4) Research supporting foundations (established mostly as incorporated foundations but sometimes in other forms).

Foundations falling under items (1), (2) and (3) correspond with indicators for colleges and universities, learned societies and private research institutes respectively. Therefore, this chapter deals with research-supporting foundations falling under category (4). Indicators of learned societies in item (2) will be discussed in the next section.

As of the end of 1989, there are about 11,800 incorporated foundations in Japan. Incorporated foundations can be divided between "national foundations" under the jurisdiction of the national government and "local foundations" under the jurisdiction of local governments. About 96 percent (246) of the incorporated foundations are reported to be mainly engaged in supporting R&D activities. Within these, 224 (about 7 percent of the total research-supporting foundations) are "national foundations", while 22 (about 4 percent) are "local foundations". The total number of supportive foundations is 253, including one aggregate corporation and 6 social welfare corporations.

This section analyzes 642 projects implemented by 253 foundations concerned with science and technology. However, taking into account the fact that some projects take multiple execution forms, the aggregate number of such projects becomes 708 (Figure 3-2-1).

Figure 3-2-1 Number of Support Foundations and Scale of Their Activities



Foundation Center Library of Japan, "Grant-Making Organizations in Japan"

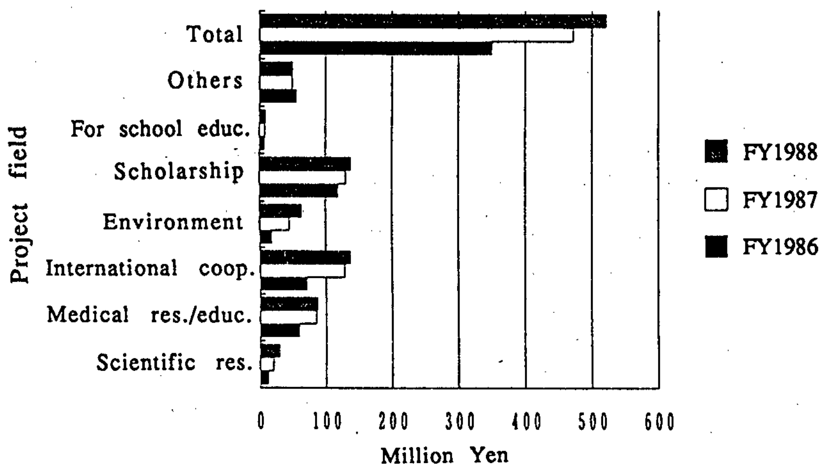
Foundation Center Library of Japan, "The Directory of Grant-Making Organizations in Japan"

The number of supportive foundations increased in recent years. In particular, 87 foundations have been established since the 1980's for the purpose of providing subsidies for research. (The number includes only those foundations which have already started subsidizing activities.) The total cost of activities by the supportive foundations amounts to 16.87 billion yen as of FY 1988, of which 7.27 billion yen (about 43 percent) is spent for subsidizing research. The scale of total activities is rather small compared with the Research Grant Program of the Ministry of Education, but these foundations are assuming a more important role in providing resources for basic research.

Engineering and medical science are the two most important beneficiaries from these subsidies for research, followed by physical and agricultural sciences, social sciences and humanities. Research on environment, education and welfare is also receiving support. When classified by subsidized projects according to research subject, medical science is highest, taking up 39.6 percent of the total project number and 36.7 percent of the total resources in 1989, followed by engineering with 24.1 percent and 24.7 percent respectively and physical science at 10.5 percent and 13.9 percent. This composition in shares is quite similar to that of general research in Expenditures for Scientific Research of the Ministry of Education, which provides approximately the same amount of subsidies.

Other than research-supporting foundations, public trusts have also been established increasingly in recent years to provide support for research. In FY 1988, 30 million yen was spent for supporting scientific research by 84 researchers. In the field of medical research and promotion of medical education, the subsidies amounted to about 90 million yen for 164 researchers (Figure 3-2-2).

Figure 3-2-2 Research Funding Support System by Public Trusts



Source: Support Foundation Reference Center
See Table 3-2-2

The first public trust was established only in 1977, and the scale of funds and activities of the trusts is small compared with that of corporate foundations. However, the task of public trusts is often similar to the promotion of science and technology, as they are engaged in facilitating international exchange, preserving the environment, promoting school education and subsidizing research. Many public trusts have been established since 1985, when "Japan Trust Project for International Research Cooperation" was launched by both the Ministries of International Trade and Industry and of Posts and Telecommunications. Furthermore, in 1990, "Public Trust for Development of Advanced Technology Engineers" was established on the suggestion of Keidanren. Public Trusts for the promotion of science and technology are thus growing steadily in scale.

The scale of support activities for science and technology through support foundations and public trusts is much smaller in Japan than in the U.S. For example, the scale of total properties and activities of all the Japanese foundations combined does not even match that of the Ford Foundation, the largest foundation in the U.S. However the growing interest of Japanese firms in donating and subsidizing activities gives us enough reasons to believe that activities of private company foundations and public trusts will gain much importance in the future. Even though these institutions do not possess juridical status, they assume the same functions as those of research-supporting foundations in that they provide public support. These forms of support for science and technology are expected to grow in the future.

3. 2. 2 Number of Learned Societies and Members

There are many registered learned societies numerous bodies which have "learned society" as their name, but it is difficult to identify the actually activities as complete data are not available. Therefore, defined as "learned societies" are those organizations which have been registered as academic research bodies with the Science Council of Japan, either on the occasion of "Survey on Academic Research Organizations", conducted every five years or at the beginning quarterly.

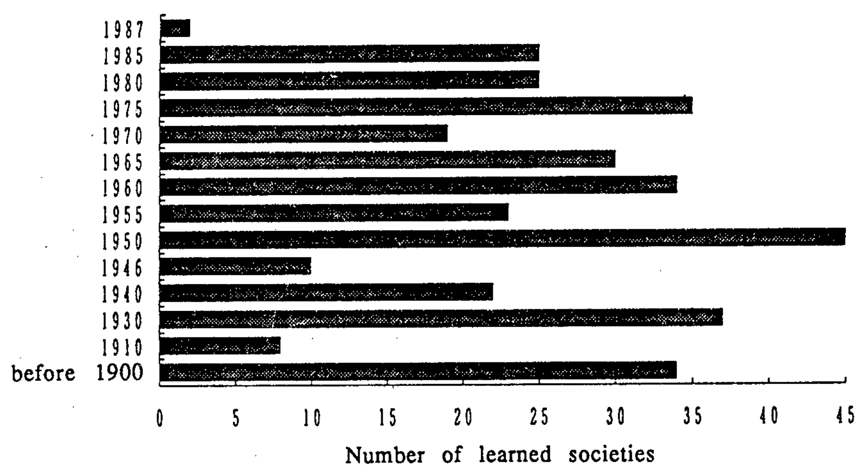
The number of registered learned societies was 785 in 1976, 1,003 in 1980 and 1,236 in 1986, for an increase of over 200 in each period. Humanities-related subjects are the most popular among learned societies, closely followed by medical science. In total, 2,096,000 individuals and 90,000 bodies comprise such societies.These numbers are based on the results of the "Survey on Academic Research Organizations" conducted by the Science Council of Japan, and it must be Noted that only those academic research bodies which meet certain criteria are subject to the survey (Note 1).

A large number of learned societies are involved in humanities and medical science. The numbers of learned societies engaged in other subjects amount to 151 for physical science, 143 for engineering and 122 for agriculture. Concerning the number of individual members in these societies, medical science has the most with 870,000 persons, followed by engineering with 520,000, humanities with 250,000 and physical science with 220,000. The average number of members per society is largest in engineering (3,600 members), followed by medical science (2,500) (Tables 3-2-3 to 3-2-5).

Chronological data on learned societies is used in the analysis. Data on the number of learned societies and of their members are based on surveys conducted after the renovation of the system adopted by the Science Council of Japan, and are collected through a different method from that of the earlier period. It is therefore difficult to analyze chronological trends in detail. The analysis is based on the establishment and number of learned societies which appear on the latest data.

The oldest learned society in Japan was established in 1878. Although some learned societies had already been established before World War II, the majority have been established after the war. The post-war era can be divided into three periods; the first period extending from directly after the war to the mid-1950's, the second from the mid-1950's to around 1970, and the third from 1970 to the present day (Figure 3-2-3).

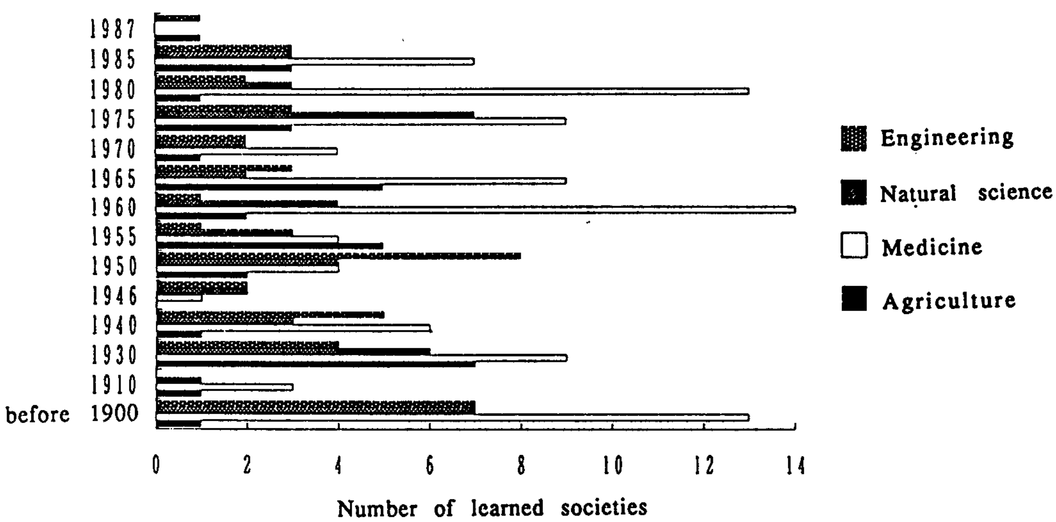
Figure 3-2-3 Total Number of Newly Established Learned Societies



The Science Council of Japan, "Directory of The Scientific Research Organization in Japan"
See Table 3-2-6

The first period corresponds to the period of reorganization of academic circles, when the start of a new collegiate system was accompanied by the establishment of learned societies in all the important subjects. In the second period, many learned societies were newly established in individual domains such as humanities and medical science. In the third period, since 1970, almost all subjects have experienced an increase in the number of learned societies in individual, new or interdisciplinary domains, but the peak in the number of new establishment differs from by subject. For example, in the physical science, establishment of new learned societies is concentrated in the mid-to late 1970's while a large number of the learned societies in engineering and agriculture were established in the early 1970's. However, an increasing number of learned societies have also been newly established since the mid-1980's concerning the latter two subjects. A large number of new learned societies in medical sciences have been established constantly since the mid-1970's (Figure 3-2-4).

Figure 3-2-4 Number of Newly Established Learned Societies by Subject



The Science Council of Japan, "Directory of The Scientific Research Organization in Japan"
See Table 3-2-6

Note:
(1) Data are adopted from Source 8, 9. The standard for selection of learned societies is not always clear, but bodies which consist of more than a certain number of individual members, have their own rules, hold meetings at least once a year and have continued to publish periodicals for a certain period are usually considered as learned societies. Those bodies with limited membership according to localities or alma matters are not included in the survey. Other than those learned societies counted in the indicators, there exist many more such as those related to colleges and universities (learned societies composed of persons concerned with specific colleges and universities), and those established quite recently. Classification by subjects is also based on the classification in the sources used, but there are slight differences in details. Compatibility can be assured only at the large classification level in the text.

Year of establishment is judged from description in the latest data. In the case where an learned society has broken up into many societies, the time of separation is adopted as the year of establishment. For example, Tokyo Mathematics Society, the oldest learned society in Japan established in 1877, after having been renamed as Tokyo Mathematics and Physics Society and then latter renamed as the Japan Mathematics and Physics Society to separate in 1946 into Japan Mathematics Society and Japan Physics Society. Therefore, 1946 is regarded as the year of establishment for these two learned societies. In some cases, data concerning year of establishment are not accurate. For example, the latest data includes those societies established in 1986, which is the year in which the survey was conducted by the Science Council of Japan. Data made public are expected to include modification and supplemented. Therefore, data on year of establishment are considered to have one to two year margin of error.

Sources:

(1) Science and Technology Policy Bureau, Science and Technology Agency, "Budget for Science and Technology."
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(3) OECD Science and Technology Indicators No.3, OECD, (Paris, France, 1989).
(4) Supportive Foundations Data Center, "Supportive Bodies in Japan Supportive: Handbook, 1988, Commentary," 1988.
(5) Supportive Foundations Data Center, "Supportive Bodies in Japan, 1990," 1990.
(6) Supportive Foundations Data Center, "Report on the Survey on Current Situations of Supportive Non-Profit Foundations," 1989.
(7) Supportive Foundations Data Center, "Report on Current Situations of Supportive Non-Profit Foundations (2)," 1990.
(8) Secretariat of the Science Council of Japan ed., "Academic Research Bodies in Japan, 1988," Printing Bureau, Ministry of Finance, 1988.
(9) Secretariat of the Science Council of Japan ed., "Epitome of Learned Societies in Japan, 1981," Printing Bureau, Ministry of Finance, 1981.

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(1) "White Paper on Science and Technology, 1990," Science and Technology Agency.
(2) "Report on the Survey of Research & Development", Statistics Bureau, Management and Coordination Agency.
(3) "Economy Handbook, 1991," Research Bureau, Economic Planning Agency
Classification of budget for science and technology by governmental agencies is based on Reference 4, 5.
(4) Hiroshi Tsuboi, "Science and Technology Budget in Japan, -Contents and Procedures-," National Expert Meeting on Science and Technology Indicators, OECD, December 1988.
(5) Masaki Tanaka, "Recent Trends in the Japanese Science and Technology Budget," National Expert Meeting on Science and Technology Indicators, OECD, December 1989.
(6) Yujiro Hayashi and Yoshinori Yamaoka, "Foundations in Japan," Chuo Koron, 1984.
(7) Tsuyoshi Kato, "Current Situations and Problems Concerning Research-Supporting Foundations in Japan," Research/ Technology/ Planning, Vol.6, No.1 (recent publication).
(8) National Institute of Resources, Science and Technology Agency, "Basic Survey on the Development of Science and Technology Indicators (interim report)," 1987.

CHAPTER 4

R&D ACTIVITIES IN INDUSTRY, ACADEMIA AND GOVERNMENT

CHAPTER 4

R&D ACTIVITIES IN INDUSTRY, ACADEMIA AND GOVERNMENT

This chapter presents indicators related to R&D expenditures, R&D scientists and engineers (R&D S/E) and R&D organizations which comprise elements of the R&D infrastructure. Needless to say these are the main and direct indicators of R&D activities. This chapter consists of four sections. Section 4.1 ("Overview of R&D Activities") examines the present state of R&D in Japan in time series and attempts to clarify trends through international comparison thus touching on the issue of international comparison of R&D capacities. Sections 4.2 through 4.4 analyze R&D activities by industry, academia and government sectors by analyzing R&D expenditures, R&D S/E and R&D organizations.

4.1 Overview of R&D Activities in International Comparison

This section clarifies the present state and general trends of R&D activities in Japan regarding R&D expenditures and the number of R&D S/E. The aim is to clarify trends in Japanese R&D activities through time series analysis and international comparison.

International comparison of R&D activities requires using values measured under identical conditions. Identical conditions mean that there is agreement in such things as definitions and data collection methods. However the actual condition is that Japan and Western countries cannot be said to be measuring R&D expenditures and the number of R&D S/E, which are the most basic R&D statistics, in the same way. Japan and the Western countries can be said to agree with the definition of such expenditures and R&D S/E (see Note and references 3 and 4). However the two are not using the same method in counting the number of R&D S/E. Hence, while Japan counts the actual number of R&D S/E Western countries are using the Full-Time Equivalent (FTE) method whereby the number of R&D S/E is estimated based on their actual working hours. FTE's idea is to distinguish between R&D and other activities and measure the number of R&D S/E based on the time they are actually engaged in R&D activities.

In any sector of a country's science and technology system, be it industry, academia or government R&D organizations, it is difficult to think that R&D S/E are engaged in R&D activities all of the time. For example they often use time for administrative tasks, teaching or meetings, etc.which are not directly related with R&D. In calculating the actual time spent on R&D activities, such time should be excluded from calculating equivalents for the actual time spent on research. Furthermore, it is argued that personnel expenditures paid in relation to such time should also be excluded from R&D expenditures. If not the number of R&D S/E and R&D expenditures are said to be overestimated. Hence FTE is based on the idea of approximating, as closely as possible, the number of R&D S/E and R&D expenditures by making adjustments to actual figures.

For example, in calculating FTE, a researcher who is spending all of his working hours for R&D activities is said to represent 1. That is, the researcher is counted as one whole unit or is said to be working on R&D activities full time. In contrast, the FTE of a researcher who is also carrying out other activities during his working hours will is represented by a value less than 1. If for example 50 percent of his working hours are spent on R&D, the FTE coefficient will be 0.5 of the total working hours.

Most Western countries are using FTE coefficients following recommendations set forth by the OECD in 1975. In contrast, Japan is the only developed OECD country which has not been using FTE. In fact the figures released through the Japanese Management & Coordination Agency reports are not FTE-converted. They have not subtracted the non-R&D time from the actual R&D S/E activity time. Hence the number of R&D S/E in Japan is an overestimate when looked at by OECD guidelines. The OECD report of science and technology indicators (reference 5) points out that the number of R&D S/E in Japan is overestimated and makes adjustments accordingly for it and related R&D expenditures. Adjusted in particular are the number of university R&D S/E. The reason given for these adjustments is one based on the definition of R&D activities that educational and R&D activities should be separated (reference 4).

However the OECD method is not without criticism. Namely, the OECD only reports FTE-converted figures and the actual number of R&D S/E engaged in R&D activities. The actual number is important when examining such things as the education of R&D S/E and specific R&D potential.

Based on the foregoing discussion and in order to conduct international comparison in such a way as to reflect the actual conditions, the following suggestions are offered.

1. Japanese R&D organizations can obtain and release only FTE data or the FTE-converted number of R&D S/E in addition to the actual number. This is made easy because the necessary techniques have already been set forth in an OECD guideline (reference 4).

2. The OECD can recommend member countries to study and report the actual number of R&D S/E in addition to the FTE-converted numbers.

FTE-based R&D statistics have not been made available in Japan to date. This chapter applies the OECD FTE conversions for Japanese R&D data in order to conduct international comparisons of R&D which more accurately reflect conditions set forth in international guidelines.

(1) The FTE conversion ratios used will be 0.7 for industry, 0.5 for academia and 1.0 for governmental R&D organization R&D S/E. The value for industrial R&D S/E is based on findings from a survey covering corporate R&D organizations (reference 6). The values for university and research organization R&D S/E are those used by the Ministry of Education. However these cannot be said to be appropriate as they are not based on findings from comprehensive surveys. For example, in the case of R&D S/E in academia, when consideration is given to a survey methods by the Institute of Future Technology (reference 6) or the Ministry of Education, proper coefficients could be closer to 0.6 or 0.7 than 0.5. Yet in comparison to 1.0 the estimate using 0.5 is believed to be more accurate. Hence, since the definitive accurate value cannot be obtained the most rational method is to use inference based on survey findings and experience.

The number of R&D S/E is FTE-converted then R&D expenditures are estimated by estimating the R&D S/E' personnel expenditures using a conversion rate.

(2) Only the most up-to-date figures were converted. This was because the FTE-conversion comprised an estimate. Also, estimating the most up-to-date figures will enable estimation of the trends over time without converting other figures for other years.

(3) From section 4.2 on, analysis is by industrial, academic and governmental sectors so that international comparison does not become important. Hence the figures were not converted. In section 4.1, statistics such as R&D expenditures flows, are not converted.

Note:
In Japan "science and technology" are often considered to refer to only natural sciences. In this case "R&D S/E" will only include natural scientists. In the U.S. also, the number of industrial R&D S/E includes only natural scientists. The number of R&D S/E in other countries however includes all natural, cultural and social scientists.
The Management & Coordination Agency study (reference 3) defines R&D S/E as those who have completed courses in colleges (excluding junior colleges)(or those having equivalent technical knowledge), have had at least two years of research experience and are conducting research on specific themes. They are divided into full-time and part-time R&D S/E. The full-time R&D S/E are mainly engaged in research inside organizations while part-time R&D S/E are engaged in regular duties outside the organization. This paper treats full-time R&D S/E as R&D S/E and refers to them in conducting international comparisons and other analyses.

The OECD's Frascati Manual (reference 4) uses occupational and educational level classification in defining R&D S/E. Based on the occupational classification it defines R&D S/E as scientists or engineers engaged in origination or creation of new knowledge, products or manufacturing methods and lists the corresponding categories of the standard international occupational classification. With the educational level classification it recommends the use of four classes based on acquisition of college degrees based on the standard international educational classification.

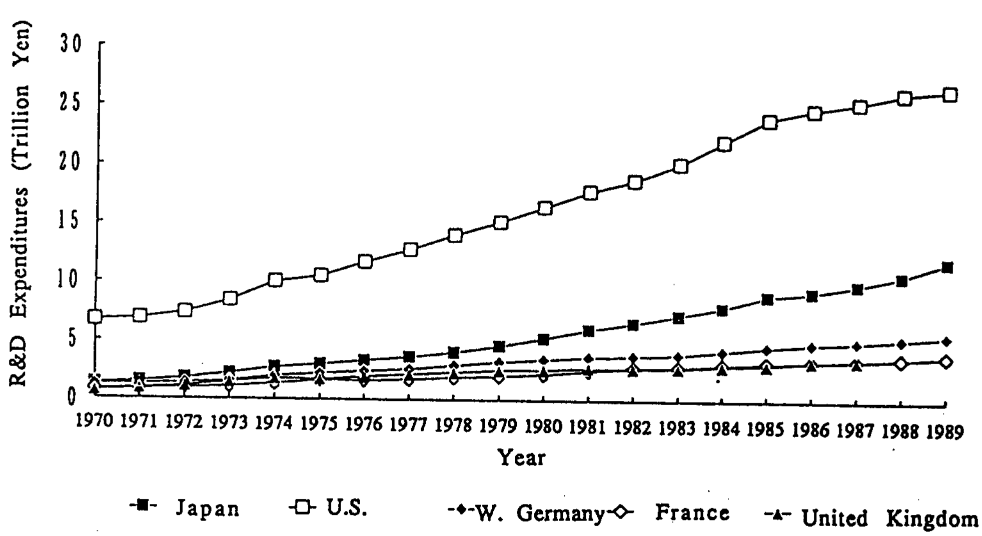
4.1.1 R&D expenditures

Since countries are reporting R&D expenditures in their own currencies it is necessary to make conversions when conducting international comparisons. In Japan the annual exchange rate (IMF rate) is generally used while the OECD uses purchasing power parity (PPP) figures (sources 2 and 3). Developed countries also usually use the OECD method in internationally comparing R&D expenditures. Economists and other experts have been arguing the pros and cons of this method and it cannot be said that there has been a consensus. However this report uses PPP conversions by giving consideration to such facts as that there are no other appropriate conversion methods and that the method can avoid the effects of speculative exchange rate fluctuations of the existing floating exchange rate system which converts country currencies of purchases for a basket of comparable goods into U.S. dollars.

(1) R&D Expenditures

Figure 4-1-1 is a pie chart showing R&D expenditures by the major industrial countries (Note 1, sources 1-6, reference 1). In 1989 the U.S. overwhelmed other countries by spending ¥26.5 trillion (Note 2) for R&D. Japan followed with ¥11.8155 trillion which was under half the U.S.amount. It was followed by West Germany (Note 3), France and the U.K. West German expenditures was ¥5.5 trillion which was around half the figure for Japan.

Figure 4-1-1 Trends of National R&D Expenditures in Selected Countries



Science and Technology Agency, "White Paper on Science and Technology"

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

OECD, "Main Economic Indicators", 1989 ık," 1991.

OECD, "International Sectorial Data Bank", 1991

Here FTE-converted R&D expenditures are estimated. Since personnel expenditures by corporations was ¥3.2475 trillion, multiplying this figure by 0.3 for non-FTE expenditures gives an adjusted figure of ¥974.3 billion. Total personnel expenditures by universities was ¥1.4224 trillion, thus multiplying it by 0.5 for non-FTE gives ¥711.2 billion for an adjusted total of ¥1.6855 trillion. Hence, subtracting this figure from the total R&D expenditures gives the FTE-converted R&D expenditures by Japan of ¥10.1 trillion which is 85.7 percent of the non-FTE-converted figure previously reported by official reports. This amount is slightly under 40 percent (38.2 percent) of the R&D expenditures by the U.S.

In the last 20 years the R&D expenditures by Japan has increased by a factor of nine. The increase rate in R&D expenditures has been greater than that for other countries. Particularly marked has been the growth in the 1980s. In 1985-1986 however the growth temporarily declined due to the effect of the weak yen and strong dollar. The subsequent growth however has exceeded that of previous years. In contrast the growth of R&D expenditures by the U.S. has slowed rapidly after 1985.

Notes:
(1) In this section R&D expenditures are the total of expenditures in the areas of natural sciences, humanities and social sciences. Also, what the Management & Coordination Agency report calls "research expenditures" are refereed to as "R&D expenditures" in this report. This is because as will be mentioned in the Notes for section 4.1.3, it is believed more reasonable to call "developmental research" only "development."
(2) The survey period differs depending by country. Japan uses the fiscal year (April to March) while the U.S. uses the calendar year. Such differences however are not taken into account since there are no accurate adjustment methods and do not become major problems when examining trends.
(3) Today the Germanies have been united. However the statistics used in this paper all date back to pre-unification. Therefore strictly speaking while the country name should be "Germany (former West Germany)." This however has been avoided.

(2) Ratio of R&D Expenditures to GNP

When international comparisons of R&D expenditures are conducted, the ratio of expenditures to GNP (gross national product) is significant and is frequently used (sources 1, 4, 5 and reference 1). By dividing R&D expenditures by GNP it becomes possible to understand the relative size of expenditures in the country's total economy or to the degree of efforts it is making in scientific and technological activities.

The ratio of R&D expenditures to GNP shows tendencies which are quite different from those observed when comparing the actual figures (Figure 4-1-2). Expenditures by Japan has favorably increased from 1.8 percent in 1970 to gradually approach 3 percent after 1983.

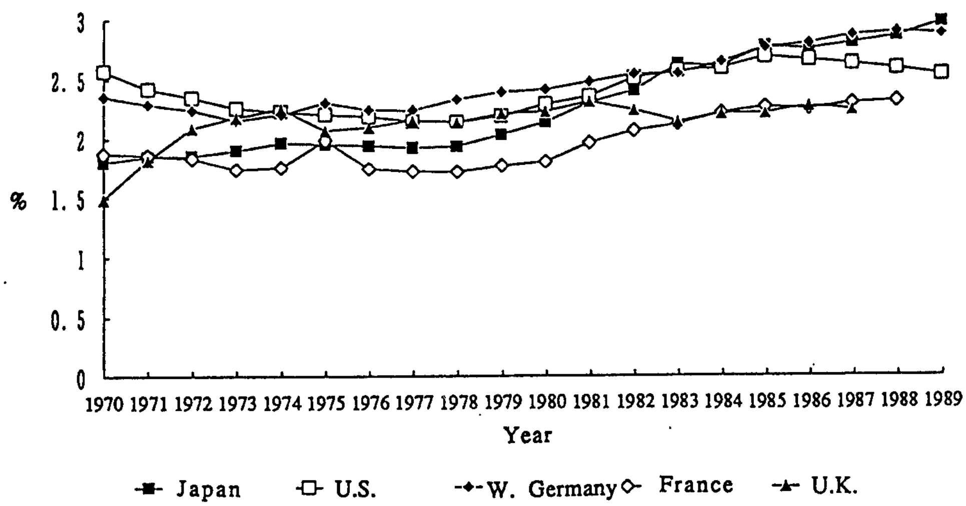
Expenditures for the U.S. have declined though slowly during the last 20 years to be outpaced by West Germany in 1974 and Japan in 1983. The ratio of R&D expenditures by the U.K. to GNP declined 0.5 percent from 1980 to 1982. Although the ratio has gradually risen after 1982 it has not recovered to the level in 1980.

The ratio of R&D expenditures by Japan to GNP has nipped and tucked with West Germany after it outran the U.S. in 1984. In 1989 Japan appears to have passed West Germany. However it is believed necessary in international comparison to convert to FTE figures so as to better reflect the actual conditions. Hence, FTE-converting the figures shows that the ratio of Japan's R&D expenditures to its GNP in 1989 was around 2.5 percent less than the reported figure. This puts Japan at the same level as the U.S.

(3) Civilian-use R&D Expenditures

R&D expenditures by Japan can characterized by very small amounts related to defense (sources 1, 5-7 and reference 1). In fact, around only 4 percent, or around ¥100 billion of the country's science and technology budget goes to defense-related R&D. When compared internationally, it is necessary to compare R&D expenditures by the private sector in addition to the total. R&D

Figure 4-1-2 Trends in Ratios of R&D Expenditures to GNP in Selected Countries



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

Science and Technology Agency, "White Paper on Science and Technology"

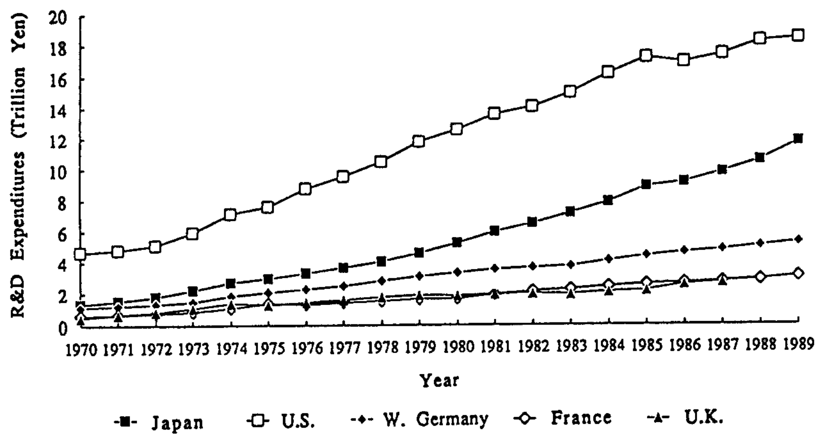
objectives differs between private and defense so that it is necessary to distinguish between the two. Hence, comparison of R&D expenditures by the private sector (Figure 4-1-3 (A), sources 1-6) shows that the U.S. far outspent other countries at ¥18.4 trillion. Since Japan spends very little on defense its private R&D expenditures came to ¥11.7 trillion which was not much different in relation to total R&D expenditures. Comparison with West Germany (¥5.2 trillion), France (¥3 trillion) and the U.K. (¥2.66 trillion) shows that Japan's edge over these major European countries has been expanding. However the gap with the U.S. is around ¥7 trillion which clearly shows the U.S. edge in private as well defense related R&D expenditures.

The ratio of defense-related R&D expenditures to total R&D expenditures in Japan is small (0.85 percent). Hence in FTE conversion, 0.85 percent of total R&D expenditures is assumed to be spent on defense. Under this assumption, FTE-converted private R&D expenditures in Japan comes to slightly over ¥10 trillion.

To examine the relationship to economic scale, examination of the ratio of civilian R&D expenditures to GNP shows patterns considerably different from comparison of the actual values (Figure 4-1-3 (B), sources 1-6). Comparing the ratio by country shows civilian R&D R&D expenditures to GNP by the U.S. never exceeding 2 percent during the last 20 years while the U.K. and France have remained on the same level as the U.S. In contrast, expenditures by West Germany and Japan has more or less increased from 1970 to 1989. In 1982 in particular expenditures for Japan exceeded West Germany's, reaching around 3 percent in 1989. In Japan only defense-related R&D

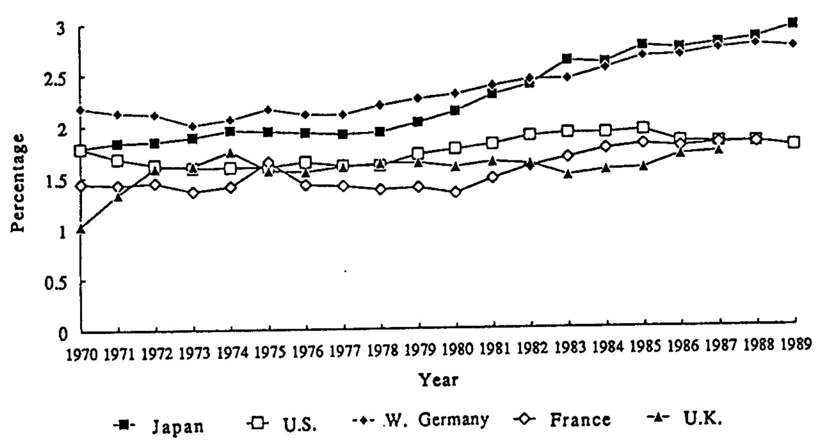
expenditures by the Defense Agency are referenced in the science and technology budget. The growth of the science and technology budget is far smaller than the growth of the total R&D expenditures. Hence in the recent years civilian-use R&D expenditures been increasing regularly. These are believed to be factors behind the tendencies shown by the graph. In 1989 the FTE-converted civilian-use R&D expenditures' ratio to GNP was 2.5 percent which was lower than West Germany's.

Figure 4-1-3 (A) Trends in Civilian R&D Expenditures in Selected Countries



Science and Technology Agency, "White Paper on Science and Technology"
See Table 4-1-3(A), Table 4-1-3(B), Table 4-1-3(C).

Figure 4-1-3 (B) Trends in Ratio of Civilian R&D Expenditures to GNP



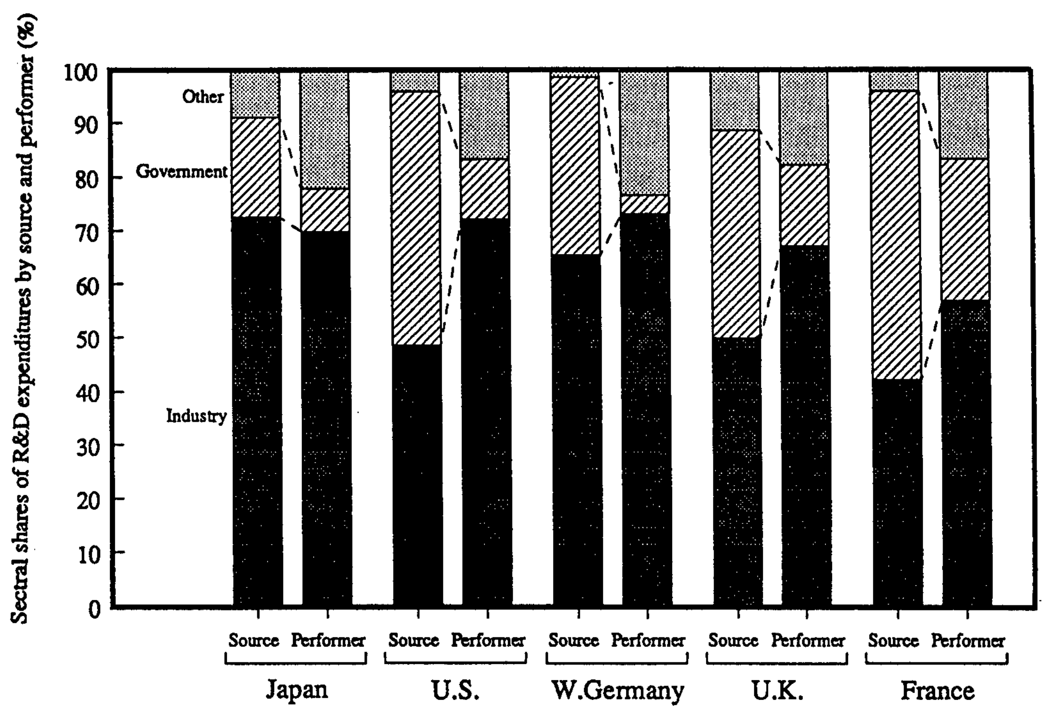
Science and Technology Agency, "White Paper on Science and Technology".
OECD, "Main Economic Indicators", 1989.
OECD, "International Sectorial Data Bank", 1991.
See Table 4-1-3(A), Table 4-1-3(D).

4.1.2 R&D Expenditures by Industry, Academia and the Government

(1) R&D Expenditures by Source and Performer

Figure 4-1-4 shows the sources and performers of R&D expenditures in the major countries by sector (Note, sources 1, 4). In terms of bearing of the expenditures the share of the industries in Japan (around 70 percent) and West Germany (around 60 percent) is considerably greater than in other Western countries (40-50 percent). In terms of the government's share, the French government's was the greatest (slightly over 50 percent) followed by that of the U.S. and the U.S. The order is reversed for industry. However, comparing Japan and West Germany whose industries provide a great portion to total R&D expenditures shows the German government's share was nearly twice the Japanese. This shows the small share born by the Japanese government in paying science and technology R&D expenditures compared to the major Western governments. In terms of the share of other organizations (including universities) such organizations had a great share in the U.K. followed by Japan.

Figure 4-1-4 Sectorial Share of R&D Expenditures by Source and Performer in Selected Countries



Science and Technology Agency, "White Paper on Science and Technology"
See Table 4-1-4

In Japan the sectorial share of R&D born in 1980 for industry was 60 percent, government 30 percent and universities and others 10 percent. Subsequently the industrial share has increased in 1989 with industry at 70 percent, government at 20 percent and universities and others remaining at 10 percent. In the U.S. the governmental R&D share, which exceeded 60 percent in the 1960s, declined every year in the 1970s. In contrast, the share of industrial R&D has increased, exceeding the government share in 1980. In the 1980s industries and government shares were more or less fixed. In 1989 the share of R&D expenditures for industry and government was 50 percent and 45 percent respectively.

In general, industry is the main performer of R&D.Its share is particularly large in West Germany, the U.S. and Japan and small in France. In France the government's share as performer of R&D is large compared to other countries' followed by the U.K., U.S. and Japan. The government's share is very small in West Germany.

Lastly, to sum up the trends of source and performer of R&D expenditures by country, while Japanese industries are both paying for R&D expenditures and performing large part of R&D activities, in the U.S., West Germany and the U.K. Government often provides funding while industry is often the performer of the R&D activities. This is the case in France where the government is often sourcing a great portion of R&D expenditures and industry is often the performer.

Note:
The "other" sources of R&D expenditures include universities, private R&D institutes and foreign countries. "Government" performers are "government R&D organizations" including public and special-status corporate R&D organizations. "Others" includes universities and private R&D institutes. In the case of the U.S. "others" include nonprofit R&D organizations other than federal or university. The U.S. federal funded or operated R&D organizations have been classified under the categories to which their organizations belong to.

(2) Trends of R&D Expenditures in Japan and the U.S. by Sector

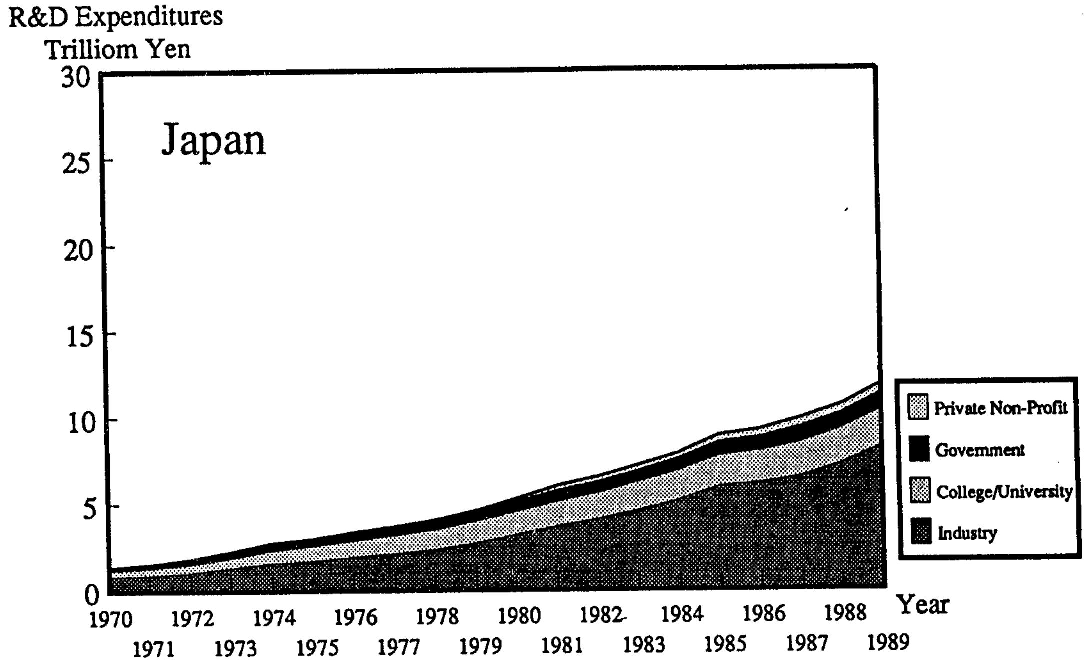
Figure 4-1-5 compares the trends of R&D expenditures by sector between Japan and the U.S. (sources 1, 2, 3, 6). The sector categories are industry, academia and others, government and private R&D institutes (see Note). The previous figure's "others" includes this figure's academia, others and private R&D institutes.

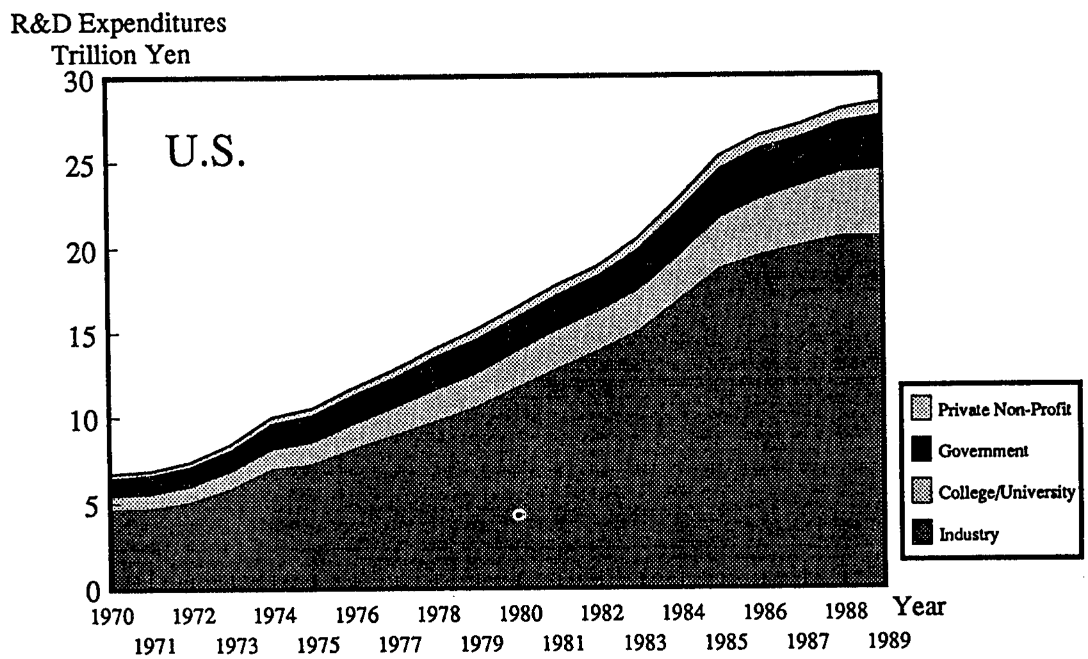
The figure shows that in both Japan and the U.S. industries are spending greatly on R&D. It also shows that overall trends are greatly affected by industry trends. In Japan, the rate of R&D expenditures by the industries has increased nine points in the 20 years from 1970 (60.7 percent) to 1989 (69.7 percent). The pace of increase has quickened after 1987. Expenditures by universities and others have consistently been declining. In fact, in contrast to the industry ratio which was 27.0 percent in 1970 it decreased nine points to 18.0 percent in 1989. The share of government R&D organizations has also decreased by slightly under three points in the same 20 years. Compensating for this decrease has been spending by private R&D institutes. Hence in Japan industry has markedly increased its share of R&D expenditures.

In the U.S. the share of industrial R&D expenditures has slightly been larger than in Japan, reaching 72.5 percent in 1989. Over time it has more or less remained on the same level or has gradually increased, by 3.4 points from 69.1 percent in 1970. As shown in the Figure 4-1-5, in absolute value, it has gradually increased from the latter half of 1985 in contrast to Japan's decrease.

In the U.S. the share of academia and others in R&D expenditures has been around half that in Japan. However, unlike in Japan, the share has remained at the same level or has gradually increased. In 1989 it was 13.6 percent. Also, R&D expenditures by U.S. government R&D organizations has gradually decreased by 4.5 percent from 1970 to 1989. The share of private R&D institutes, which account for around 3 percent of the total R&D expenditures, has gradually decreased. In general the range of increase and decrease in the U.S. has been smaller than in Japan.

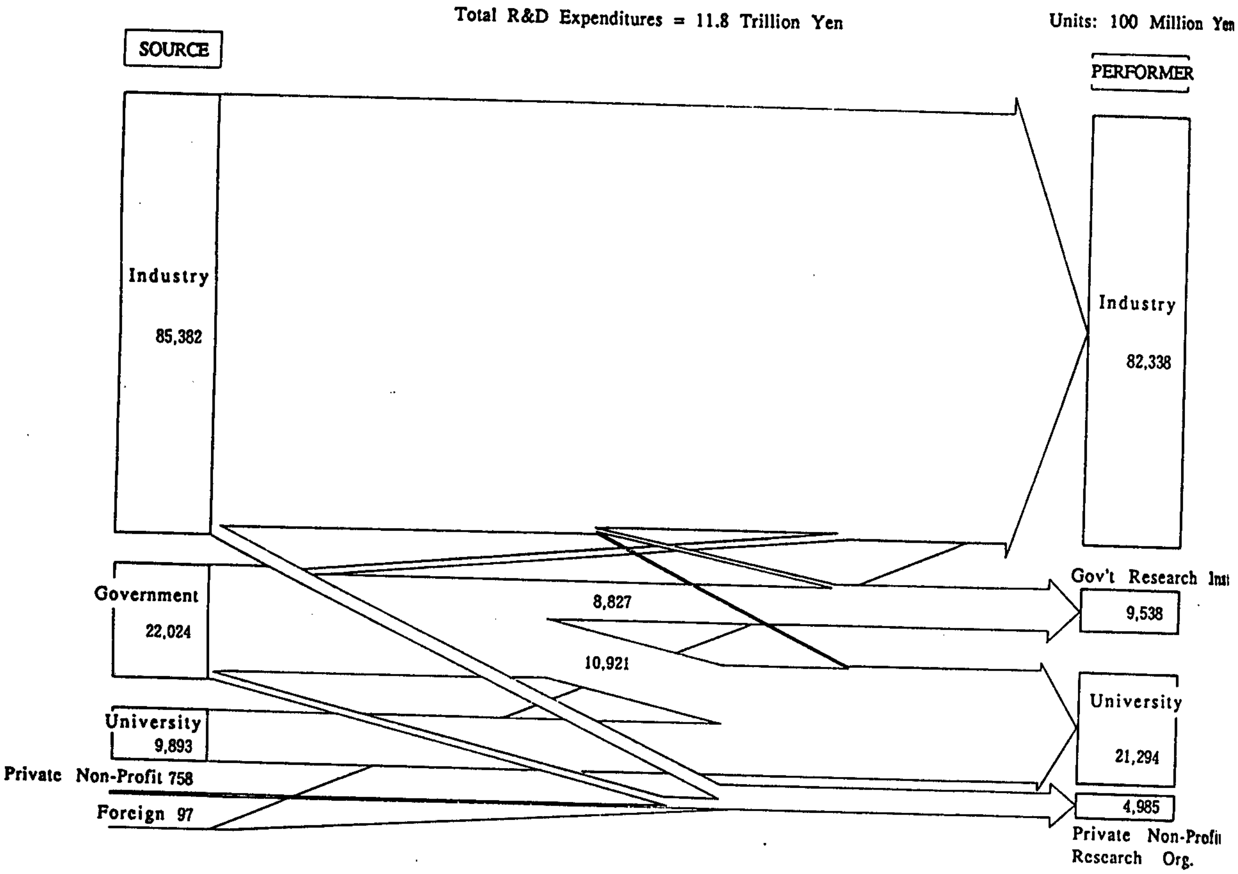
Figure 4-1-5 Sectorial Trends of R&D Expenditures in Japan and the U.S.





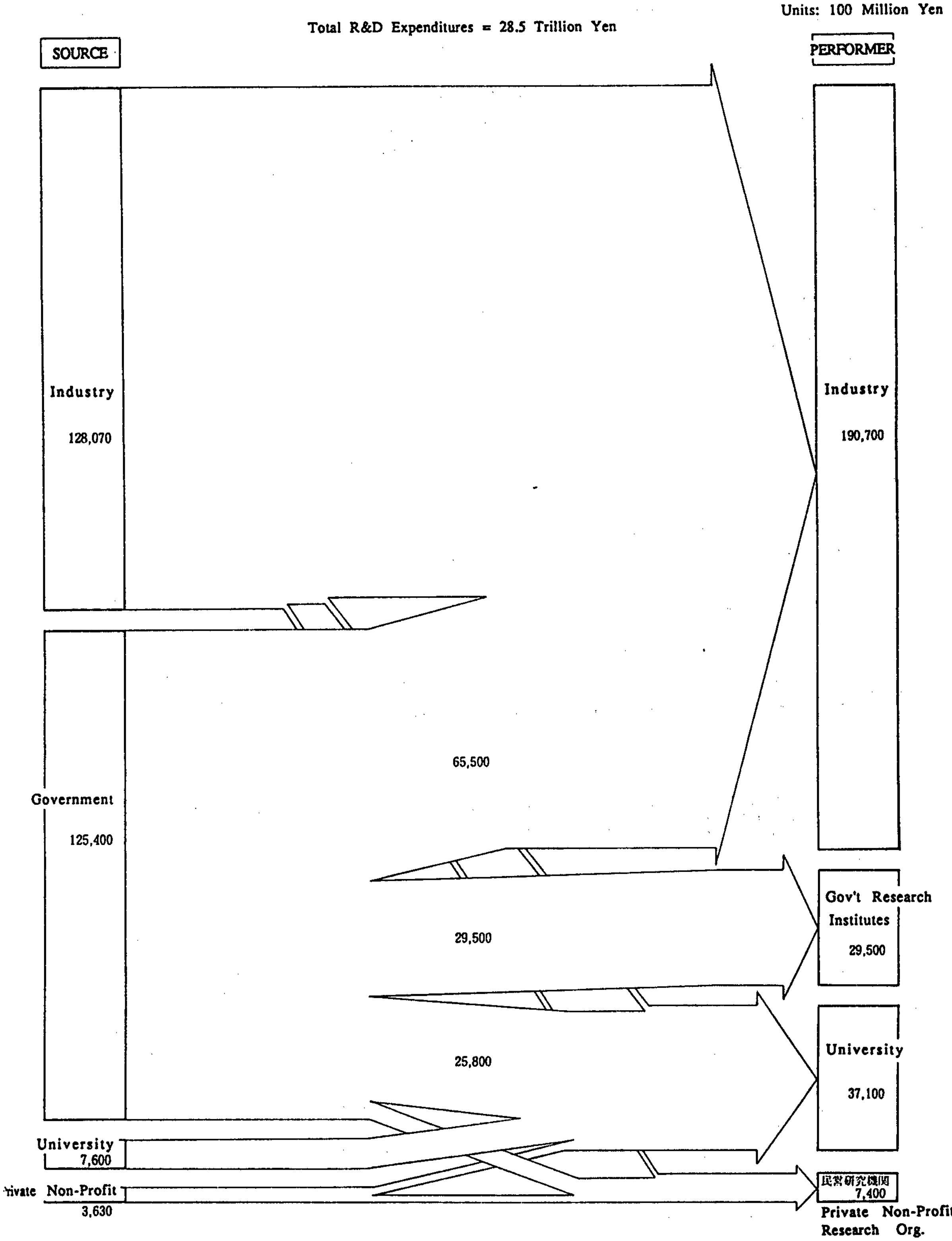
Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"
NSF, "National Patterns of R&D Resources:1990"
See Table 4-1-5

Figure 4-1-6 (A) Sectorial Flow of R&D Expenditures in Japan (FY 1989)



Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"
See Table 4-1-6(A).

Figure 4-1-6 (B) Sectorial Flow of R&D Expenditures in the U.S. (FY 1989)



NSF, "National Patterns of Science and Technology Resources".
See Table 4-1-6(B).

Note:
Japanese "government R&D organizations" refer to national and public R&D organizations and special-status corporations whose main operation is R&D. U.S. "government R&D organizations" include those of state governments. U.S. "universities and others" include Federally Funded Research Centers (FFRDCs).

(3) Flows of R&D Expenditures

In sectorial analysis of R&D expenditures, the three sectors examined are industry, academia and the government. Two aspects are analyzed; providers of resources for R&D (sources) and users of such resources (performers). Figures 4-1-6 (A) and (B) compare this flow between Japan and the U.S. (sources 1, 2, 3, 6).

As already mentioned, in Japan industry is both the major source and performer of around 70 percent of R&D expenditures, far outpacing other sectors. For example, governmental R&D expenditures to industry in 1989 was only 4.7 percent. This was only 1.2 percent of industrial R&D. This ratio is very small compared to the U.S. or even European countries. In terms of bearing of the R&D expenditures by Japanese universities, the government's share has declined every year in the 1980s. In contrast, while industry's share has been small compared to that of government's, it has increased every year in the 1980s (the share in 1989 was over twice that of 1980). Hence the flow of expenditures from industry to universities has been increasing.

Examining R&D expenditures flows in the U.S. shows a large flow from government (45 percent share) to industry. In 1989 slightly over 50 percent of the government's share went to industry. This figure was around 30 percent of all R&D expenditures by industry. In comparison to the Japanese government's share of R&D expenditures by industry, the U.S. government's share has been on a very high level. As in the U.S., there is a large flow from the government to industry in West Germany, France and the U.K. In fact, the ratio of the R&D expenditures provided by industry and paid by industry was 67 percent in the U.S., 83 percent in West Germany, 74 percent in France and 78 percent in the U.K. while for Japan it was 97 percent.

In terms of R&D expenditures by U.S. universities and others the government's share has declined and industry's increased in the 1980s. This tendency was similar in Japan.

4.1.3 R&D Expenditures by Characteristic of Work

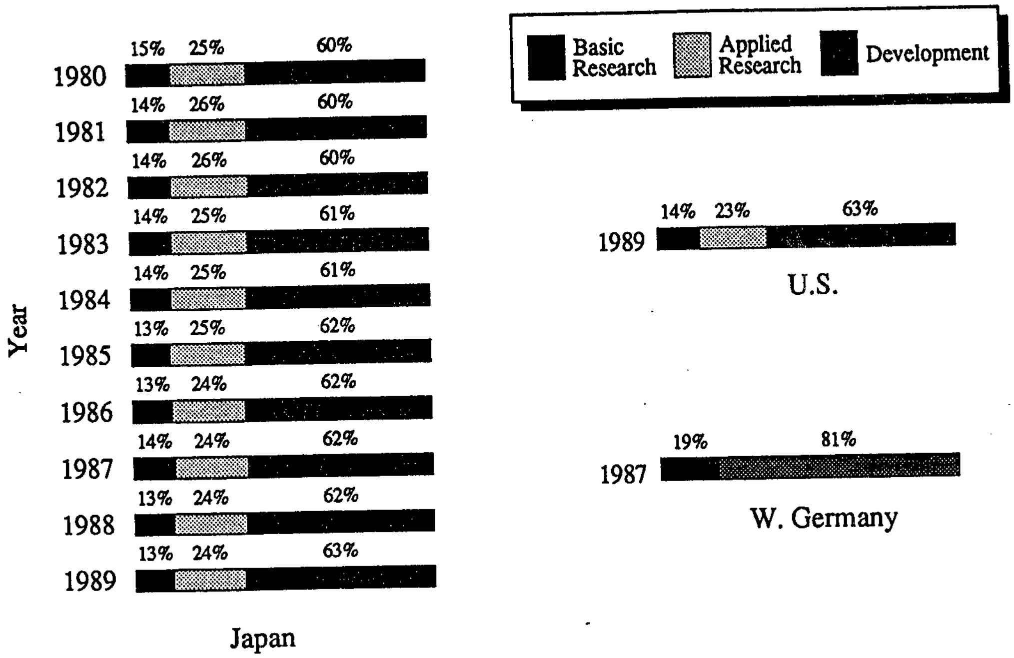
R&D activities can be classified into three work characteristics; basic research, applied research and development (Note). There has been a mounting interest in internationally comparing the size of expenditures on basic research in particular and its ratio to the total R&D expenditures (references 7, 8).

Figure 4-1-7 shows the share of R&D expenditures by the major countries by characteristic of work (sources 1, 4). In Japan expenditures for basic research account for 13-14 percent of all R&D. In the U.S. it is more or less on the same level as in Japan whereas in West Germany and France it is on a level higher than both Japan and the U.S. at around 20 percent.

Figure 4-1-8 (sources 1, 2, 3, 6) compares Japanese and U.S. expenditures on basic research by industry,academia and the government. When comparing industrial basic research expenditures there is no major difference between the two countries. When consideration is given to the difference in the scale of the overall economic activities in these countries Japanese industries can be said to be spending relatively more on basic research. In fact, while the ratio of basic research expenditures by Japanese industries to total R&D expenditures was 6.5 percent in 1988 the U.S. figure was 3.1 percent.

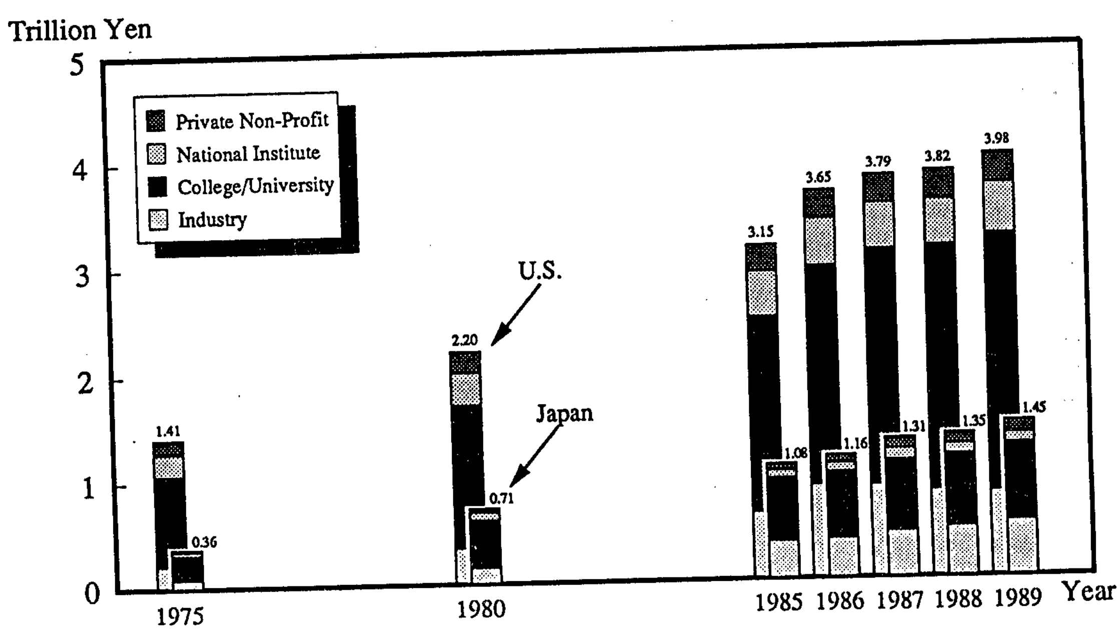
The ratio of basic research expenditures by Japanese universities has consistently been declining in the last decade to below 50 percent in 1988. In the U.S. it has exceeded 60 percent and is gradually increasing. The tendency of increased expenditures for basic research in the two countries is the opposite of that industrial R&D.

Figure 4-1-7 R&D Expenditures by Characteristic of Work in Selected Countries



Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"
See Table 4-1-7

Figure 4-1-8 Sectorial Trends in Basic Research Expenditures in Japan and the US



Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development" See Table 4-1-8

An overview of Japanese and U.S. patterns of basic research expenditures shows that the difference between the total expenditures on such research was still large in the 1980s. For example the total basic research expenditures by Japanese universities, national research institutes and others fell far short of the total expenditures by U.S. universities and R&D organizations.

Note:

The Management & Coordination Agency study (reference 3) defines research expenditures by characteristic of work as those internally spent by natural science divisions for natural sciences and classified by characteristic of work into basic research, applied research and development.

"Basic research" is defined as theoretical or experimental research conducted to develop hypotheses or theories or to acquire new knowledge on phenomena or observable facts without directly giving consideration to specific applications or uses. "Applied research" refers to research which aims to ascertain the possibility of practical application by establishing specific goals or that which explores new applications of methods which are already in practical application using knowledge discovered through basic research. "Developmental" comprises utilization of the knowledge acquired from basic and applied research and actual experience and research designed for introduction of new materials, equipment, systems or processes or their improvement. Hence the definition captures "research" in the broad sense by including development. However, when consideration is given to the definition's contents or international comparison it is believed more reasonable to treat "developmental research" as "development." Hence this paper uses the latter.

The Frascati Manual also uses a more or less similar definition. It however calls development "experimental development."

4.1.4 Trends in the Number of R&D Scientists and Engineers

(1) Number of R&D S/E

Figure 4-1-9 shows the trends of the major countries' number of R&D S/E (sources 1, 4, 6). It can be seen that the number in the U.S. has far exceeded that in other countries in the 1970s and the 1980s and has greatly increased from the latter 1970s. The number in Japan has followed that in the U.S. and has been increasing steadily.

Sectorial examination of the number of R&D S/E by country in the 1970s and the 1980s shows that in Japan and the U.S. industrial R&D S/E have increased by around 200,000 during the last 20 years, greatly contributing to the increase of the overall number of R&D S/E. The increase of industrial R&D S/E in West Germany (by 50,000) and the U.K. (by slightly under 30,000) has been small compared to Japan and the U.S. The increase of industrial R&D S/E, which has accounted in all these countries for 60 to 80 percent of all R&D S/E, has served as a factor to increase the total number of R&D S/E. In France both industrial R&D S/E and those of government R&D organizations have increased by 20,000 so that in 1987 total number of R&D S/E has exceeded that of the U.K.

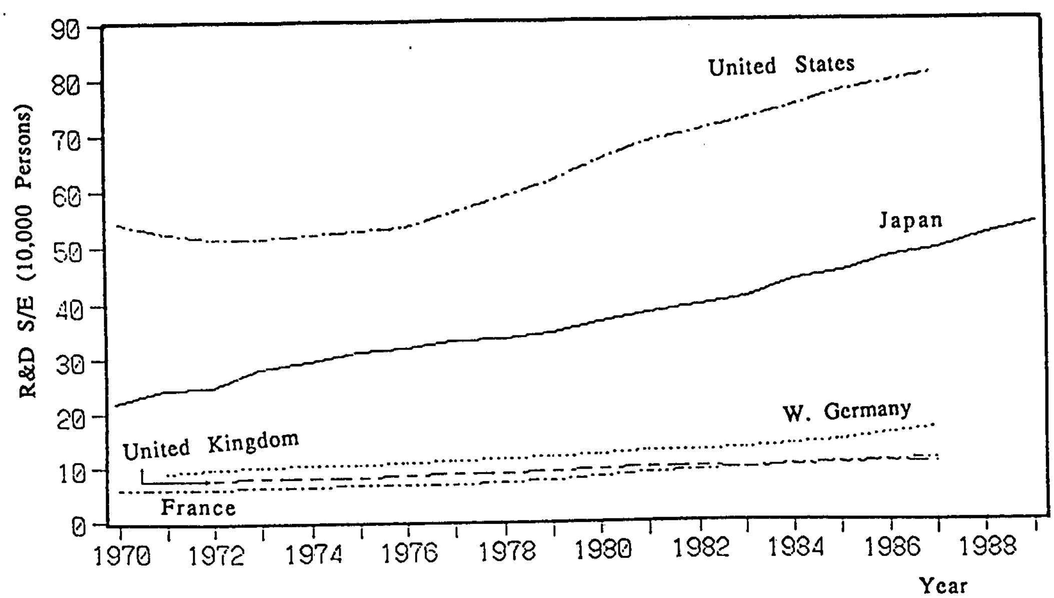
In Japanese universities the number of R&D S/E has increased greatly by around 80,000 in the last 20 years. This is believed to have been due in part to establishment and expansion of new and old universities. In contrast the number of R&D S/E belonging to government R&D organizations has not fluctuated perhaps due to a reduction of positions.

Japan had 535,000 R&D S/E in 1989 and 560,300 in 1990. The U.S. had 949,000 in 1988, West Germany 166,000 in 1987 and France 115,000 in 1988. FTE-converting the figures for international comparison shows that Japan had around 360,000 R&D S/E in 1990 which is around 65 percent of the actual reported number.

(2) Number of R&D S/E per 10,000 Employees

In making an international comparison on the number of R&D S/E, their relative number in relation to the labor force and to total population are as important as their absolute number. In this sense, the following two indices have been adopted; the number of R&D S/E per 10,000 employees (hereinafter referred to as number of R&D S/E per labor force) and number of R&D S/E per 10,000 persons (hereinafter referred to as number of R&D S/E per population).

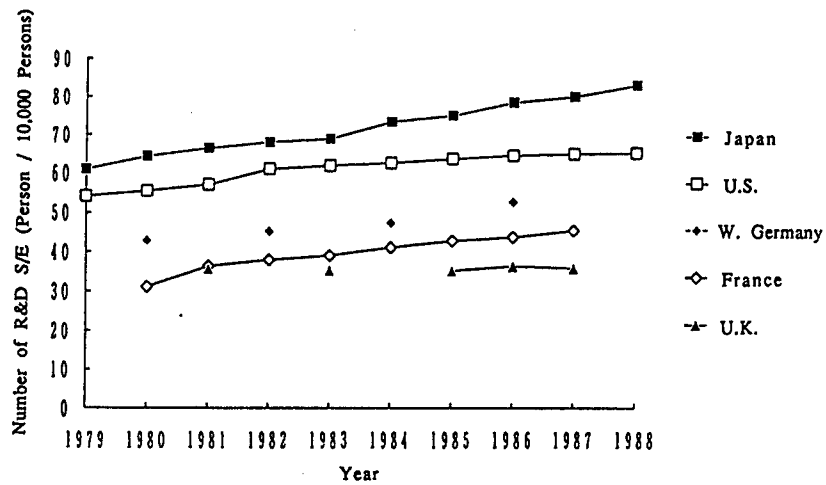
Figure 4-1-9 . Number of R&D Scientists and Engineers in Selected Countries



Science and Technology Agency, "White Paper on Science and Technology"

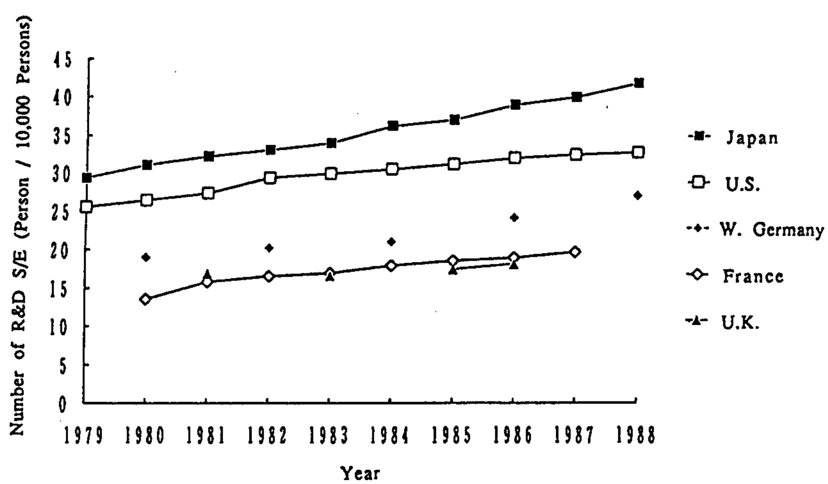
Figures 4-1-10 (A) and (B) show the number of R&D S/E per 10,000 employees and population (sources 1, 4, 8). In either case the Japanese figures are on the same level as the U.S. After 1984 in particular the Japan-U.S. gap in the ratio of the number of R&D S/E has widened. While in 1988 the number of R&D S/E per 10,000 employees was 83 in Japan that in the U.S. was 65. While the number per unit population was 42 in Japan that in the U.S. was 33. In West Germany and France also the ratio of R&D S/E has been increasing. However the ratio has been around half that in Japan and the U.S. In the U.K. it has been remaining at the same level. From these findings it appears that Japan has relatively more R&D S/E than the U.S. and other countries compared to its workers or total population. However, FTE converted figures show Japan's number of R&D S/E per 10,000 employees was slightly over 50 and that per unit population is slightly under 30.These FTE adjusted figures for R&D S/E personnel do not reach the U.S. levels.

Figure 4-1-10 (A) Number of R&D Scientists and Engineers per 10,000 Employees



Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development".
OECD, "Main Science and Technology Indicators", 1989.
See Table 4-1-10(A), Table 4-1-10(B), Table 4-1-10(D),

Figure 4-1-10 (B) Number of R&D Scientists and Engineers per 10,000 Persons



Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development".
OECD, "Main Science and Technology Indicators", 1989.
See Table 4-1-10(A), Table 4-1-10(B), Table 4-1-10(E),

4.2 Industrial R&D

4.2.1 R&D Expenditures by Industry

Intramural R&D expenditures (Note 1) by Japanese industry in FY 1989 amounted to a little more than 8.2 trillion yen, representing 70 percent of total R&D and largely exceeding the amounts spent in academia and government (source 1, the following analysis uses data made available by this source).

Figure 4-2-1 shows the trends of R&D expenditures by industry. In major industries (business categories, see Note 2) Figure 4-2-1 (A) shows the breakdown in values and Figure 4-2-1 (B) in shares. Examining recent years trends of industrial R&D expenditures as a whole indicates shows that while there was a favorably increase from the latter 1970s it slowed down after 1985 and again increased considerably in 1988 and 1989.

Industrial R&D expenditures serve as an indicator of specific to total industry trends. Examination of R&D expenditures by industry show the electric machinery industry has consistently had a large share. After 1980 in particular the share has further increased. Following in share were the chemical and transport machinery industries. These top three industries accounted for 65 percent of all industrial R&D expenditures. Moreover the share of these three industries in total R&D expenditures for Japan reached 45 percent in 1989.

Notes:
(1) Intramural R&D expenditures refer to funds spent by companies, R&D organizations or universities for personnel expenditures, raw material expenditures, for purchase of tangible fixed assets (or their depreciation) and other expenditures (source 1). They include corporate funds internally used as R&D expenditures and externally sourced funds used as R&D expenditures but do not include R&D expenditures paid outside for such things as commissioned (or joint) research.

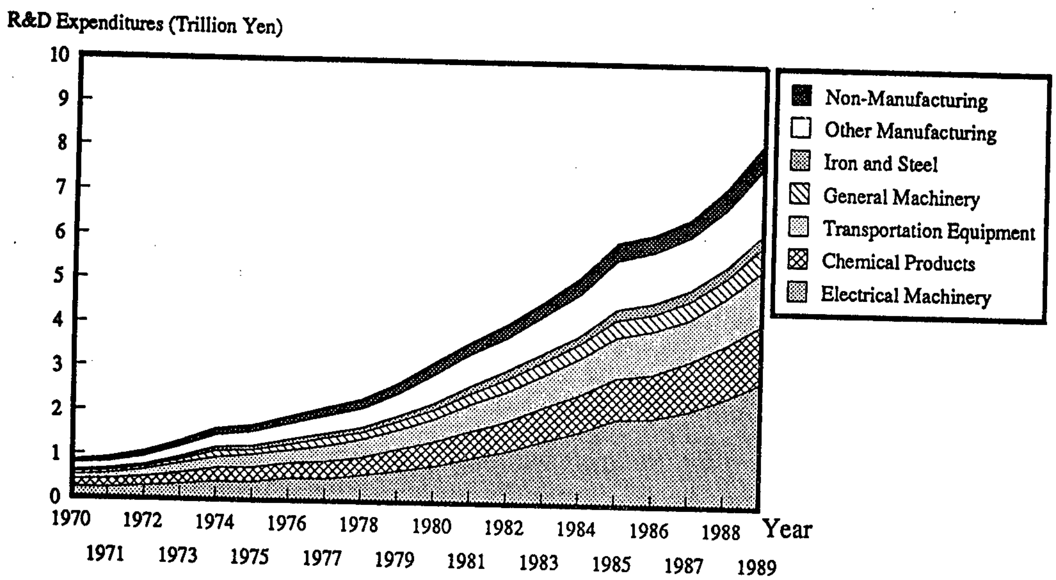
(2) Table 4-A shows the industrial (business) classification.

Table 4-A Industrial Business Classifications

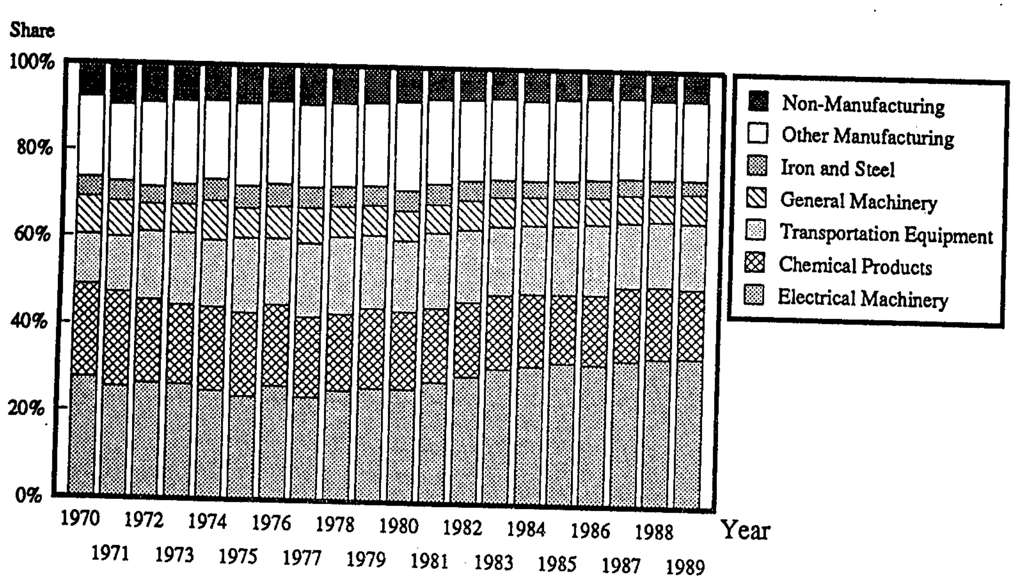
Macro	Meso	Micro
Agriculture, forestry and fisheries		
Mining		
Construction		
Manufacturing	Food	
	Textiles	
	Pulp and paper products	
	Printing and publishing	
	Chemicals	Industrial chemicals and chemical fibers
		Oils and paints
		Drugs and medicines
		Other chemicals
	Petroleum and coal products	
	Plastic products	
	Rubber products	
	Cheramics	
	Iron and steel	
	Non-ferrous metals and products	
	Fabricated metal products	
	General machinery	
	Electrical machinery	Electrical machinery, equipment and suplies
		Communication and electronics equpment
	Transport equipment	Motor vehicles
		Other transport equipment
	Precision instruments	
	Other manufacturing	
Transport, communication and public utilities		

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

Figure 4-2-1 R&D Expenditures in Industry



(A) Trends of R&D Expenditures



(B) Trends of Share

Source: Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"
See Table 4-2-1

4.2.2 Industrial R&D Expenditures by Product Area

Trends in Japanese industrial R&D can be clarified by analyzing expenditures in product area and business in addition to the expenditures by industry. In Japan analysis of R&D expenditures by business category and product area have been undertaken since 1970. The analysis is conducted using these time series data (Note 1).

(1) R&D Expenditures by Product Area

Figure 4-2-2 shows industrial R&D expenditures in 1989 by product area (Note 2). Product areas with R&D expenditures exceeding ¥100 billion are indicated. Total R&D expenditures by product area shown in this figure are ¥7.9 trillion which is around two-thirds of all R&D expenditures in Japan (¥11.8 trillion). This covered 95.6 percent of all R&D expenditures by companies, etc. (¥8.2 trillion). By product area, expenditures in the area of communications, electronics and electric equipment instruments exceeded ¥2.26 trillion (28.7 percent). This was followed by the motor vehicles ¥1.20 trillion (15.2 percent). Following these were electric machinery other than communications, electronics and electric equipment instruments (¥840.4 billion, of which electric appliances accounted for ¥496.8 billion), general machinery and equipment (¥642.5 billion), pharmaceuticals (¥566.9 billion) and organic and inorganic chemicals, chemical fertilizers and chemical fibers (¥452.5 billion).

Figure 4-2-3 examines share trends of major product areas in total R&D expenditures. R&D expenditures in the area of communications, electronics and electric equipment has not only had the largest share during the period covered, but has greatly increased its share in the 1980s (by 11 points from 1981 to 1989). It can be said that industry has been making great R&D efforts in this area. Overall R&D expenditures have also grown during this period which means that the absolute value of R&D expenditures in this area has also grown dramatically. Examining trends for other areas in the 1980s shows that although there have been some fluctuations, the share of R&D expenditures in the areas of motor vehicles, electric machinery and equipment, general machinery and equipment and pharmaceuticals has remained on the same level.

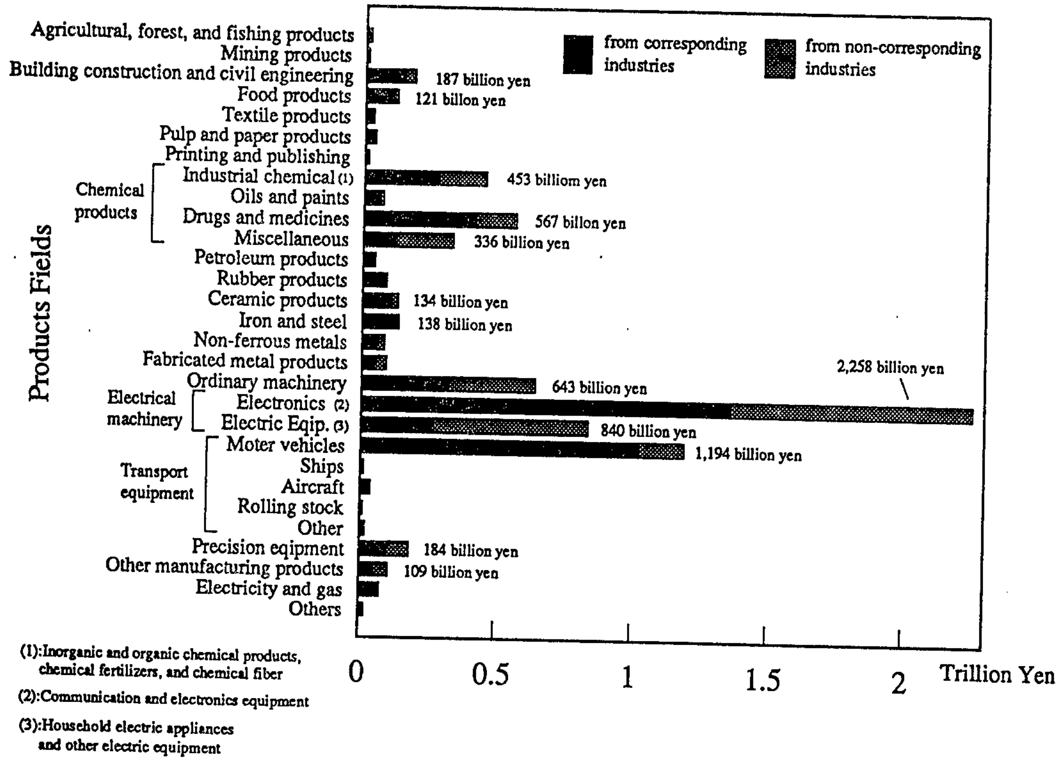
The marked growth of the share of the communications, electronics and electric equipment area in the recent decade or so needs to be examined in more detail. The growth has not been because of a decline in the share of a specific or a small number of other product areas but because of decline of the shares of many other areas (including the "other" product area in Figure 4-2-3). Also, as will be shown, examination of R&D expenditures into this product area and the ratio of such expenditures shows that the ratio of expenditures has been declining. Hence the marked growth its share is more ascribable to a contribution by the communications, electronics and electric equipment industry itself rather than by other industries. These show that R&D in Japanese industry is centered in electronics.

Notes:
(1) This analysis uses the Management & Coordination Agency study section on "In-House R&D Expenditures by Industry and Product Area" covering firms capitalized at over ¥100 million.

There are some problems in classifying these expenditures as basic research which by definition is conducted "without directly giving consideration to specific application or use" by product area. However, although the share of basic research expenditures by firms has been increasing in the recent years, expenditures on applied and development research still accounts for over 93 percent (see Chapter 4, Section 4.1.3). Given this situation the error is believed to be small.

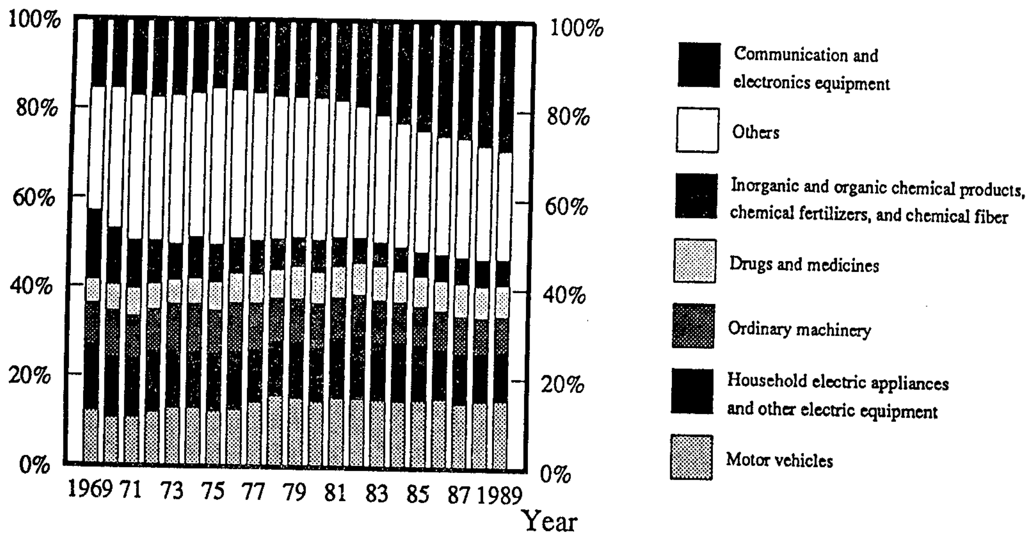
For reference examination is on the Management & Coordination Agency study "In-House R&D Expenditures by Industry and Product Area." The companies (entities) surveyed, were asked to report intramural R&D expenditures (regardless of whether the fund was their own or externally sourced) by "Classification by Product Area." Total R&D expenditures by product area were assumed to coincide with total R&D expenditures by the company. When the funds could not be classified by product area companies were asked to report the value by calculating it using a rational proportional method such as by taking account of the number of R&D S/E.

Figure 4-2-2 R&D Expenditures by Product Area (FY 1989)



Source: Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"
See Table 4-2-2

Figure 4-2-3 Share Trends of R&D Expenditures by Major Product Areas



Source: Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development" See Table 4-2-3

(2) The study's statistical table provides 31 product areas. This analysis (Figure 4-2-2) has reclassified them into 29 for correspondence to business categories. Hence the chemical fertilizers and organic and inorganic chemical industry products and chemical fibers were combined into "chemical and other products" and electric home products and other electric machinery and equipment into "electric machinery and equipment."

(2) Trends of Penetration from other Businesses

This section analyzes R&D expenditures from the aspects of business category and product area. Figure 4-2-2 shows R&D expenditures in the product areas by classifying them by businesses for which the product area is the core business and entrants as coming from other businesses (Note). The ratio of R&D expenditures in the product areas by entrants from other businesses is called penetration ratio and its value penetration value.

Marked with the largest penetration value is communications, electronics and electric equipment. Of the total R&D expenditures in this area of ¥2.258 trillion around 60 percent or ¥1.366 trillion was spent by the communications, electronics and electric equipment industry for which the area was core business. The remaining ¥892.1 billion was spent by entrants from other businesses. It can hence be seen that the reason for the great R&D expenditures in this area is not only because of the expenditures by this industry marked with a large industrial scale but because of large expenditures by other businesses. However ¥387.8 billion of the penetration value of ¥892.1 billion was spent by the electric machinery and equipment industry belonging to the same meso classification (electric machinery industry). The penetration value less this amount was ¥504.2 billion. Further breaking down shows that ¥227.9 billion was spent by the transport, communications and public utility industry which is closely associated with this product area. The rest was made up of expenditures amounting to ¥55 billion by machinery, ¥45.7 billion by the precision machinery, ¥35.1 billion by the steel, ¥35.8 billion by the ceramics and ¥34.3 billion by the chemical industry.

The product area marked with the next largest penetration value was that of electric machinery and equipment. The penetration value was ¥576 billion and the penetration ratio 68.5 percent. Of this amount ¥384.9 billion was entry from the technologically close communications, electronics and electric equipment industry. The penetration value from industries other than electric machinery was ¥191.1 billion.

If these two electric machinery areas are combined into one area (R&D expenditures of ¥3.1 trillion) the total penetration value from industries other than electric machinery comes ¥695.3 billion and the penetration ratio 22.4 percent. This shows the great mutual entry by the communications, electronics and electric equipment and the electric machinery and equipment industries.

Other product areas marked with large penetration values were general machinery and equipment, chemicals and motor vehicles. The penetration value in the case of general machinery and equipment was ¥325.5 billion. Entry was large from the transport machinery industry excluding automobile (¥107.5 billion).

The chemical product areas marked with large penetration values were chemical and other products (¥175.9 billion), pharmaceuticals (¥152 billion) and other chemicals (¥216.8 billion). When these three areas are combined into one product area (chemicals) by adding oils and fats and paints the R&D expenditures comes to ¥1.4292 trillion of which 21.4 percent or ¥305.2 billion was entry from industries other than chemicals. Large entries to the chemicals area were from the plastic products (¥67.7 billion), foodstuffs (¥63.9 billion), ceramics (¥37.3 billion) and petroleum and coal (¥24.1 billion) industries.

The motor vehicle area penetration value was ¥166.1 billion. Large entries were from the electric machinery (¥97.2 billion) and machinery (¥27.7) industries. Although this area is marked with a large penetration value it is small compared to its R&D expenditures (penetration ratio of 13.9 percent). Hence it can be seen that the area has highly been intensified.

Note:
The Management & Coordination Agency study does not divide R&D expenditures by penetrated, corresponding or non-core business. Also, in it there is no one-to-one correspondence between product areas and business categories. Hence the R&D expenditures in the five product areas of ships, aircraft, railway vehicles, other transport machinery and electricity and gas were not categorized based on the belief that there were no suitable business categories for which these product areas comprised core business.

(3) R&D in Non-Core Businesses

The Management & Coordination Agency's "In-House R&D Expenditures by Industry and Product Area" totals R&D expenditures in the form of a matrix of industries and product areas. Therefore, classifying R&D expenditures by product area by industry provides a view of penetration levels from other industries. Also, classifying R&D expenditures by industry into product areas indicates industrial trends. Moreover, since the study has accumulated data covering a period of around 20 years it makes available precious data for analyzing the dynamics of R&D in industry. In fact detailed quantitative studies have been conducted using these data (Note 1, references 9, 10).

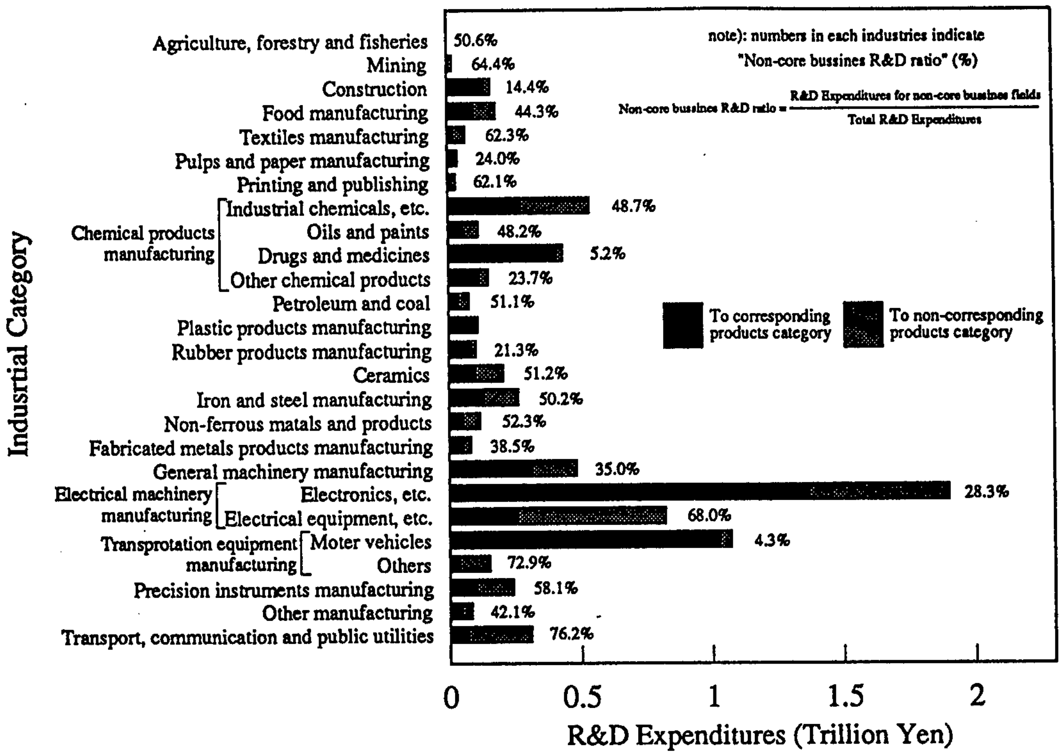
This section examines R&D trends by using the ratio of R&D expenditures in non-core businesses as an indicator of industrial diversification. The non-core business ratio of R&D expenditures refers to the ratio of R&D expenditures in non-core businesses to total R&D expenditures by the given industry. It is the opposite measurement of the foregoing penetrated ratio of R&D expenditures by product area (Note 2).

Figure 4-2-4 shows R&D expenditures by business category by dividing it into that spent on core business and non-core business products as well as the non-core business ratio (Note 3). In terms of meso classification, the business categories with particularly large R&D expenditures were the electric machinery, chemical and transport machinery industries in this order. The order coincides with that of the businesses with low non-core business ratios (electric machinery 8.3 percent, chemical 10.2 percent and transport machinery 11.3 percent). In terms of R&D, these three businesses can be said to be supporting Japan's manufacturing industry. They are all marked with large R&D expenditures and are also directing much of such expenditures to their core business.

Trends of business categories are examined by separating the three businesses based on micro classification and analyzing R&D expenditures by product area. The non-core business ratio for the electric machinery industry as one category was 8.3 percent. However, when it is divided into the communications, electronics and electric equipment business and electric machinery and equipment business the values increase to 28.3 percent and 68.0 percent, respectively. This shows frequent mutual entry within the electric machinery industry. In fact, around 90 percent of the R&D expenditures by the communications, electronics and electric equipment business in non-core businesses was in the electric machinery and equipment business. Likewise, the electric machinery and equipment business spent ¥387.8 billion in R&D in the area of communications, electronics and electric equipment which was greater than its core business R&D expenditures of ¥264.5 billion.

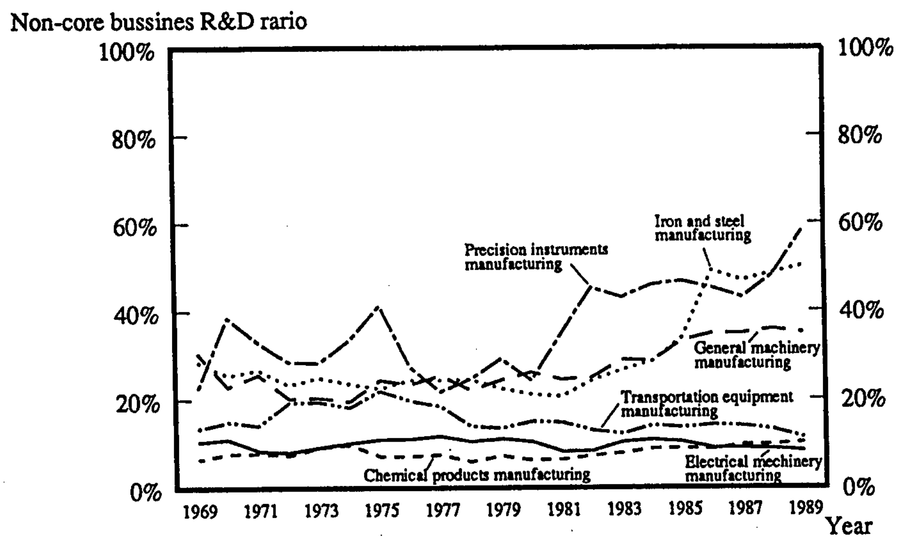
The chemical industry is made up of the pharmaceutical, chemical and chemical fibers, oils and fats and paints and other chemical industries. In the pharmaceutical industry most of the R&D expenditures went to its core business (¥414.9 billion, 94.8 percent) hence its non-core business ratio was very low. In the chemical and chemical fibers industry ¥276.8 billion (51.3 percent) of R&D expenditures went to the core business and ¥175.1 billion (32.5 percent) to other chemical industry. Outside the chemical industry a large portion of expenditures (¥29.1 billion, 5.4 percent) went to the communications, electronics and electric equipment industry. In the oils and fats and paints industry ¥61.7 billion (51.8 percent) went to the core business and ¥44.9 billion (37.8 percent) to other chemical industries. In the other chemical industry ¥118.8 billion (76.3 percent) went to the core business and ¥8.9 billion (5.7 percent) to general machinery and equipment and ¥7.9 billion (5.1 percent) to electric machinery and equipment. It can be seen that

Figure 4-2-4 R&D Expenditures and Non-Core Business Ratios by Industrial Category



Source: Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"
See Table 4-2-4

Figure 4-2-5 Trends of Major Industrial Non-Core Business Ratios



Source: Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"
See Table 4-2-5

although these businesses all belong to the chemical industry they exhibit different characteristics in terms of non-core business expenditures.

In the transport machinery industry the motor vehicles industry invested mostly in its core business area (¥1.281 trillion, 95.7 percent). Investment in other areas was very small such as ¥28.1 billion (1.9 percent) in the area of transport machinery other than autos and ¥16 billion (1.5 percent) in that of general machinery, both of which are relatively closely related. The other transport machinery industry sees more R&D spent in the area of general machinery than in its core business area.

In other industries, the machinery industry's core business ratio was large at 65.0 percent. The machinery industry spent more on communications, electronics and electric equipment (11.3 percent) than on precision industry products (5.9 percent) or motor vehicles (5.7 percent) which are believed to be relatively close. This is believed to be a succinct example of "technological fusion" (reference 11). The steel industry's core business ratio was 49.8 percent. It spent more on communications, electronics and electric equipment (13.2 percent) than on metal products (6.3 percent), nonferrous metals (3.4 percent) or general machinery and equipment (8.7 percent) which are believed closer to its core business. The precision machinery industry's core business ratio was 41.9 percent. It made large R&D expenditures in such areas as general machinery and equipment (29.1 percent) and communications, electronics and electric equipment (18.7 percent). These are also believed to reflect technological fusion.

Figure 4-2-5 shows trends of major business category non-core business ratios. The electric machinery industry and chemical industry's non-core business ratios have always been low during the period covered hence they have consistently poured energy into core business R&D. The transport machinery industry's non-core business ratio increased until 1975 but has subsequently decreased stabilizing to a low level in recent years. The machinery industry non-core business ratio has gradually been rising since the mid 1970s while the ratio for the steel industry has markedly increased in the 1980s. The precision machinery industry has greatly fluctuated but has not gone below 40 percent after 1982 and has markedly increased in 1988 and 1989.

Notes:

(1) Reference 1 is a representative analysis conducted which applies data on which this indicator is based. The non-core business ratio could also be based on sales instead of R&D expenditures. Reference 12 uses sales-based non-core business ratios.

(2) The industries marked with large non-core business R&D expenditures ratios can generally be said as those whose R&D expenditures have diversified. However, since it is not possible to tell if such expenditures are concentrated in a small number of product areas or dispersed, the indicator is insufficient in representing diversification. The ratio of entry from other businesses ("penetrated ratio") is also insufficient as it lacks the information on the distribution of the entering businesses.

(3) As per the Management & Coordination Agency report, the analysis has used the meso classification of business categories. However the chemical, electric machinery and transport machinery industries were subdivided into micro classifications. Dividing the R&D expenditures into that in the core and non-core businesses involves some arbitrariness because there was no perfect correspondence between product areas and business categories. R&D expenditures by the plastic products industry and the transport, communications and public utilities businesses was not categorized as it was believed that they did not properly correspond to core business product areas.

4.2.3 Number of Industrial R&D Scientists and Engineers

It was in 1971 that the number of R&D S/E in the manufacturing industry topped 100,000 (Figure 4-2-6). The number (excluding those specializing in the humanities and social sciences) of around 40,000 in 1960 expanded 2.5 times during the decade. It then tripled to 300,000 in the 20 years from 1971 to 1990. The oil crises occurred during the 1970s and 1980s and many of the manufacturing businesses in particular gave up hiring college graduates at that time. However the number of R&D S/E has consistently increased since then. This shows the tendency for the manufacturing businesses to emphasize R&D. This section examines R&D in industries from the angle of R&D S/E. It will examine the trends of industrial R&D S/E using Management & Coordination Agency statistics (source 1). That study however does not include the humanities and social sciences as areas of specialization of industrial R&D S/E until 1969. Hence the analysis will use the statistics dated after 1970.

(1) Number of R&D S/E by Industrial Category

The number of R&D S/E in manufacturing grew 3.3 times during the 20 years from 1970 to 1990. The greatest increase was by around 50,000 during the five years from 1970 to 1975 and from 1985 to 1990. During the five years from 1975 to 1980 the increase was slightly smaller by around 30,000 (Figure 4-2-6). By examining the number of R&D S/E by business category it becomes possible to better understand the R&D activities in the Japanese manufacturing industry.

By industry, in 1970 13 percent of all R&D S/E were engaged in the chemical and chemical fibers, 12 percent in the electric machinery and equipment and 17 percent in the communications, electronics and electric equipment (Note). Subsequently there has not been marked increase in the number of R&D S/E engaged in the chemical and chemical fibers industry even in actual number thus their share in the total number of R&D S/E has declined to 6 percent in 1990. Similarly, although the actual number of R&D S/E engaged in the electric machinery and equipment industry has tripled in the last 20 years their share (11 percent) has somewhat declined compared to 20 years ago. Markedly increasing both the actual number and share of R&D S/E has been the communications, electronics and electric equipment industry. The actual number has increased by a factor of six during the twenty year period and the share from 17 percent in 1970 to 28 percent. It is clear that this industry has drastically been increasing the number of R&D S/E in Japanese manufacturing. A similar tendency can also be seen regarding R&D expenditures and can be said to show the characteristic of R&D in Japan to focus on electronics.

On the other hand, the share of the R&D S/E engaged in the motor vehicles industry has been growing from 5 percent in 1970 to 8 percent in 1990. The growth however has been small. The actual number of R&D S/E however has grown by a factor of five in the past 20 years. The number in 1990 was around 25 percent of that in the communications, electronics and electric equipment industry.

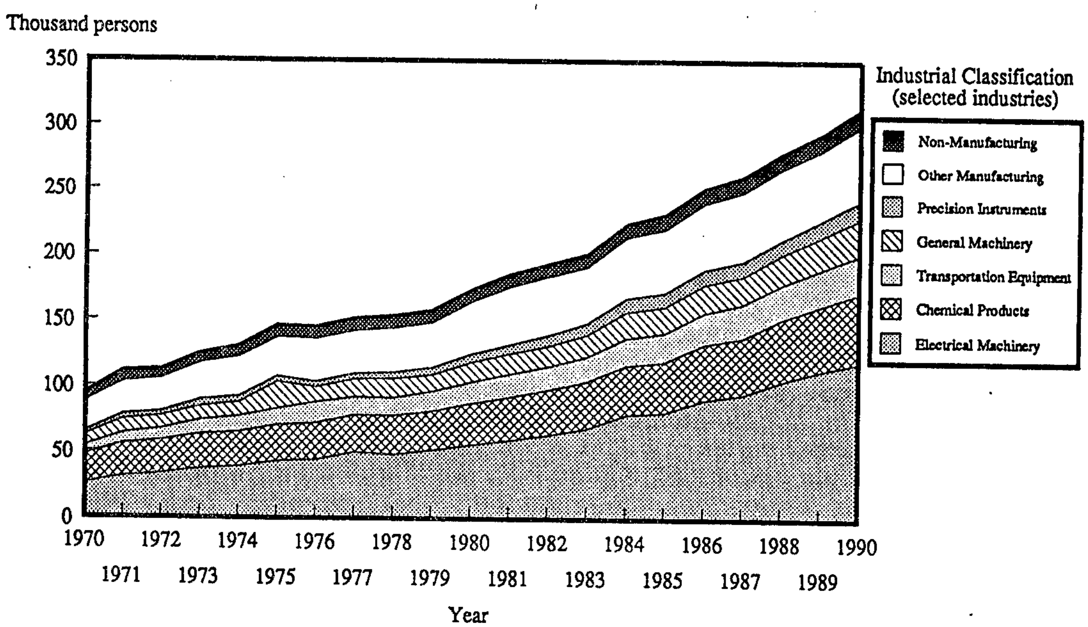
In the last 20 years the number of R&D S/E in the pharmaceutical and precision machinery industries has slightly increased. However their shares have been very small compared to the communications, electronics and electric equipment industry.

Note:
The analysis uses the micro industrial classifications. Figure 4-2-6 however uses the meso classification to avoid complications.

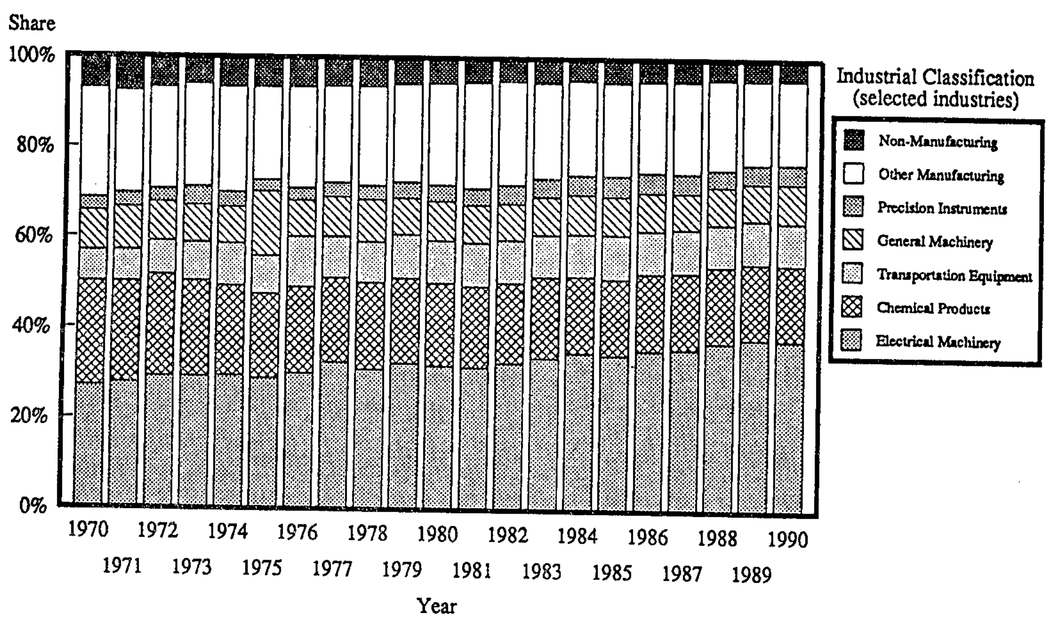
(2) Number of R&D S/E by Specialization

Examining the share of R&D S/E by specialty shows engineering with the greatest share, 61 percent, in 1990 followed by science with 27 percent. Among natural sciences the share of those specializing in agriculture and health was only around 3 percent each and that of humanities and social sciences 1 percent (Figure 4-2-7). Therefore the overwhelming number of R&D S/E specialized in engineering or the sciences. The R&D S/E area of specialization in the manufacturing industry is often determined by student field of study choice in college or graduate school. Since in Japan many of the students of science departments are engineering students it is natural for the number of R&D S/E specializing in engineering to increase.

Figure 4-2-6 Trends of Number of Industrial R&D S/E (by industry)



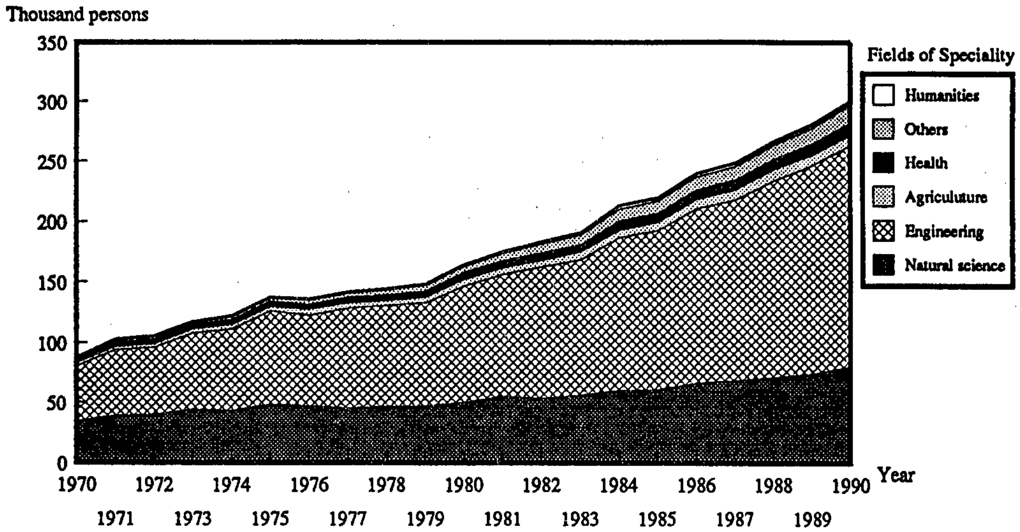
(A) Trends of Number of R&D Scientists and Engineers



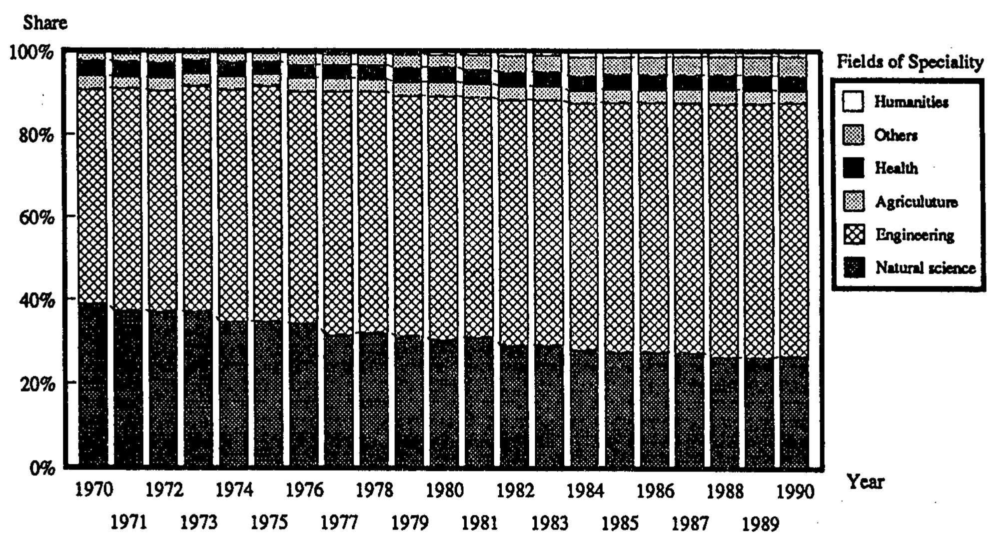
(B) Trends of Share

Source: Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"
See Table 4-2-6

Figure 4-2-7 Trends of Number of Industrial R&D S/E (by specialization)



(A) Trends of Number of R&D Scientists and Engineers



(B) Trends of Share

Source: Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"
See Table 4-2-7

4.2.4 R&D in Research-Intensive Industries

The U.S. Commerce Department and the OECD for example define research-intensive industries or products as those with R&D expenditures per sales of over 2.5 percent, those with the number of R&D S/E per total employees of over a certain level or specific industries or products such as the aircraft industry (references 1, 4, 5). Japan does not seem to use such a definition. However the index of intensity of how much R&D expenditures or research personnel are being placed per industry is important. Hence the analysis has used ratios for R&D expenditures per sales and R&D S/E per 10,000 employees as indicators of R&D intensity.

Calculating the R&D expenditures per sales and industry shows the average for all industries was 2.72 percent. It was 3.29 percent in the case of the manufacturing. If the indicator is indicative of R&D intensity the research intensity of the manufacturing industry from the viewpoint of R&D expenditures was 1.21 times the industry average. The number of R&D S/E per 10,000 employees was 476 for all industries and 577 for manufacturing. Manufacturing research intensity from the viewpoint of personnel was 1.21 times the industrial average which is the same as when looked at from R&D expenditures.

Figure 4-2-8 shows manufacturing research intensity over time. It shows that while R&D expenditures ratios to sales more or less remained at the same level in the 1970s it grew significantly in the 1980s. The number nearly doubled (1.87 times) during the ten years from 1981 to 1990. In contrast, unlike the case of R&D expenditures the ratio of R&D S/E to 10,000 employees more or less increased at a fixed rate during the same period. It has grown 2.73 times during the 20 years from 1971 to 1990 and by 1.65 times during the 10 years from 1981 to 1990. These tendencies can be said to show the fact that the manufacturing industry has steadily been intensifying its R&D.

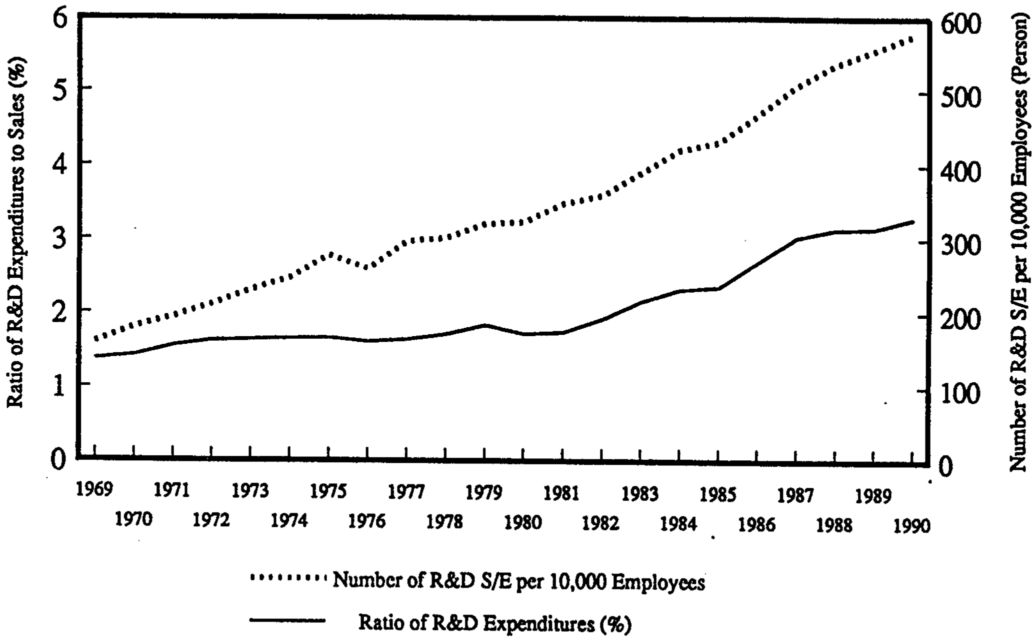
Figure 4-2-9 shows research intensity by industry. Manifesting the greatest R&D expenditures intensity is the pharmaceutical industry (7.50 percent). This industry is said to require large investments in the testing process mainly related to safety in the product development process. The findings succinctly corroborate this. Following in R&D expenditures intensity are the communications, electronics and electric equipment (6.10 percent), electric machinery and equipment (5.47 percent) and precision machinery (5.16 percent) industries. It can be seen that the R&D expenditures intensity is great among high-tech industries which spend greatly in software development. Following these were chemical industries such as other chemical (4.11 percent), chemical and chemical fibers (4.09 percent) and oils and fats and paints (3.93 percent). While the automobile industry's intensity exceeded the total manufacturing industry average it was only 3.48 percent.

In terms of the number of R&D S/E per 10,000 employees and industry, manifesting high intensities are the oils, fats and paints (1,172), other chemical (1,088), communications, electronics and electric equipment (1,094) and chemical and chemical fibers (938) industries. This was considerably different from the order of intensity based on R&D expenditures. Many of the industries with high employee-researcher ratios were those related to chemistry and are believed to be process industries.

The relationship between R&D expenditures ratio to sales and of R&D S/E to employees is more or less proportional except for the preceding top ranking industries. Hence, there is a tendency for industries with high sales-R&D expenditures ratio to also manifest high employees-R&D S/E ratios.

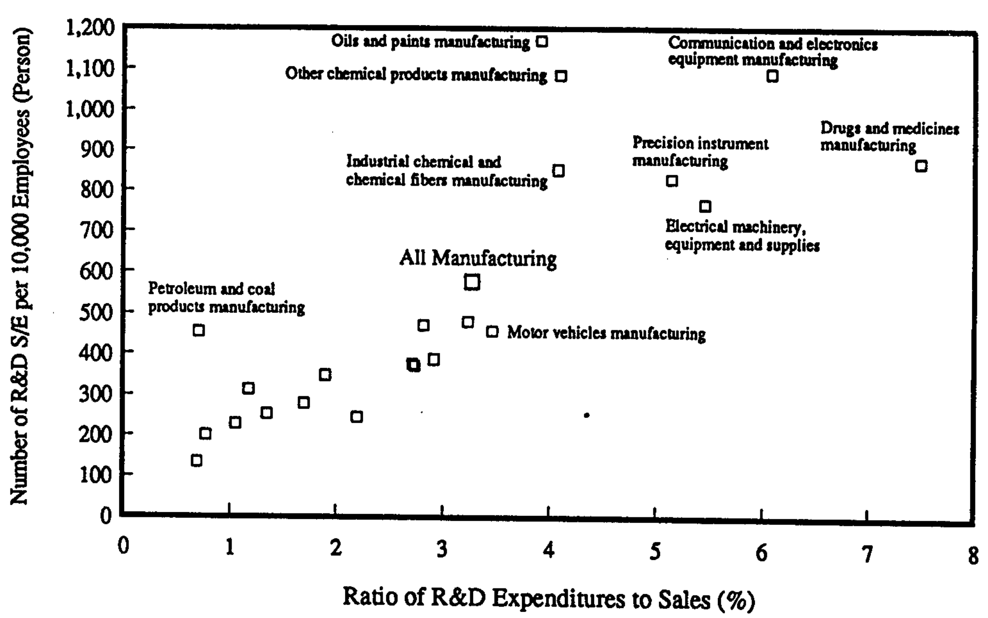
Examination of research intensity by scale of capital shows that in general, the greater the capital scale the greater the sales to R&D expenditures ratio and employee-researcher ratio. However these ratios of firms with the smallest capital scales (¥5 million to under ¥10 million) were greater than those of the firms above them by one rank (¥10 million to ¥100 million). This suggests that these are research-centered firms or research-intensive firms.

Figure 4-2-8 Trends of Research Intensity



Source: Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"
See Table 4-2-8 and Table 4-2-9

Figure 4-2-9 Research Intensity by Industry



Source: Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"
See Table 4-2-8 and Table 4-2-9

4.2.5 Number of Industrial R&D Laboratories

In the recent years Japanese firms are actively establishing laboratories. This trend is referred to as the "second laboratory boom." In the high growth period there was a "central laboratory boom" and the recent trend is said a "basic laboratory boom" (references 13, 14). There are many reasons for establishing laboratories which reflect the firms' response to R&D progress. Therefore the number of laboratories can be seen as an indicator to complement the R&D expenditures and number of R&D S/E which are representative infrastructure indicators.

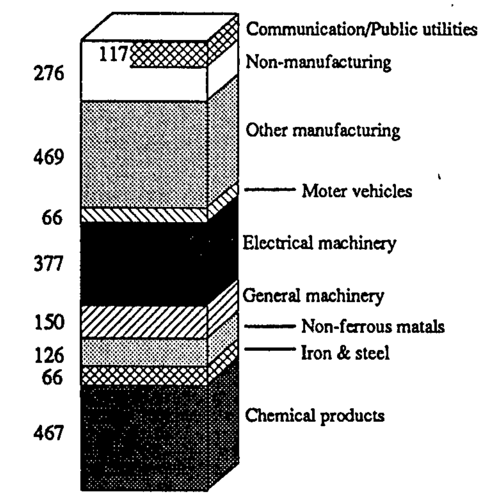
The Japan Economic Journal Inc. (*Nihon Keizai Shimbun*) has followed Japanese firms' laboratories by industry and research area (Note, source 9). The analysis has selected and analyzed 470 manufacturers for this study. Figure 4-2-10 (A) shows the number of laboratories by industry in Japan. The chemical and electric machinery industries have a large proportion of laboratories.

Many firms belonged to these industries. The number of laboratories per firm was obtained by dividing the number of laboratories by the number of firms (Figure 4-2-10 (B)). Public utilities businesses namely communications and gas had many laboratories. For manufacturing, chemicals, steel, shipbuilding, fibers and other exceeded the average for all industries.

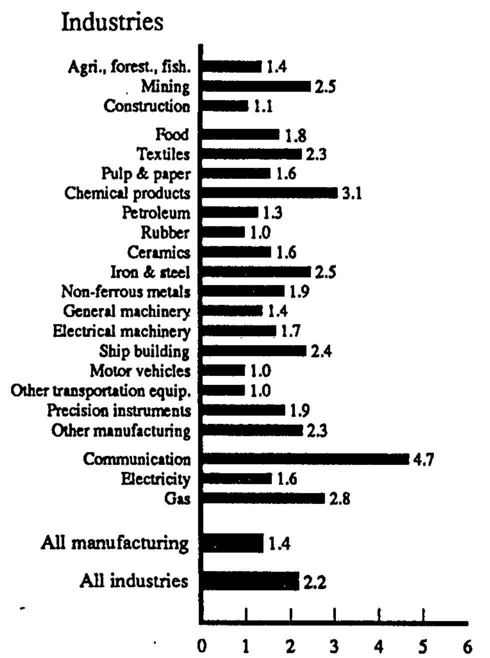
Figure 4-2-10 (C) shows the number of laboratories by research area. The areas of chemicals and electricity and electronics had many laboratories. These were followed by biotechnology.

Note: The analysis was conducted by the National Institute of Science and Technology Policy (NISTEP) using source 9. The business categories were different from the ones used in the Management & Coordination Agency study.

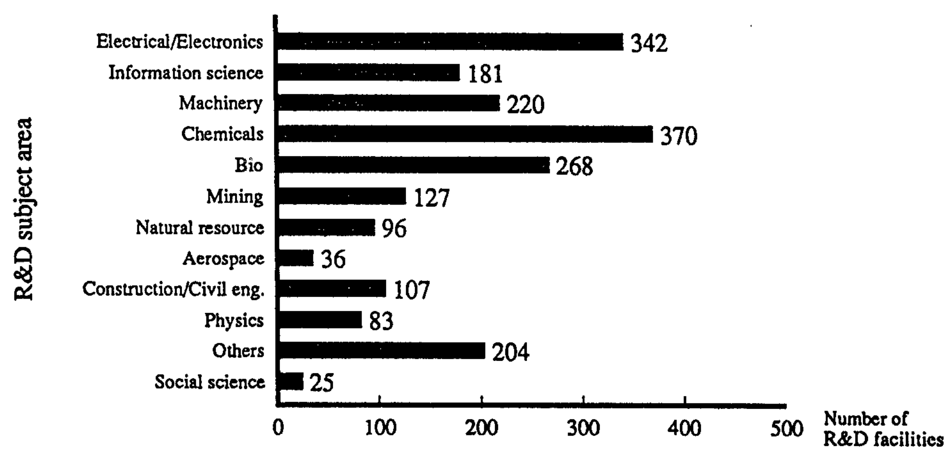
Figure 4-2-10 Number of Industrial R&D Laboratories



(A) Number of R&D Laboratories by Industry



(B) Number of R&D Laboratories per Enterprise



(C) Number of R&D Laboratories by Subject Area

Source: Nihon Keizai Shinbun Inc., "NIKKEI Company Information", 1990
See Table 4-2-10

4.3 R&D in Academia

4.3.1 R&D Expenditures at Universities

R&D expenditures at universities (Note 1) can be divided into ordinary/standard expenditures, paid depending on the content and necessity of research, and specific project-oriented expenditures. Expenditures for developing research facilities and equipment also has a large share of the total.

These ordinary R&D expenditures are designed to develop the foundation for R&D S/E to freely conduct research. At national universities it includes personnel and instructor expenditures and their research and traveling expenditures. In the case of private universities, the national government subsidizes the personnel and other educational and research activity expenditures in general.

Special R&D expenditures also include miscellaneous expenditures. One of these is based on the Ministry of Education's scientific research grants designed to markedly develop excellent academic research and to contribute toward promotion of learning in Japan. They are granted to research voluntarily planned by university R&D S/E or researcher groups deemed especially important in view of the academic trends in Japan.This is expected to produce high level research results.

Examining R&D expenditures trends in universities by type of institution (Note 2, Figure 4-3-1) shows the amount for private universities has grown more than that of national universities after 1974. If the 1970 figures are converted to 100 the indices for 1980 were national universities 332, public universities 267 and private universities 420. Those for 1989 were: national 502, public 451 and private 691. One of the reasons for the low growth of the expenditures for national universities is believed to be due to the tightening of the national finances due to the recession triggered by the first oil crisis. In 1989 total university expenditures are broken down as follows; national ¥899.2 billion, public ¥114.3 and private ¥1.1158 trillion. Private universities have had a large share of the expenditures.

Figure 4-3-2 shows R&D expenditures for universities by academic field. Conspicuous has been a leveling off of the expenditures in agriculture. 1970 figures converted to indices of 100 base for 1980 were science 426, engineering 360, agriculture 309, health 402, all natural sciences 379 and humanities and others 348. Those for 1989 were science 728, engineering 576, agriculture 435, health 638, all natural sciences 603 and humanities and other 551. It can be seen that R&D expenditures in scientific areas has drastically increased during this period.

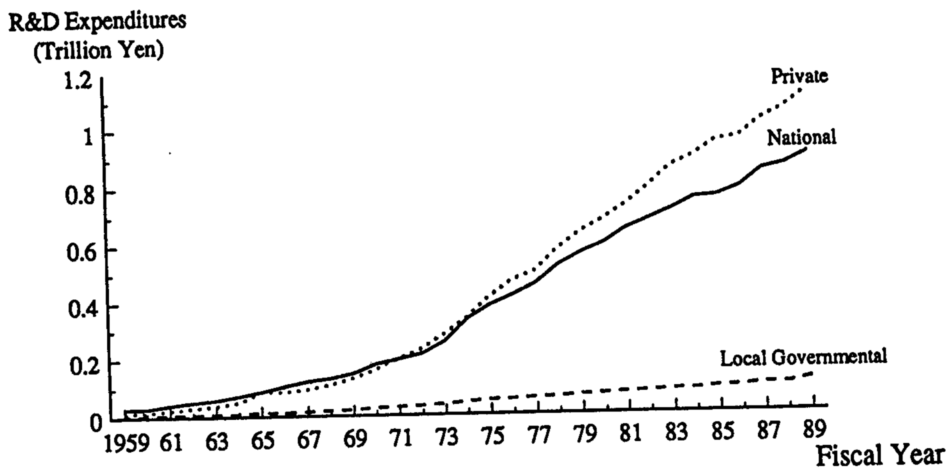
By academic field, R&D expenditures were science ¥187 billion, engineering ¥481.8 billion, agriculture ¥99.8 billion, health ¥543 billion, all natural sciences ¥1.3116 trillion and humanities and other ¥817.7. Hence R&D expenditures in agriculture for in 1989 particularly small.

Notes:

(1) Universities as defined in the Management & Coordination Agency report include colleges, junior colleges, technical colleges, university laboratories, inter-university research institutes and others.

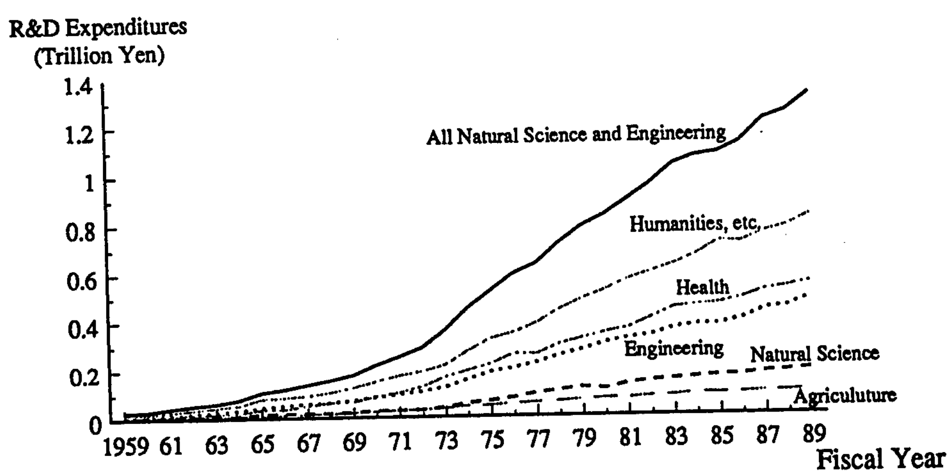
(2) R&D expenditures at universities are those for personnel, raw materials, and for purchase of tangible fixed assets.

Figure 4-3-1 Trends of R&D Expenditures by Universities (by type of institution)



Source: Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"
See Table 4-3-1

Figure 4-3-2 Trends of R&D expenditures by Universities (by academic field)



Source: Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"
See Table 4-3-1

4.3.2 Number of University R&D S/E

In 1990 university R&D S/E numbered 205,509. These included those enrolled in doctorates courses and medical staff in addition to instructors. The greatest number of R&D S/E were instructors accounting for 71.2 percent or 146,456. 28,203 (13.7 percent) were enrolled in doctorates courses and 30,850 (15.0 percent) were medical staff.

Figure 4-3-3 shows trends of the number of R&D S/E by type of institution. The number at national and private universities has increased at more or less identical and firm rates. At one time however (from 1978 to 1984) the number at national universities exceeded that of private schools. The number at public universities rapidly increased in 1973 and has remained on the same level since.

By academic field (Figure 4-3-4) the greatest number of R&D S/E were natural scientists (134,133, accounting for 65.5 percent). The social sciences and humanities accounted for 71,376 or 34.7 percent. The ratio between natural scientists and social sciences and humanities was around 2 to 1. Over time, in 1961 the natural-social science ratio was 48.4 to 51.6 hence R&D S/E in social sciences and humanities were more numerous. However the next year the ratio reversed to 54.1 to 45.9 and the ratio of natural scientists has gradually increased since. For example, in 1973 the ratio drastically increased from 56.5 percent to 60.1 percent. This was the year in which the total number of R&D S/E drastically increased. It can be seen that the increase was ascribable to increase of natural scientists.

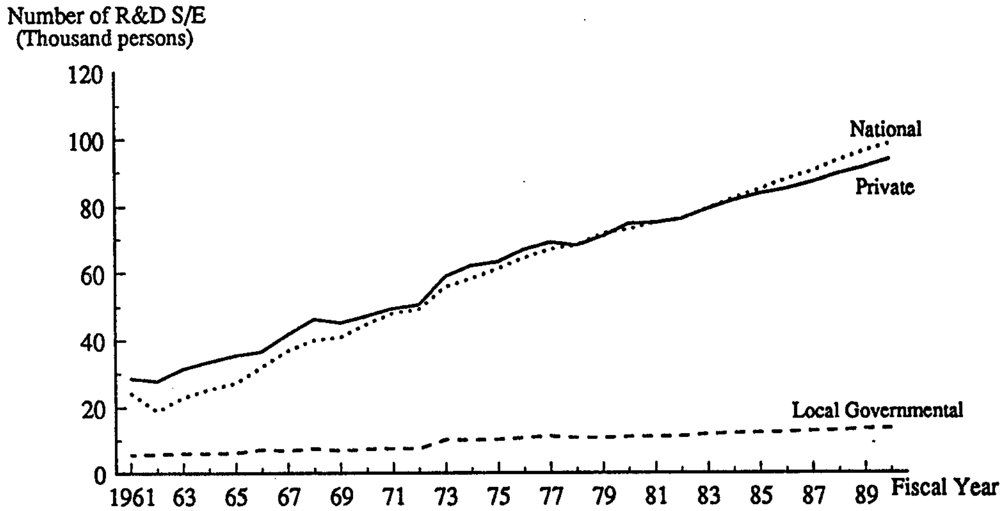
The natural sciences are made up of science, engineering, agriculture and health. Most numerous were health R&D S/E numbering 80,547 and accounting for 39.2 percent of all R&D S/E. They have increased by 6.0 percent in the last 15 years. Following were engineering R&D S/E totaling 33,279 and accounting for 16.2 percent of all R&D S/E. They have increased by 2.2 percent during the last 15 years which is small compared to R&D S/E in health. Science R&D S/E numbered 12,528 (6.1 percent) and agriculture 7,779 (3.8 percent) for an increase of 3.4 percent and 1.1 percent. Recent trends in the number of natural science R&D S/E show that the health R&D S/E not only have had a large share but have increased at a high rate. Also, while the share for science R&D S/E has been small the rate of increase has exceeded that of health related R&D S/E.

4.3.3 R&D Expenditures per University R&D S/E

R&D expenditures per university R&D S/E is an indicator of the quantitative relationship between R&D expenditures and the number of R&D S/E. Figure 4-3-5 examines this trend by kind of institution. After 1971 the growth of expenditures by private universities exceeded that at national universities. With 1970 figures indexed at 100 the 1980 indices were national 219, public 184 and private 270. In 1989 the indices had grown to national 265, public 252 and private 338. The expenditures in 1989 were national ¥9.59 million, public ¥8.52 million and private ¥11.35 million. Private universities are focusing their expenditures mostly per researcher. Before 1970 national universities spent the most. In 1971 the situation drastically reversed and ever since private universities have consistently been spending proportionately the most.

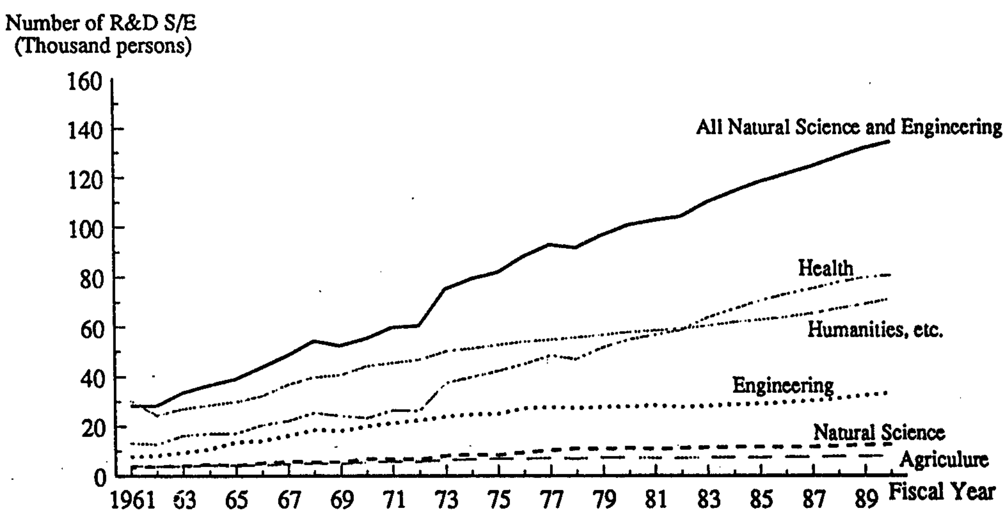
Figure 4-3-6 shows trends of R&D expenditures per university researcher by academic field. Conspicuous has been leveling off of expenditures in the area of health. If the 1970 figures are converted to 100, indices for 1980 were science 267, engineering 269, agriculture 250, health 186, all natural sciences 221 and humanities and others 271. In 1989 the indices were science 388, engineering 365, agriculture 320, health 208 and all natural sciences 269. It can be seen that the expenditures in the science areas have drastically expanded during this period. In total amounts, expenditures in 1989 were science ¥14.93 million, engineering ¥14.48 million, agriculture ¥12.83 million, health ¥6.74 million and all natural sciences ¥9.78 million. It can be seen that the expenditures in health has been small.

Figure 4-3-3 Trends of Number of University R&D S/E (by type of institution)



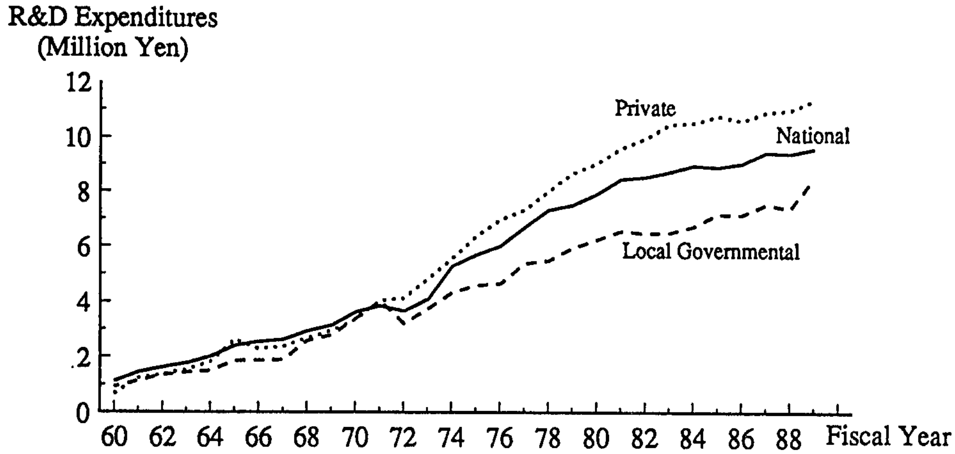
Source: Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"
See Table 4-3-2

Figure 4-3-4 Trends of Number of University R&D S/E (by academic field)



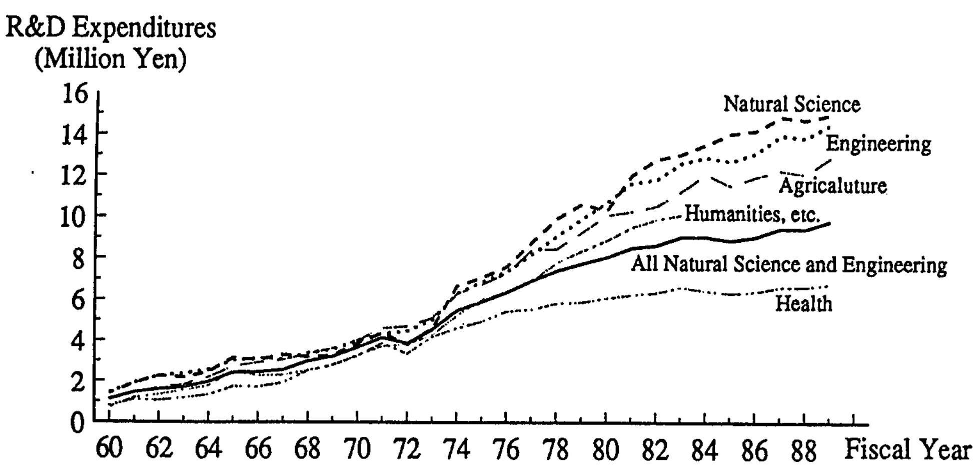
Source: Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"
See Table 4-3-2

Figure 4-3-5 Trends of R&D Expenditures per University Researcher (by type of institution)



Source: Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"
See Table 4-3-3

Figure 4-3-6 Trends of R&D expenditures per University Researcher (by academic field)



Source: Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"
See Table 4-3-3

As mentioned university R&D S/E are made up of instructors, those enrolled in doctorate courses and medical staff. Comparing these by kind of institution (national, public and private) shows that many of the national university R&D S/E belong to doctorate courses, many of public university R&D S/E are medical staff and many of private university R&D S/E are instructors and few enrolled in doctorate courses. When comparing the R&D expenditures per researcher it will be necessary to take these factors related to the composition of R&D S/E into account.

4.3.4 Number of University R&D Laboratories

This analysis has used the department as the unit of the university research organization. This is the same as with the Management & Coordination Agency report. According to the said report, in 1990 (source 1) the number of university and other departments totaled 2,187. 1,231 or 56.2 percent of these were university departments. This was followed by junior college departments (588, 26.8 percent). University laboratories numbered 191 or 8.7 percent and others 177 or 8.1 percent.

By kind of institution national universities had 647 or 29.5 percent of all university departments. Public universities had 151 (6.9 percent) and private universities 1,389 (63.5 percent). Hence private universities had the greatest number of departments.

By academic field humanities and social science departments were the most numerous at 890 (40.6 percent). The breakdown was literature 314 (14.3 percent), law 98 (4.4 percent), economics 321 (14.6 percent) and other 157 (7.1 percent). There are more or less equal numbers of economics and literature departments. Second numerous were natural science departments (752, 34.3 percent). The breakdown was science 102 (4.6 percent), engineering 318 (14.5 percent), agriculture 75 (3.4 percent) and health 257 (11.7 percent). Engineering departments were the most numerous among natural science departments. Among other departments (545, 24.9 percent) home economics departments numbered 208 (9.5 percent), educational 178 (8.1 percent) and other 159 (7.3 percent).

A total of 538,554 persons belonged to these departments. By kind of institution 441,880 or 82.0 percent belonged to university departments. When compared with the ratio of university departments (56.2 percent) this shows the large size of university departments. Next in number were those belonging to junior colleges (66,125, 12.2 percent) followed by those belonging to university laboratories (14,404, 3.3 percent).

By kind of institution 200,822 (37.2 percent) belonged to national universities. The size of national university departments can be inferred by comparing the number with with the ratio of national university departments (29.5 percent). This was followed by public universities (35,173 persons, 6.5 percent) and private universities and others (302,559, 56.1 percent). It can be seen that private university departments are relatively small.

4.4 R&D in Governmental Institutes and R&D Foundations

Here R&D organizations refer any of the following:

(1) National R&D institutes
(2) Semi-governmental corporations which conduct R&D as their principal activity (hereinafter referred to as semi-governmental R&D institutes)
(3) Public R&D institutes established by local governmental authorities
(4) Private R&D institutes mainly foundations

Unlike universities and industries these R&D institutes all specialize in R&D. However their characteristic is quite different. The belong to government offices and promote R&D in areas marked with strong social or administrative needs. The research corporations are mainly financed or subsidized by the government or privately funded. Along with national R&D institutes they play major roles in the national R&D system. Because research corporations can amass talent widely from the government and private sectors, can flexibly be operated as an organization and can introduce private funds, they are instrumental in efficiently promoting goal-oriented R&D. They play major roles today as R&D grows in scale and complexity. Public R&D institutes contribute towards the promotion of regional areas by conducting R&D in meeting with the area's actual conditions. Private R&D institutes are nonprofit organizations and are still few in number in Japan. However they are making contributions of a kind different from other R&D organizations and expectations are placed on their further development in the future. Among these organizations the national R&D institutes and research corporations are usually treated as government R&D organizations.

4.4.1 R&D Expenditures by R&D organizations

R&D expenditures by Japanese R&D organizations reached ¥1.4523 trillion in 1989. This was 12.3 percent of all R&D expenditures in Japan. Examining the ratio's trends in the recent years shows that it has been declining as with the expenditures by universities.

Figure 4-4-1 shows the trends of R&D expenditures by kind of research organization. It shows that private R&D institutes and research corporations have been spending large amounts in R&D and public R&D organizations small amounts.

Conspicuous has been the growth over the years of R&D expenditures by private R&D institutes. In contrast it can be seen that the growth of R&D expenditures by national and public R&D organizations has been small compared to other organizations.

4.4.2 Number of R&D S/E at R&D organizations

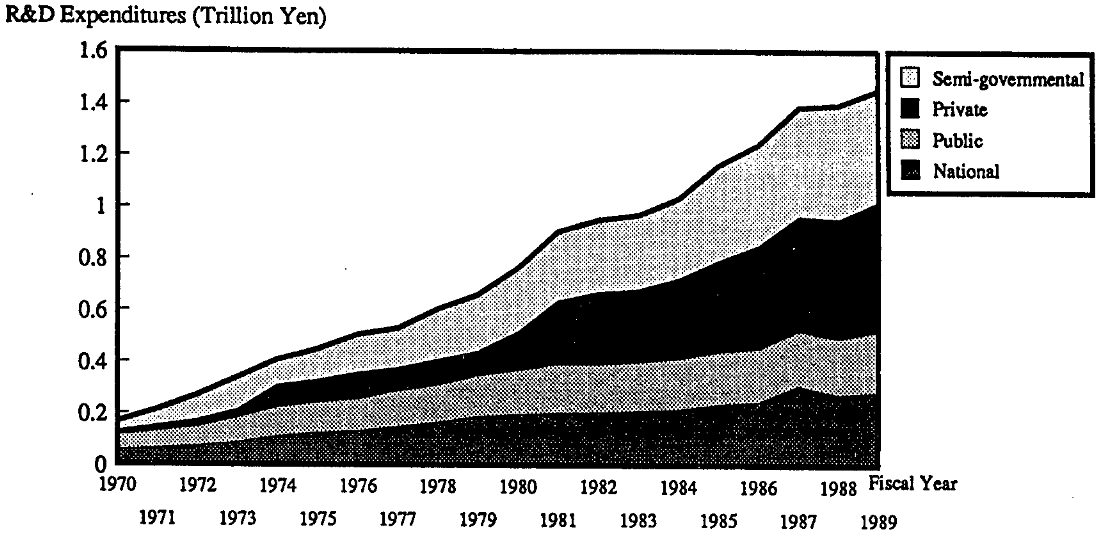
In 1990 R&D S/E working at R&D organizations in Japan numbered 40,819. This was 7.3 percent of the total number of R&D S/E in Japan that year (560,276). Examining the recent trends shows that their growth has been on the lowest level compared to corporations, etc., and universities. In particular, as the total number of positions has been reduced due to fiscal restraint so that the number of R&D S/E is also being reduced.

Figure 4-4-2 shows trends of the number of R&D S/E at R&D organizations. It can easily be seen that the number at has been leveling off. At public R&D institutes also the number virtually did not increase in the 1970s. The number at research corporations has also been remaining on the same level. In contrast that at private R&D institutes has been increasing. The growth has been marked in the 1980s in particular. It can even be said that the increase of R&D S/E at R&D organizations has been due to their increase at private R&D institutes.

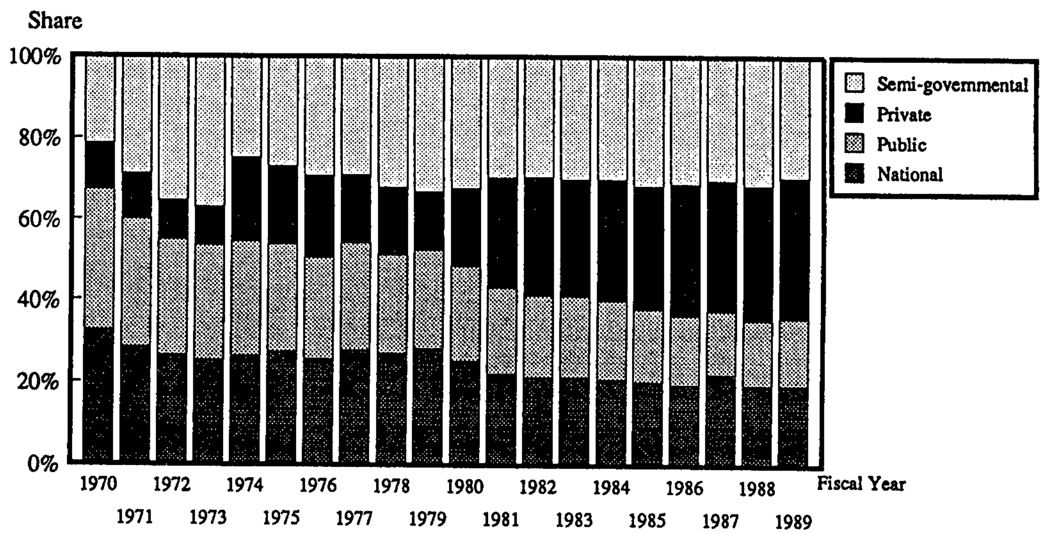
The number of R&D S/E by kind of organization is shown in Figure 4-4-2. Only the share of private R&D institutes has been increasing while the other shown decreases. When looked at from the viewpoint of R&D personnel it can be said that the share of government R&D organizations in particular has markedly been decreasing.

The share of R&D S/E is compared with that of R&D expenditures (Figure 4-4-1). In recent years the share of R&D expenditures has been larger than that of R&D S/E at research corporations and private R&D institutes. In contrast the share of R&D S/E has been larger than that of R&D expenditures at national and public R&D institutes. This succinctly reflects the characteristic of R&D activities at these R&D organizations where the former require large R&D expenditures for equipment and facilities while the latter do not require such expenditures. In particular it can be seen that research corporations are conducting large-scale R&D.

Figure 4-4-1 Trends of R&D Expenditures by R&D Organizations



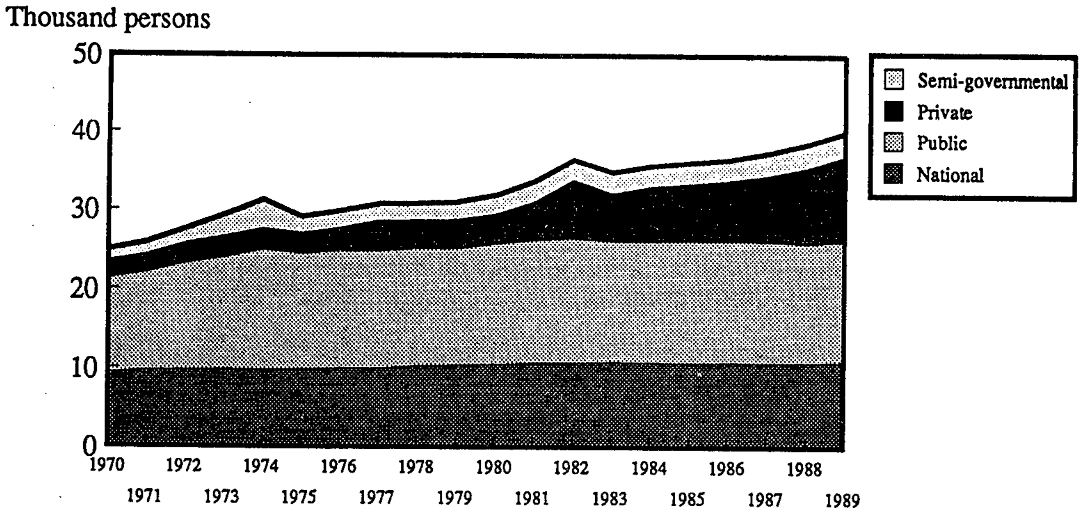
(A) Trends of R&D Expenditures



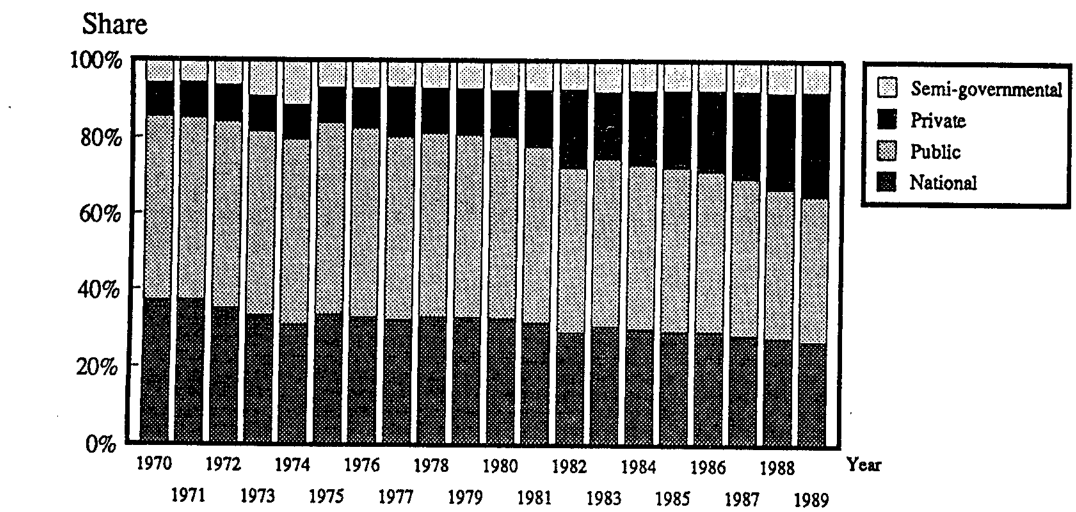
(B) Trends of Share

Source: Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"
See Table 4-4-1

Figure 4-4-2 Trends of Number of R&D S/E at R&D Organizations



(A) Trends of Number of R&D S/E



(B) Trends of Share

Source: Statistics Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development"
See Table 4-4-2

4.4.3 Number of Laboratories in R&D Organizations

Along with R&D expenditures and number of R&D S/E the number of laboratories is an important indicator of R&D infrastructure. The Management & Coordination Agency report does not cover the number of laboratories. However in the case of R&D organizations it is believed possible to consider the number of organizations covered as being almost the same in number to the number of laboratories. Hence the number of R&D organizations covered by the report is converted into an R&D indicator. In 1989 there were 97 national R&D laboratories, 8 research corporations and 586 public R&D institutes. Over the years there virtually have been no changes in the number of national R&D laboratories and research corporations. The number of public R&D organizations in contrast has been fluctuating. Recently it has been decreasing every year after the peak of 642 organizations in 1983. The number of private R&D laboratories has steadily been increasing despite fluctuations. After 1983 in particular it has drastically increased every year so that the number in 1988 was around 1.7 times that in 1982.

Classifying the R&D organizations by academic field (science, engineering, agriculture and health) shows that over half of the specialized in engineering and agriculture, public R&D organizations in agriculture and research corporations in science.

Sources:

(1) Management & Coordination Agency Statistics Bureau, "Report on the Survey of Research & Development."
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(1) Science and Technology Agency, "White Paper on Science and Technology."
(2) Science and Technology Agency Science and Technology Policy Bureau, "Science and Technology Handbook."
(3) Management & Coordination Agency Statistics Bureau, "Report on the Survey of Research & Development."
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(6) Institute of Future Engineering, "Study of Actual Condition of Western R&D Statistics and Comparison with Japanese," 1987.
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CHAPTER 5

REGIONAL R&D ACTIVITIES

Chapter 5

Regional R&D Activities

Interest in regional science and technology activities is growing in recent years. Policies such as the Fourth Comprehensive National Development Plan have focused on regional development wherein the main objective is to reverse the tendency to concentrate activities in Tokyo and consequently to promote a multipolar pattern of national land use throughout Japan. Concurrently, developments in science and technology have been significant, contributing for example to the rapid formation of new social infrastructures including information and communication networks. In addition, the important role of technological innovation in the advancement of industrial technology and in the development of the economy as a whole are gaining widespread recognition, and as a consequence, science and technology are considered to be main contributors to the revitalization of regional economies. In recent years, local government authorities are drawing up regional development plans centered upon R&D activities and are implementing regionally oriented policies for the promotion of science and technology, including the establishment of councils for that purpose.

Higher educational institutions such as universities are the main facilities which supply human resources by training scientists and engineers. They also play central roles in joint industry-university R&D as can be seen in the Technopolis Plan. Hence they occupy an important position as a core in promoting science and technology in local areas.

Also important is the role of private enterprises in mediating between R&D and regional development activities. Corporate activities in local areas are characterized by a bimodial relationship between R&D and production activities. Scientific and technological activities contribute to the area through production and the state of regional development affects the industrial production and R&D activities. This chapter analyzes the characteristics of scientific and technological activities carried out in Japan by indexing basic data related to science and technology by region.

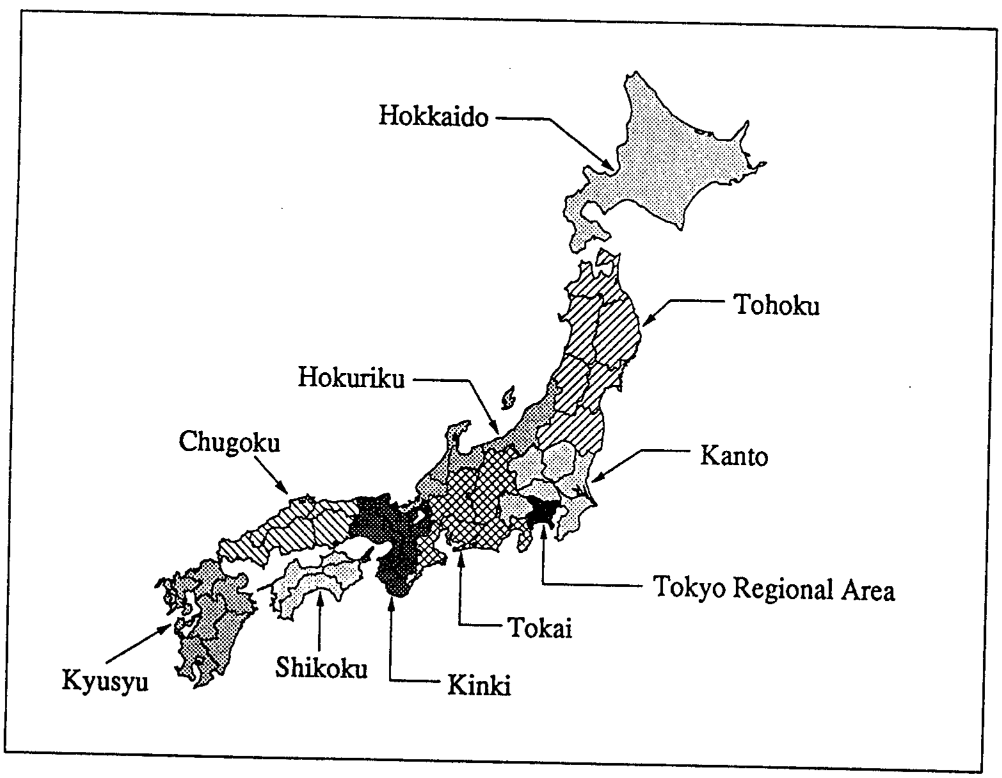
5.1 Regional Distribution of R&D Facilities

The regional distribution of R&D facilities are a starting point in the quantitative analysis of local scientific and technological activities. Regions are shown in Figure 5-A. Tokyo and Kanagawa Prefecture were separated from the Kanto district and combined into "TRA."

Table 5-A Regional Classification

Region	Prefectures
Hokkaido	Hokkaido
Tohoku	Aomori Iwate Miyagi Akita Yamagata Fukushima
Kanto	Ibaraki Tochigi Gumma Saitama Chiba Yamanashi
Tokyo Regional Area	Tokyo Kanagawa
Hokuriku	Niigata Toyama Ishikawa Fukui
Tokai	Nagano Gifu Shizuoka Aichi Mie

Region	Prefectures
Kinki	Shiga Kyoto Osaka Hyogo Nara Wakayama
Chugoku	Tottori Shimane Okayama Hiroshima Yamaguchi
Shikoku	Tokushima Kagawa Ehime Kochi
Kyusyu	Fukuoka Saga Nagasaki Kumamoto Oita Miyazaki Kagoshima Okinawa



5.1.1 Regional Distribution of University Departments

A comprehensive study of regional distribution of university departments should cover all departments and faculties. However, to prepare an indicator focusing on scientific and technological activities the analysis has focused itself on science and engineering departments by excluding cultural science departments. For example, the main role of health departments and faculties is to execute educational activities such as training of doctors and pharmacists. For this reason some of the data were excluded in preparing the index.

As shown in Table 5-B the TRA had 28 percent of all university departments and the Kinki area 18 percent. Slightly under 50 percent of all universities in Japan were concentrated in these two regions. They also had large shares of science and engineering departments. However many science departments are also found in the Chugoku, Hokkaido and Tohoku districts. Also, engineering departments are widely distributed in the Hokuriku, Hokkaido and Kyushu districts. In actual number however they were overwhelmingly concentrated in the Tokyo and Kinki areas.

The coefficient of variance (Note) is used to determine the indicator of regional concentration of university departments. It is obtained by dividing the standard deviation of the share of the given department by its share in all departments. The smaller the coefficient the more uniform the regional distribution and the greater the coefficient, the greater the regional concentration.

The coefficients show that health, engineering, social science and cultural science departments are relatively evenly distributed throughout the country. In comparison science and agriculture departments are unevenly distributed. Commerce, home economics and art departments are very unevenly distributed. This is believed to reflect the results of the educational policies such as those establishing and expanding health-related departments on a nation-wide scale to eliminate the problem of shortage of doctors or the establishing engineering departments throughout the country to train technicians.

Note:

(1) The coefficient of variation is obtained as follows.

$$\text{Coefficient of variance} = \frac{\left(\sum_j (x_{ij}-m_i)^2 / N\right)^{1/2}}{\left(\sum_j x_{ij} / N\right)^{1/2}}$$

where

i: department

j: region

m_i: the department's share in the total number of departments

x_{ij}: share of department i in region j

N: number of regions

The coefficient is obtained by first obtaining the average and standard deviation of the regional share of the department and dividing the standard deviation by the average. The more uneven the regional distribution the greater the standard deviation, hence greater the coefficient.

Table 5-B Number of Academic Departments by Region

	Humanities	Social science	Natural science	Engineering	Agriculture	Health
Hokkaido	5	14	1	6	5	8
Tohoku	7	12	3	7	4	11
Kanto	10	22	4	10	3	12
Tokyo Regional Area	56	96	9	29	12	41
Hokuriku	5	6	3	7	1	10
Tokai	20	30	3	11	8	17
Kinki	50	68	8	16	6	26
Chugoku	12	13	5	9	5	10
Shikoku	6	4	2	2	3	7
Kyusyu	15	32	5	22	9	21
All Japan	186	297	43	119	56	163
Coefficient of variation	0.81	0.91	1.47	1.03	1.76	0.77

	Marchant marine	Home economics	Education	Arts	Others	Total
Hokkaido	0	0	2	1	20	62
Tohoku	0	3	8	0	30	85
Kanto	0	0	8	1	43	113
Tokyo Regional Area	1	11	11	14	152	432
Hokuriku	0	0	5	1	22	60
Tokai	0	8	10	5	63	165
Kinki	1	9	12	9	80	295
Chugoku	0	4	6	2	28	94
Shikoku	0	3	4	1	17	49
Kyusyu	0	1	11	2	60	182
All Japan	2	43	77	36	515	1,537
Coefficient of variation	3.34	2.44	1.53	1.48	0.32	---

Source: National Institute of Science and Technology Policy, "Basic Survey of Regional Science and Technology Promotion - Preliminary Report" 1989

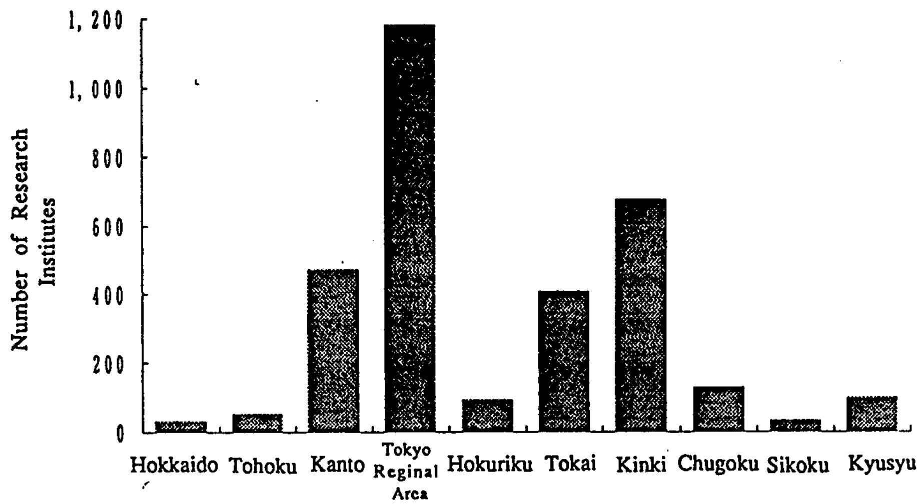
5.1.2 Regional Distribution of Private Firm R&D Facilities

In 1989 there were 3,179 private R&D facilities throughout the country. Figure 5-1-1 shows their regional distribution.

A quarter (763) of all R&D facilities are concentrated in Tokyo. This was followed by Kanagawa's 417 (13 percent) and Osaka's 374 (12 percent). As can be inferred from the fact head office functions are concentrated in these prefectures, the major reasons for establishing R&D facilities in these regions are believed to be ease of information collection, employment and acquisition of research equipment and materials. Examining the relationship between industrial output and R&D expenditures shows that R&D facilities are not necessarily located near production functions. The R&D facilities in these two major urban areas are believed to be located away from production bases. 1,554 or around half (49 percent) of all R&D facilities were located in these areas.

In contrast R&D facilities in other areas are believed to be located near production bases. Hence they manifest strong proximity between R&D and production bases. 1,096 or around a third (34.5 percent) of all R&D facilities were located in these areas.

Figure 5-1-1 Number of Private R&D Facilities by Region



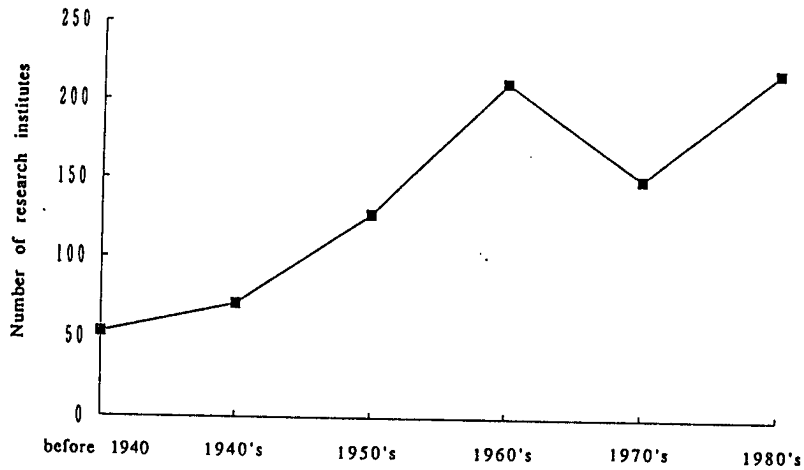
National Institute of Science and Technology Policy, "Basic Survey of Regional Science and Technology Promotion - Preliminary Report"

5.1.3 Distribution of R&D Facilities by Year of Establishment

Examining the year of establishment of R&D facilities shows there have been two peaks, one in the 1960s when 211 (23 percent) of the facilities were established and the other in the 1980s when 283 (26 percent) were established (Figure 5-1-2).

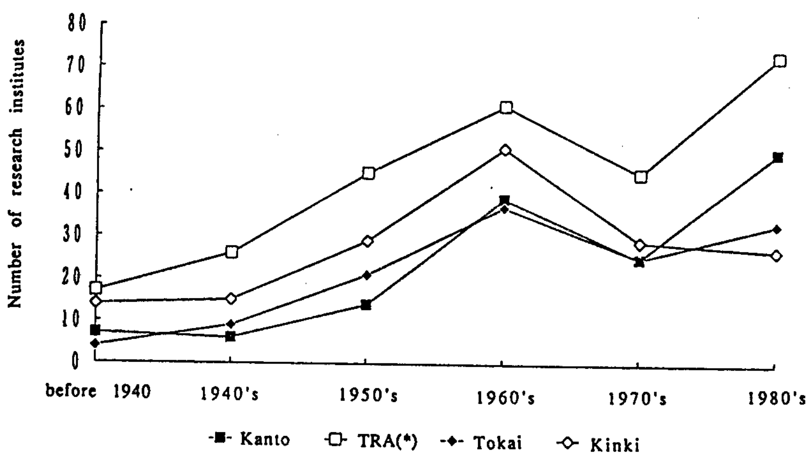
While the TRA has the greatest number of R&D facilities, the number slowly increased until the first peak, slowly decreased, and again rapidly increased to form the second peak (Figure 5-1-3). Establishment of R&D facilities in the Kanto district took on a pattern similar to Tokyo's but the fluctuations have not been so slow. In both areas the second peak was greater than the first. In contrast the Kinki area's pattern of establishment of R&D facilities has been the opposite of Tokyo's. Although the number of R&D facilities established was larger than that of Tokyo or Kanto until the first peak, in the second peak there was not only a decrease in the number established but the total number gradually decreased as well. The number of facilities established in the Tokai district has been smaller than in Tokyo or Kanto but the pattern has been similar. However more were established in the first peak and the increase in the second has not been so rapid.

Figure 5-1-2 Year of Establishment of Private R&D Facilities (total)



National Institute of Science and Technology Policy, "Basic Survey of Regional Science and Technology Promotion - Preliminary Report"
See Table 5-1-2

Figure 5-1-3 Year of Establishment of Private R&D Facilities (by region)



(*)Tokyo Regional Area
National Institute of Science and Technology Policy, "Basic Survey of Regional Science and Technology Promotion - Preliminary Report"
See Table 5-1-2

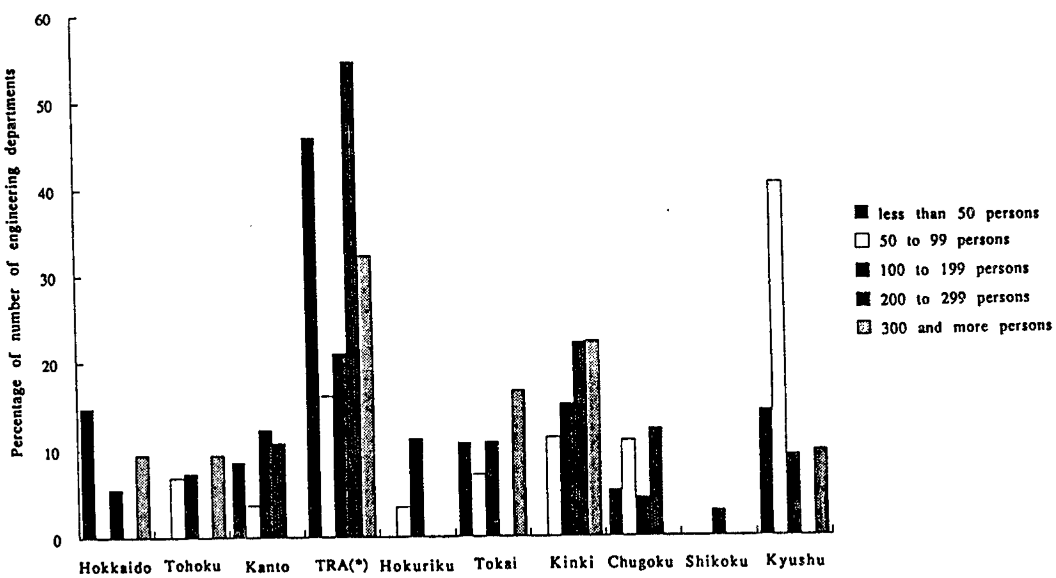
5.2 R&D Personnel at Universities

R&D personnel distribution is analyzed regionally by focusing on instructors and graduate students at universities. Analysis is on data for the number of instructors and students of engineering departments institution (national, public or private) and size of department.

National universities in the Kanto and Shikoku districts had slightly fewer engineering department instructors than the national average. For example the Hokuriku district had slightly more but the regional difference was generally small. In the case of private universities however Tokyo (Tokyo and Kanagawa) had over twice the number of both instructors and students than the national average hence showing marked concentration.

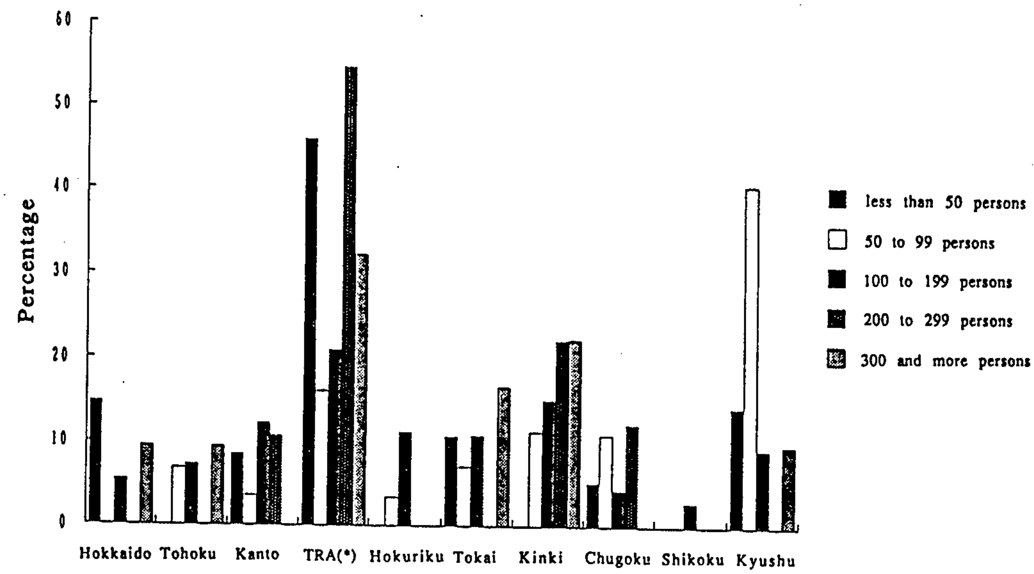
Comparison of the number of students by undergraduate, master's and doctorate candidates shows that there is small regional difference in the number of national university undergraduates while private university undergraduates are markedly concentrated in the TRA. Both national and private university graduate students enrolled in doctorate courses are concentrated in the Tokyo and Kinki areas. Graduate students enrolled in master's courses also exhibited regional concentration but it was midway between the level for undergraduates and doctorate candidates. Along with instructors, graduate students are believed to shoulder the burden of university R&D activities. R&D potential looked at from the viewpoint of the number of research personnel is believed to be higher in the Tokyo and Kinki areas.

Figure 5-2-1 Regional Distribution of Engineering Departments by Size of Department



(*)Tokyo Regional Area
National Institute of Science and Technology Policy, "Basic Survey of Regional Science and Technology Promotion - Preliminary Report"
See Table 5-2-1

Figure 5-2-2 Regional Distribution of Engineering Department Faculty



(*)Tokyo Regional Area
National Institute of Science and Technology Policy, "Basic Survey of Regional Science and Technology Promotion - Preliminary Report"
See Table 5-2-2

Figures 5-2-1 and 5-2-2 show the distribution of engineering departments and their faculty by department size. In the case of engineering departments with over 300 faculty members, the TRA had 30 percent of all departments and 32 percent of faculty members. In other areas 20 percent of the engineering departments in the Kinki and Tokai districts and 10 percent of those in the Hokkaido, Tohoku and Kyushu districts had over 300 faculty members. There were no such large engineering departments in the Kanto district other than the TRA and the Hokuriku, Chugoku and Shikoku districts. These large universities are former imperial universities and some are private universities. In terms of the number of faculty staff belonging to engineering departments having over 300 members, the Kinki area had 70 percent of those in Tokyo, the Tokai district 50 percent and the Hokkaido, Tohoku and Kyushu districts around 30 percent.

5.3 R&D Activities at Private R&D Facilities

The study examined private R&D facility activities by region in terms of R&D personnel and R&D expenditures. R&D activities are concentrated in the Tokyo and Kinki areas. This is believed to indicate advantageous situations such as ease of access to science and technology information and securing of personnel. The findings have hence numerically corroborated the fact that R&D activities in Japan are concentrated in the major urban areas. These two regions overwhelmed others in terms of the actual number of R&D S/E and R&D expenditures so that it became difficult to compare with other regions. The following analysis was thus conducted using shares to identify regional characteristics.

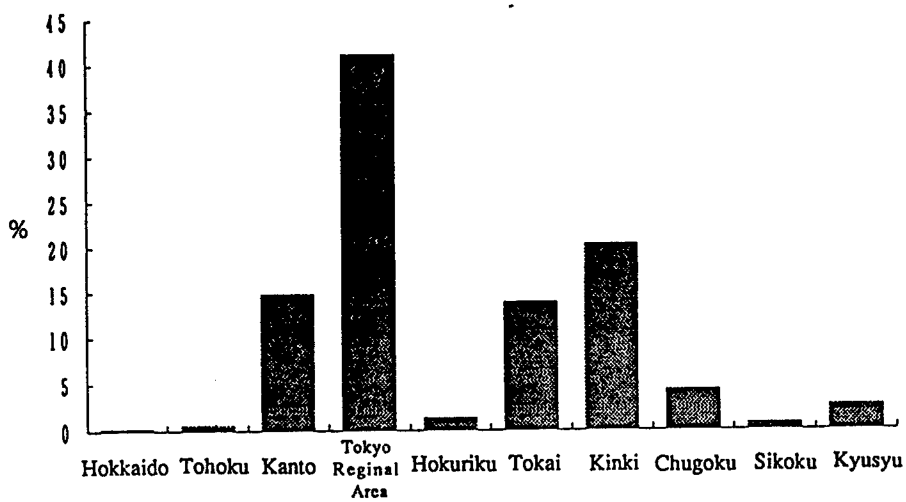
5.3.1 Distribution of R&D S/E and R&D Expenditures

Figures 5-3-1 and 5-3-2 show regional distribution of R&D S/E and R&D expenditures. 41 percent of the R&D S/E concentrated in Tokyo followed by 21 percent in Kinki, 15 percent in Kanto and 14 percent in Tokai. These were followed by Chugoku (4 percent), Kyushu (3 percent) and Hokkaido, Tohoku, Hokuriku and Shikoku (1 percent or less). Hence they most concentrated in Tokyo followed by Kinki.

In terms of regional distribution of R&D expenditures 36 percent are concentrated in Tokyo followed by Kinki (20 percent), Kanto (17 percent), Tokai (15 percent), Chugoku (7 percent), Kyushu (3 percent) and Hokkaido, Tohoku, Hokuriku and Shikoku (under 1 percent). Both R&D S/E and R&D expenditures are concentrated in Tokyo, Kinki, Kanto and Tokai. Hence the following analysis focuses on these four regions.

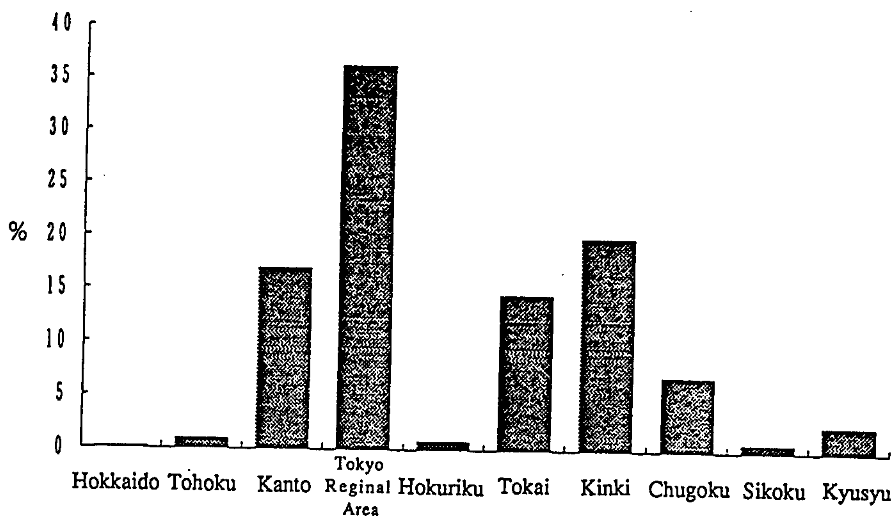
Figure 5-3-3 shows the relationship between the share of R&D S/E (horizontal axis) and R&D expenditures (vertical axis). The two are more or less proportional. In Kanto and Tokai, R&D expenditures per researcher were slightly larger than the national average.

Figure 5-3-1 Regional Share of R&D S/E



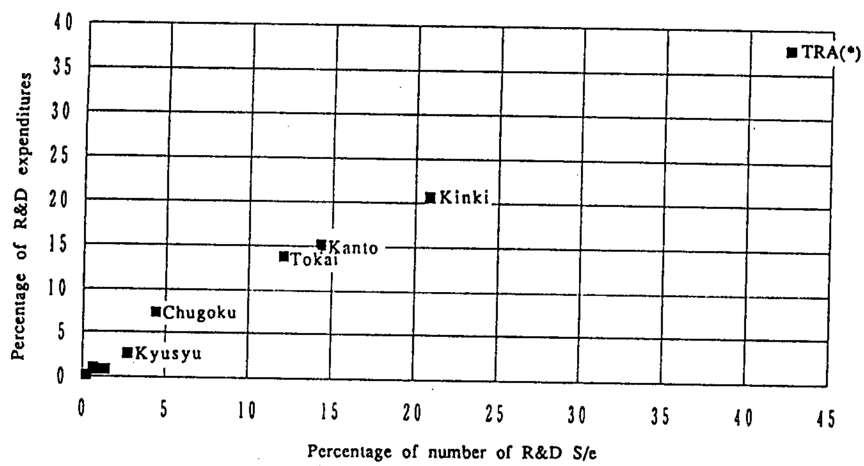
National Institute of Science and Technology Policy, "Basic Survey of Regional Science and Technology Promotion - Preliminary Report"

Figure 5-3-2 Regional Share of R&D Expenditures



National Institute of Science and Technology Policy, "Basic Survey of Regional Science and Technology Promotion - Preliminary Report"

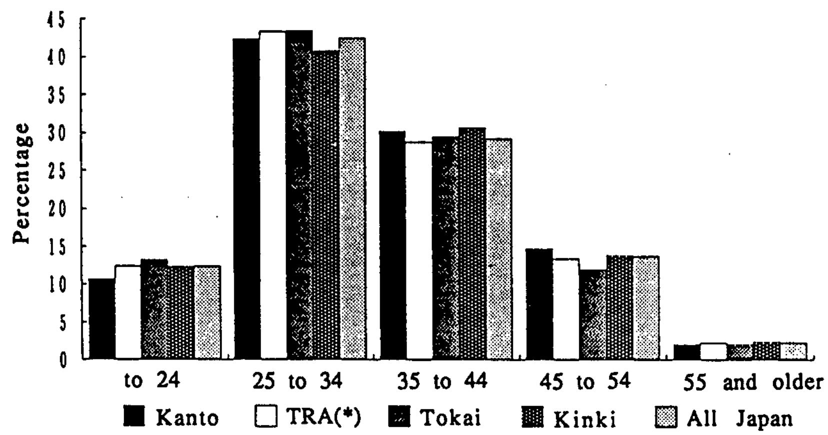
Figure 5-3-3 Relationship between Shares of R&D S/E and R&D Expenditures



(*)Tokyo Regional Area
National Institute of Science and Technology Policy, "Basic Survey of Regional Science and Technology Promotion - Preliminary Report"
See Table 5-3-8

Figure 5-3-4 shows the distribution of R&D S/E by age. The R&D S/E age composition was similar across regions. In terms of national average, 12 percent were under 25, 43 percent from 25 to 34, 29 percent from 35 to 44, 14 percent from 45 to 54 and 2 percent over 55. Nearly half the R&D S/E were from 25 to 34 which is considered to be the research-productive age bracket. By region there were slightly more R&D S/E aged 25-34 in the TRA than the national average. In the Kinki area the share of those aged 35-45 was slightly larger than the national average.

Figure 5-3-4 Distribution of R&D S/E by Age Group

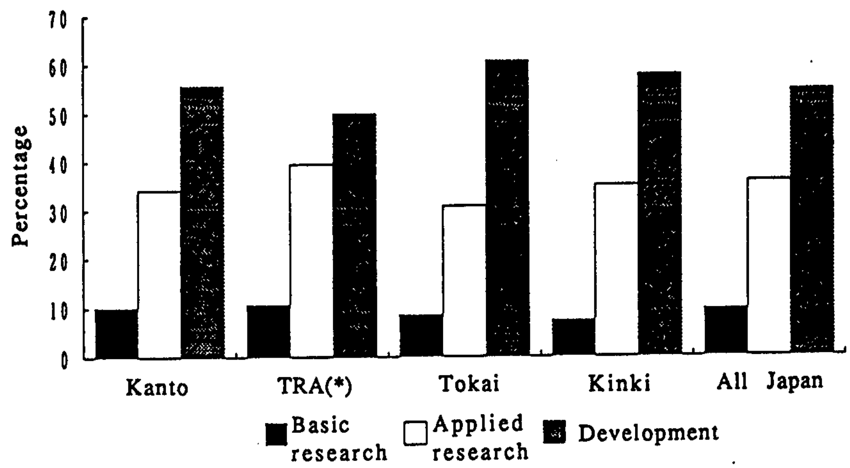


(*)Tokyo Regional Area
National Institute of Science and Technology Policy, "Basic Survey of Regional Science and Technology Promotion - Preliminary Report"
See Table 5-3-4

Figure 5-3-5 shows the share of R&D S/E by characteristic of research (basic research, applied research or development). The national average was basic research 10 percent, applied research 36 percent and development 55 percent. The ratio of R&D S/E engaged in basic research was around 10 percent in Kanto, Tokyo, Tokai and Kinki. The share of those involved in applied research was largest in Tokyo while the share of those engaged in development was largest in Tokai.

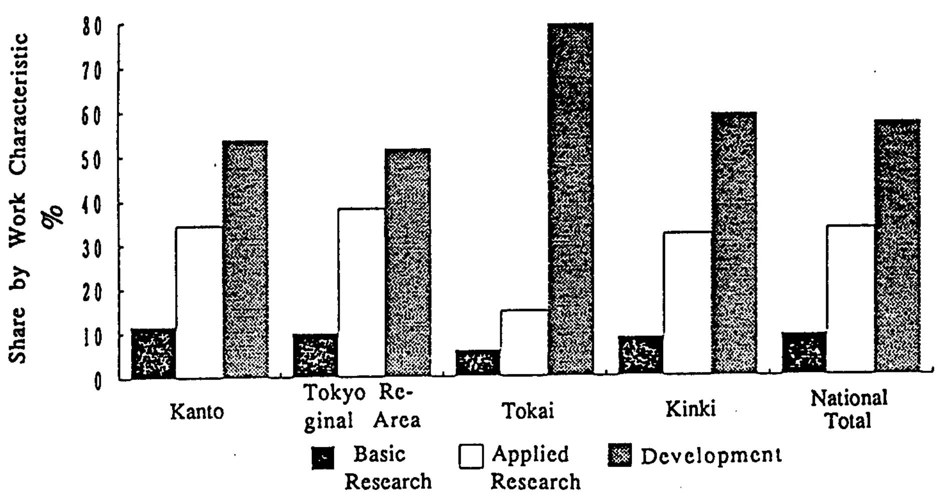
Figure 5-3-6 shows R&D expenditures by characteristic of work. The national average was basic research 9 percent, applied research 34 percent and development 57 percent. A Tokyo-Kinki comparison shows that the share of basic research and applied research expenditures was larger in Tokyo and that of development expenditures was larger in Kinki. The ratio of basic research expenditures in Tokai was smaller than the national average and that in Kanto, Tokyo and Kinki more or less the same as the national average. In Tokai where the share of basic research expenditures was small the share of development expenditures far exceeded the national average at around 80 percent.

Figure 5-3-5 Number of R&D S/E by Characteristic of Work



(*)Tokyo Regional Area
National Institute of Science and Technology Policy, "Basic Survey of Regional Science and Technology Promotion - Preliminary Report"
See Table 5-3-5

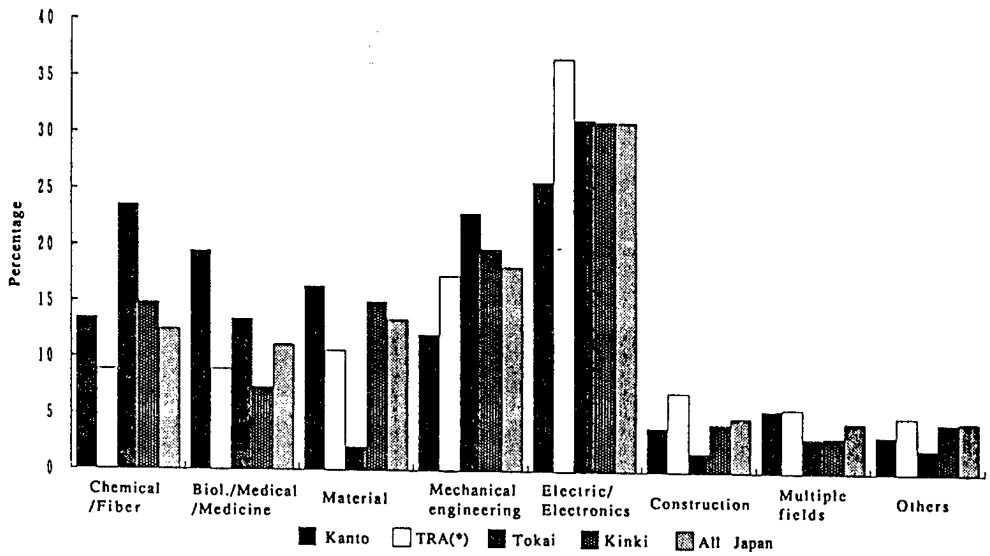
Figure 5-3-6 R&D Expenditures by Characteristic of R&D



National Institute of Science and Technology Policy, "Basic Survey of Regional Science and Technology Promotion - Preliminary Report"

Figure 5-3-7 shows the number of R&D S/E by research area. The areas used were chemicals and fibers, biological medicine, materials, mechanical engineering and electronics and electrical engineering. In the Kanto area there were many biological medicine and materials R&D S/E. While 41 percent of all R&D S/E were concentrated in Tokyo only around 30 percent of chemicals and fibers, biological medicine and materials R&D S/E were concentrated in Tokyo. In contrast more mechanical engineering (40 percent) and electronics and electrical engineering R&D S/E (50 percent) were concentrated in Tokyo. In the Kinki area there were fewer biological medicine R&D S/E.

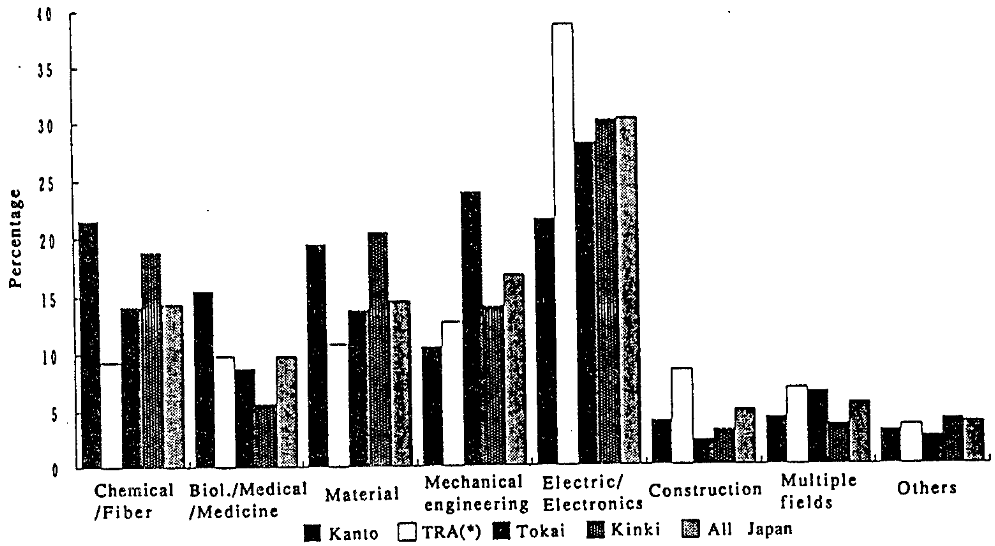
Figure 5-3-7 Regional Distribution of R&D S/E by Characteristic of R&D



(*)Tokyo Regional Area
National Institute of Science and Technology Policy, "Basic Survey of Regional Science and Technology Promotion - Preliminary Report"
See Table 5-3-7

R&D expenditures by research area showed clearer regional differences compared to the number of R&D S/E (Figure 5-3-8). In the Kanto district the shares of chemicals and fibers, biological medicine and materials were largest and those of mechanical engineering, electronics and electrical engineering smallest. In the TRA the share of electronics and electrical engineering was particularly large as was that of biological medicine. However the shares of chemicals and fibers and materials were smaller than that for Kinki . In the Tokai area the share of R&D S/E for mechanical engineering was particularly large. In Kinki the shares of chemicals and fibers and materials were particularly large, exceeding those for the TRA. However R&D work in biological medicine was very small, even smaller than the Kanto district.

Figure 5-3-8 Regional Distribution of R&D Expenditures by Area of Research



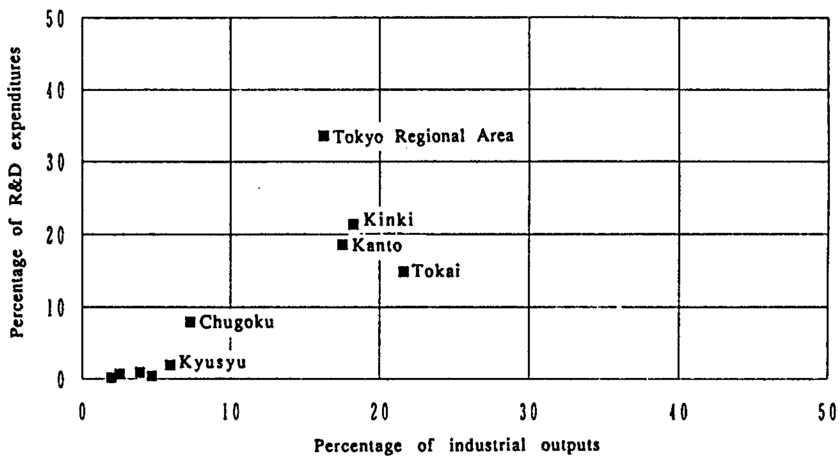
(*)Tokyo Regional Area
National Institute of Science and Technology Policy, "Basic Survey of Regional Science and Technology Promotion - Preliminary Report"
See Table 5-3-9

5.3.2 Industrial Output and R&D Activities

R&D and industrial production activities are believed to be closely related. To examine their relationship Figure 5-3-9 compares the various regional shares of industrial output (Note, sources 3 and 5) and R&D expenditures. The TRA share of R&D expenditures was overwhelmingly larger than that for other regions. R&D activities in Japan are mainly carried out in the TRA. In the Kinki area also R&D activities were more active or concentrated than production activities. In contrast production and R&D activities are balanced in the Kanto region. In the Tokai region production activities are more active than R&D. In other regions production is the main activity although its share is below 10 percent.

Note:
Industrial output means the factory shipment value given on MITI's industrial statistics table.

Figure 5-3-9 Relationship between Industrial Output and R&D Expenditures



National Institute of Science and Technology Policy, "Basic Survey of Regional Science and Technology Promotion - Preliminary Report" -
See Table 5-3-8

Sources:

(1) Ministry of Education, "Report of Basic Survey on Schools (Higher Education)."
Also use other than designated statistics (Management & Coordination Agency Notification No. 4, Gazette No. 18545, December 16, 1988), provisions of Sub-Section 2 of Section 15 of the Statistics Law.

(2) Ministry of Education, "Statistical Report of School Teachers."
Also use other than designated statistics (Management & Coordination Agency Notification No. 4, Gazette No. 18545, December 16, 1988), provisions of Sub-Section 2 of Section 15 of the Statistics Law.

(3) Ministry of International Trade and Industry, "Industrial Statistical Table (1986)."

(4) Management & Coordination Agency Statistics Bureau, "National Census (1985)."

(5) National Institute of Science and Technology Policy No. 2 Research Group, "Basic Study of Promotion of Science and Technology in Local Areas (Interim Report)," March 1989 (report conducted with Special Coordinating Funds for the Promotion of Science and Technology 1988).

(6) National Institute of Science and Technology Policy No. 4 Study and Research Group, "Basic Study of Promotion of Science and Technology in Local Areas < I >)," March 1990 (report conducted with Special Coordinating Funds for the Promotion of Science and Technology 1988).

CHAPTER 6

ACHIEVEMENTS OF R&D ACTIVITIES

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In comparison to the infrastructure indicators for R&D, those related to achievements in science and technology R&D are not as advanced. There could be two reasons for this situation. One reason is technical. Compared to infrastructure indicators, it is often difficult to acquire appropriate data. Another is lack of understanding on just what R&D achievements mean and specifically, what kind of quantitative measurements should be used for indicators. Regarding the former issue, the development of the computer-aided technology and of data bases in particular, has considerably reduced technical difficulties. As for the latter issue, understanding regarding the progress of the sociology of science and the study of science and technology policies is progressing. Also, there have been many achievements in the accumulation by various countries of experience and effort regarding designing of science and technology indicators.

This chapter therefor discusses indicators related to R&D achievements in some detail. The cascade structure for indicators, which served as the guideline in structuring this chapter, divides R&D achievement indicators into those indicating direct and indirect achievements of R&D activities and calls the former "R&D achievements" and the latter "contributions of science and technology." This chapter discusses the main direct indicators of "R&D achievements." Section 6.1 refers to scientific papers and their citations. Section 6.2 discusses patents and plant varieties. Section 6.3 discusses standards. Section 6.4 discusses awarding of scientific and technological achievements. This last indicator will be discussed by distinguishing it from the others as a subjective indicator of the contents of R&D achievements which cannot be measured using quantitative or objective indicators such as the number of Scientific Papers.

6.1 Scientific Papers

There can be said to be two main objectives of R&D. One is to explore the cause and effect relationships and laws related to natural and social phenomena and the other is to develop technologies for the application of these accomplishments in society. Achievements often appear in the form of scientific papers. The experience and knowledge generated through the latter also sometimes appear in the form of scientific papers. By thus being published in the form of papers, R&D achievements become common intellectual property. Indicators related to scientific papers are believed to indicate the level of R&D achievements and their contribution toward scientific and technological knowledge.

In preparing the indicator related to scientific papers it is difficult to directly do the calculation using the enormous number of scientific and technical journals. Hence a data base of the literature is used. Internationally, the Science Citation Index Database (SCI, references 1, 2) is often used. Some of the reasons are that it covers all of areas of science and technology, is the only database which makes available data on papers cited and appropriately selects the journals from which it collects papers. On the other hand, compared to other databases specializing in specific areas the CHI data base has only collected a small number of papers in each area and that it has mainly contains English-language papers. This chapter has prepared the indicators related to Scientific Papers mainly using a secondary database prepared by CHI Corporation based on SCI data (source 1, hereafter referred to as CHI). CHI selects papers from SCI by choosing certain journals and classified the number of papers and citation by country and academic field. It has become a world-wide standard as a database for creating macro indicators.

6.1.1 Number of Papers

The most basic indicator of Scientific Papers is simply their total number. Due to efforts in various countries in recent years with R&D and development of science and technology, the number of papers produced world wide has markedly been increasing. However it is difficult to accurately count the number of papers produced globally or even just for Japan. While in counting it it is necessary to use a database of literature but there is a limit to what a database can cover. Selection of journals into a data base is also affected by the policy of the developer. As an example of estimating the total number of papers, in 1982 1,741,000 papers were produced in the world and 227,400 in Japan (reference 3).

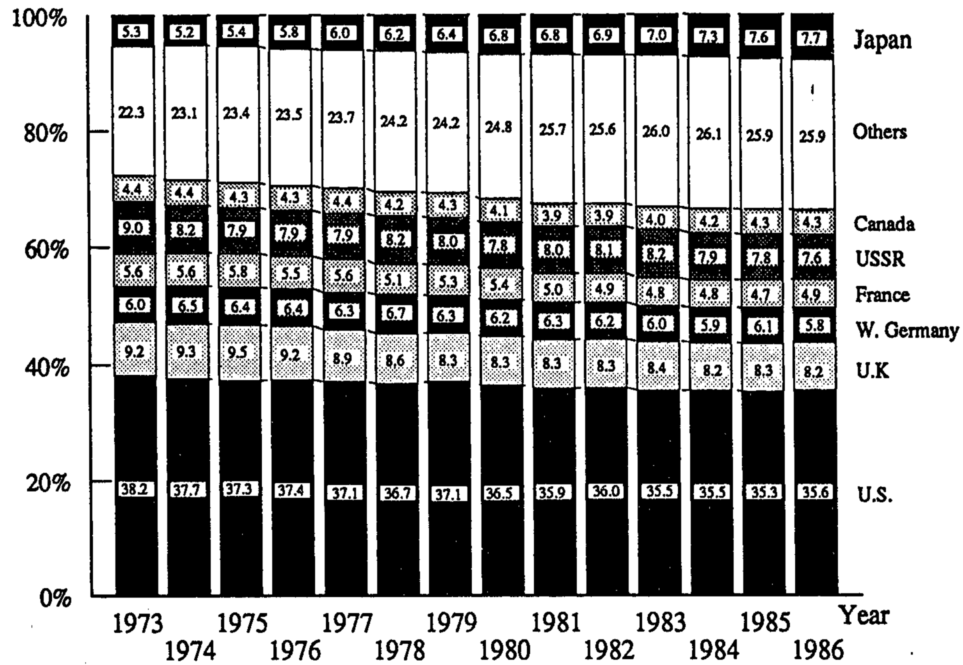
The total number of papers analyzed in this chapter as reflected in the CHI data base showed that from 370,000 to 390,000 papers a year and around 120 per journal are produced. CHI collected data for approximately 25,000 Japanese papers in 1981 and around 30,000 in 1986 and the number was increasing. It must be remembered that these figures do not stand for the actual total number of papers (Note 1). They should be seen as those indicating the scale of the object of analysis before going into the more detailed analysis below.

Examination of world shares of scientific papers can give a global and quantitative view of the level of Japan's R&D achievements and their degree of contribution to the world. Figure 6-1-1 shows yearly production trends of country paper shares. During the period covered, the U.S. has consistently had an overwhelming share of over 30 percent of the global production. The share however has been decreasing. While Japan's share ranked sixth in the world in 1975 it has exceeded France's in 1976, West Germany's in 1979 and the Soviet Union's in 1986 to rank third following the U.S. and the U.K. In a near future it is expected to exceed the U.K.'s. Among the countries shown, only Japan has been increasing its share and its growth has been considerable. Since CHI is US-based, the number of papers produced in Japan is believed to be underestimated compared to those produced in the English-language world. Therefore it is possible that Japan has already become the world's second foremost producer of scientific papers after the U.S. after the mid 1980s.

As for share of papers it is necessary to examine trends by scientific and technological area in more detail. Figure 6-1-2 divides papers into eight areas based on the kind of journal and has calculated Japan and U.S. shares produced in each area. In 1986 Japan's overall share of scientific publications was 7.7 percent (see Figure 6-1-1). In contrast, its shares in the material sciences such as engineering, chemistry and physics were larger at 12.7 percent, 10.7 percent and 8.6 percent, respectively. Shares were relatively smaller in the areas of mathematics (3.4 percent) and earth and space science (3.7 percent). In terms of concentration by area, there was a three fold gap between engineering marked with a large share and mathematics and earth and space science marked with small shares. In comparison to the share by area ten years ago, in 1976 Japan's shares of paper production has increased in all areas except mathematics. The share growth of engineering papers has particularly been marked, more or less doubling hat decade. The shares for life sciences papers such as medicine and biology have increased more than the overall share. Comparing the U.S. and Japan, even in the area of chemistry where the gap was the smallest there was a two fold gap. In mathematics and earth and space science there was a gap of a magnitude of ten between Japan and the US.

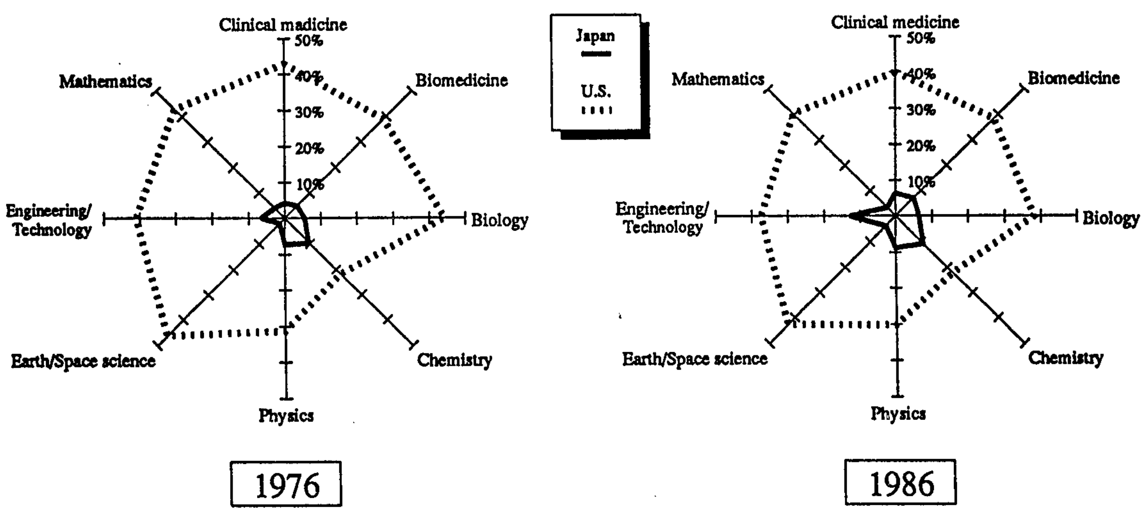
Note:
SCI places emphasis by covering papers deemed important rather than all papers. It must also be remembered that CHI collects papers by limiting journals to around 3,100 based on SCI. Hence figures mentioned should not be seen the results of counting total number of papers produced in the world or Japan but rather as an sample number of papers printed in some of the world's major scientific journals.

Figure 6-1-1 Country Share Trends in the Output of Scientific Papers



Source: Computer Horizons, Inc. "Science & Engineering Literature Data Base 1989"
See Table 6-1-1

Figure 6-1-2 Japanese and U.S. Share of Scientific Papers by Area of Research



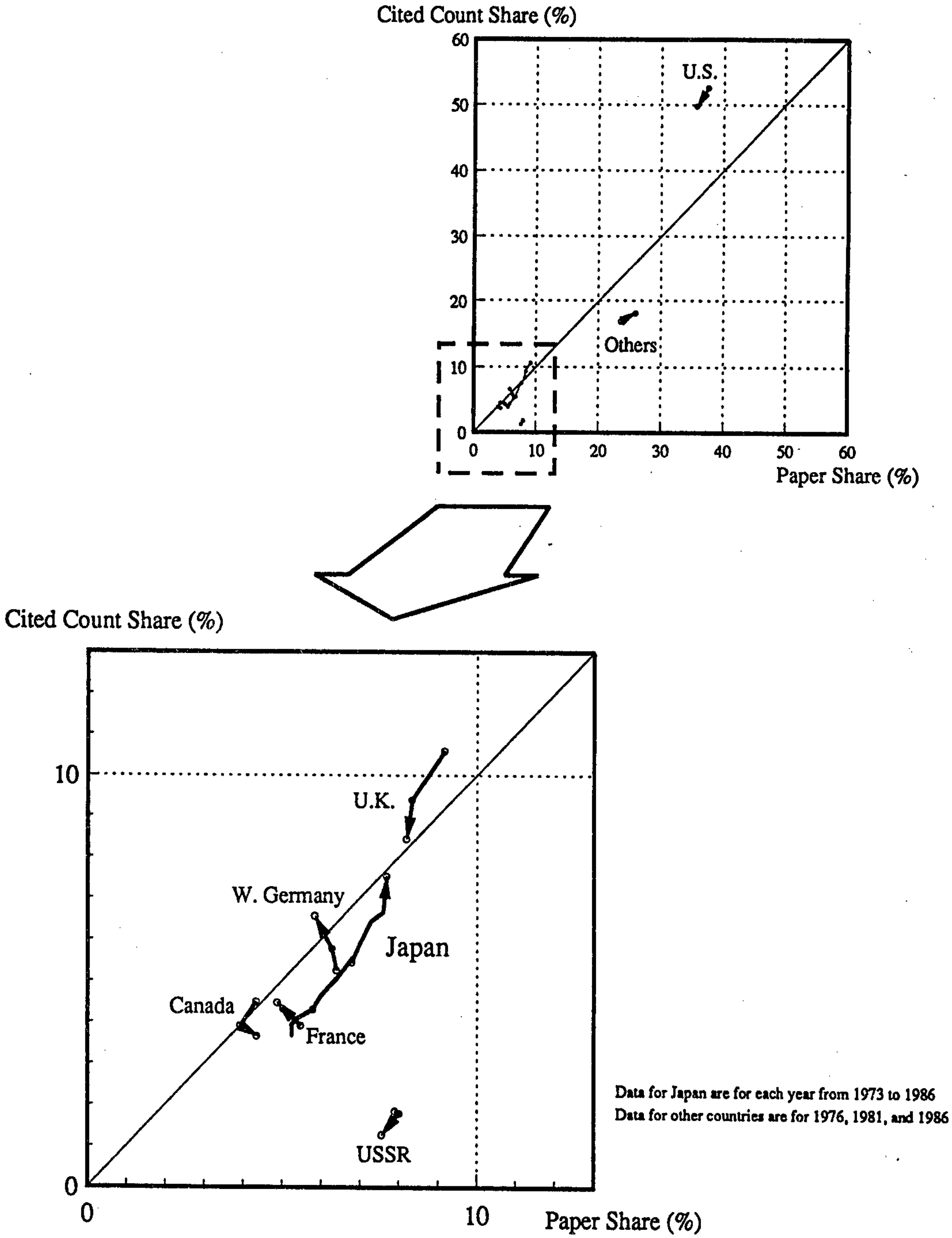
Source: Computer Horizons, Inc. "Science & Engineering Literature Data Base 1989"
See Table 6-1-2

6.1.2 Scientific Paper Citations

The total number of papers produced is insufficient as an indicator of R&D achievements. A qualitative examination is also required. Often used as a quantitative indicator of the quality of papers is the number of times a paper is cited. Behind this is the idea that often-cited papers are deemed outstanding papers. There however are criticisms. Criticisms include papers are arbitrarily cited, general reports or so-called review papers are often cited even though they lack originality, there is a tendency for R&D S/E to cite colleague papers on a priority basis and finally papers containing mistakes are cited just to point out those mistakes. Regarding these criticisms the following ideas are adopted in this paper. First, the number of times a paper is cited is indicative not just of quality but of influence. A large number of papers are being produced and it is said that many are not read by other R&D S/E even if they are published (Note 1). Given such circumstances, if papers are cited they can be considered to have influenced the development of science and technology irrespective of their quality (Note 2). Next, the macro-level number of citations at the national level is believed to represent quality. This is because it is difficult to think that only papers from certain countries are cited to point out mistakes or for having been produced by close associates. It is hence assumed that there is no major difference across countries in the way R&D S/E cite papers. What determines the frequency of citation on the national level is basically the average quality of papers produced in that country. Also, individual papers which are very often cited are also believed to comprise quality papers. There are cases where a paper is cited over a thousand times and it is natural to assume that these are quality papers. An attempt to select the ten most often cited papers as high-quality papers is believed worthwhile (reference 4). However care will be required in using the citation frequency as a yardstick in evaluating individual researches or R&D S/E because of the foregoing problems such as citation by close associates.

The U.S. which has been producing the largest number of papers has a citing share larger than its paper share. Around half the papers cited in the world are US origin. Over time however the U.S. citing share has been declining reflecting a relative decline in the U.S. publications. The U.K. citing share is larger than the paper share reflecting high quality. However its citing share has been declining more than its paper share so its relative citation index has been declining as well. In contrast, Japan's citing share has exceeded that of West Germany's along with the paper share to rank third in the world. Japanese papers are therefore considered to be highly influential in the world. However the number of citations for Japan is small compared to that of total papers produced so that the quality of its papers seems to be below the world's average level. However number of citations have markedly been increasing so that Japan's relative citation index has approached 1 in 1986. Although the West German and French share of papers has been declining their citation share has been increasing. As with the English-language countries such as the U.S. and the U.K., Canadian papers' influence in the world has been declining.Soviet papers are seldom cited compared to number of papers. It is known that in the Soviet Union highly excellent research is being conducted in certain areas but it is said that the overall level of R&D is not so high. The data seem to support this view. However, influences such as social systems and language barriers do not make it possible to make conclusions that papers produced by some countries are low-quality solely based on these data. However it is certain that Soviet papers' influence in the world is small. Although this is not shown in the data, countries such as India are also marked with small citation shares compared to paper shares (in 1986 its paper share was 2.3 percent as opposed to a citation share of 0.8 percent) which is also a tendency marking the Soviet Union. Among "other" countries those with large citation shares were mostly Western countries. It can hence be seen that even the NIES which have undergone rapid economic development in the recent years have had small influence in the scientific publications world. These findings keenly show that at the present point in time at least scientific endeavors are still centered in Western countries.

Figure 6-1-3 Citation Frequency Trends of Scientific Papers in Selected Countries



Source: Computer Horizons, Inc. "Science & Engineering Literature Data Base 1989"
See Table 6-1-3

Notes:

(1) A recent survey shows 55 percent of papers collected by SCI from 1981 to 1985 were not cited even once during the five years after they were printed (references 6, 7).

(2) To add, when a paper is cited for a "mistake" for example, even if the paper was not cited for quality it could create a controversy in the research community. If so the paper can be said to have influenced science and technology and indirectly contributed. The degree of such influence will be represented by the number of citations. (To further add, it is the research community which decides if a theory is right or wrong and such decision is an important process of R&D.) Also, there may be cases in which the number cited of dubious quality papers are attributed to close associates. However, mutual citation by papers printed by passing screening in academic journals becomes possible only when there are research groups of some level. Hence such papers are considered to reflect research activities behind such citing.

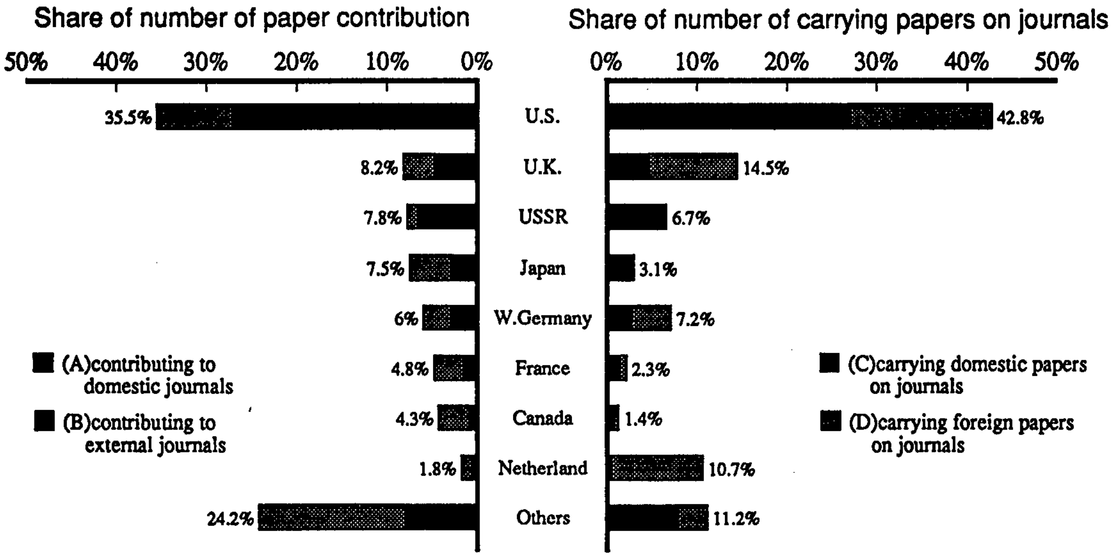
The foregoing section has examined the two basic indicators namely the number of papers and their citation by country. However the relationship between papers and countries is more complex. When examining papers from a national viewpoint it is also useful to look at the matter from diverse angles such as international co-authorship, contribution across borders or the relationship between citing and cited countries. The following section attempts several of these examinations. Based on these indicators it becomes possible to catch a glimpse of international trends of scientific and technological activities. Also, as mentioned Japan's paper production and citations have been increasing at a pace unprecedented in the world. The indicators discussed below show that greatly contributing to this phenomenon has been progress of internationalization of Japanese papers.

6.1.3 Internationality of Scientific Papers and Journals

Scientific papers are usually published in academic journals. Such journals constitute the media for presenting papers and are also very important as media for internationally spreading the achievements of R&D. The number of journals published in a country reflects that country's position in R&D and degree of internationalization. Internationalization is also believed to indicate the degree of contribution it makes through publication of the scientific journals. The study calculated the number of journals covered in CHI by country. Figure 6-1-4 shows the number of academic journals published by country on the right and the number of papers produced on the left. The number of papers carried was used as the unit of the number of journals. Since journals carry different numbers of papers the number of papers carried was believed more appropriate as a unit. Also, using it facilitates comparison with the number of papers produced. Both in the case of the number of papers produced and of journals published country shares are used instead of actual numbers. In terms of the share of scientific journals showed the U.S. overwhelmed with 40 percent (the length of the bar graph on the right). It was followed by the U.K., the Netherlands and West Germany. These countries are publishing more scientific journals than they are producing papers. The U.S. and the U.K.'s share of published scientific journals comes to slightly under 60 percent when combined. Although this is greatly due to the fact that English is the standard language of science and technology their influence is quite impressive. What requires attention is that the Netherlands has been publishing many journals. It can be said a super power in the publication of academic journals following the U.S. and the U.K. In contrast Japan's share of journals published is only under half of its share of papers produced. Of course this is limited to the papers collected by CHI (Note 1). However there is no denying that few international academic journals are being published in Japan.

Not all papers are contributed to journals are published in the same country. They are also contributed to journals published in other countries. In Japan there has been a tendency to contribute high-quality papers to foreign academic journals. This comprises an "export of papers" and is designed to present excellent research achievements to the world, obtain evaluation on a global level and contribute toward developing the world's scientific and technological base. In contrast when countries make available media for presenting papers (academic journals) papers are also contributed from other countries which correspond to "imports". They are affected by the country's position in R&D and trends of internationalization. Also, if publication exports and imports can be measured it is possible to calculate what amounts to "scientific paper trade balance". Figure 6-1-4 shows the number of papers produced by dividing them into those

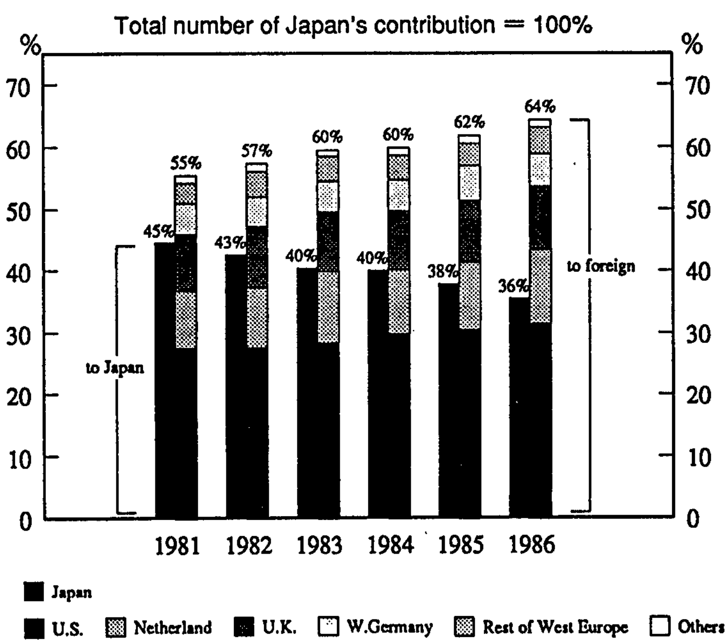
Figure 6-1-4 Number of Scientific Papers Produced by and Scientific Journals Published in Selected Countries (aggregate for 1984-1986)



Note that (A) = (C)

Source: Computer Horizons, Inc. "Science & Engineering Literature Data Base 1989"
See Table 6-1-4

Figure 6-1-5 Trends of Papers Contributed from Japan To Publications (by country)



Source: Computer Horizons, Inc. "Science & Engineering Literature Data Base 1989"
See Table 6-1-5

contributed in the country and abroad. It also shows the number of papers carried (previously this was treated as "number of academic journals published") by separating them into domestic and foreign (Note 2). The figure shows that many of the papers produced in the U.S. are contributed to U.S. journals. Also, although domestic papers are more numerous in terms of the number carried, a considerable number are also contributed from abroad so that the U.S. "scientific paper balance" is in the red. In the U.K. many papers are contributed to domestic journals but the ratio of those contributed to foreign journals is higher than that of the U.S. In terms of the number of papers carried more papers are contributed from abroad, hence the country is also running a large deficit. In the Soviet Union few papers are contributed to foreign journals and even fewer are contributed from abroad. In Japan many of the papers produced are contributed to foreign published academic journals. In contrast few foreign papers are contributed to Japanese published journals hence its paper balance is running a great surplus.

Figure 6-1-4 shows that many Japanese papers are contributed to foreign journals. Then to which countries are they being contributed to? Figure 6-1-5 shows trends of the destinations of Japanese papers. Even during the short period from 1981 to 1986 the ratio of papers contributed to foreign journals has upped nearly 10 percent. The greatest destination has been the U.S. and the rate of increase has also been the greatest. It can be said that Japan is not only increasing the number of papers published but also internationalizing its paper publishing activities.

As mentioned Japan has been quantitatively increasing its R&D achievements. It has also been increasing its influence in the world as shown by the citation rates. However, as these two indicators suggest, it is believed necessary for Japan to enrich its contribution through publication of international academic journals which are important in spreading the achievements of R&D.

Notes:

(1) CHI has not made the names of the journals from which it collects papers public. However they include around 80 journals published in Japan which are believed to include Japanese language journals. This is based on a list of journals collected by SCI published in the form of a booklet (reference 1) and the related data are also made available. By comparing these and CHI's data it is believed that CHI is collecting perhaps all of the Japanese academic journals collected by SCI.

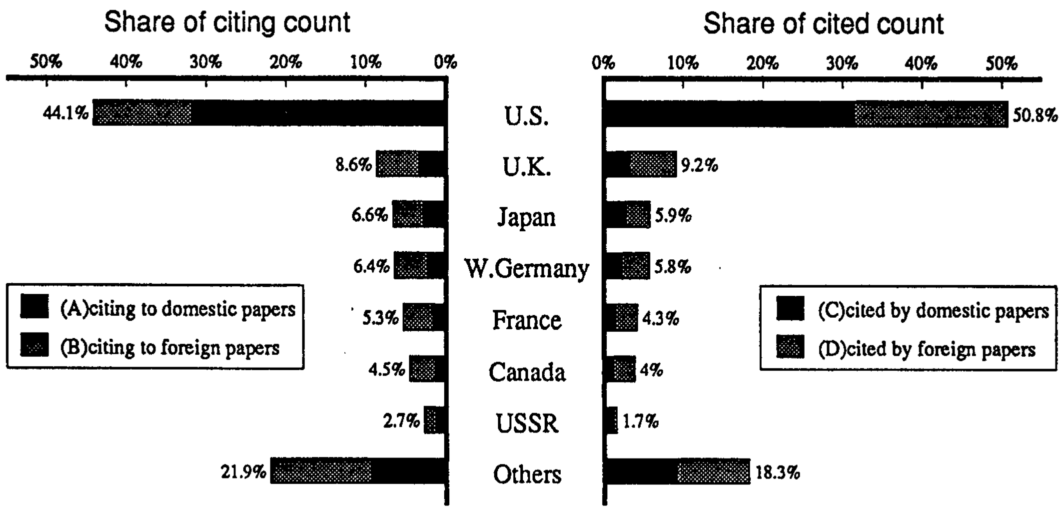
(2) If contribution to foreign academic journals can be likened to exports those to domestic journals can be likened to "domestic shipments." Likewise, publishing of papers contributed from abroad corresponds to imports and printing of domestic papers to "domestic procurements." It should be Noted that domestic shipments (the number of papers contributed to domestic journals in the left-hand graph) equals domestic procurement (the number of domestic papers carried in the right-hand graph).

6.1.4 Citation Flows

Flows in the form of paper contributions between a country producing papers and the one publishing academic journals is one type of international flow. Paper citations can also be thought of as flows this time between the country citing papers and the one being cited. This is called citation flow.

Figure 6-1-6 shows the citing share on the left and cited share on the right by country. Citations are divided into those for domestic and foreign papers. The number cited is divided into the number of domestic and foreign papers. First, in order to show country differences of paper citing, the number of times one country's authors cited their own papers is compared to that of foreign paper citations (left-hand graph). U.S. authors more often cited their own papers than foreign origin papers. On the other hand, other countries more often cited foreign papers over domestic ones. Part of the reason is believed to be the fact that the U.S. has an overwhelming share of the papers. Moreover, as an indicator of the international position of a particular country's papers as objects of citation, this study has measured foreign and domestic paper citations (right-hand graph). In terms of citation by foreign papers the U.S. naturally occupies the top position internationally followed by the U.K. Comparing Japan and West Germany shows that while Japan has the edge in terms of the total number of citations, West Germany has the edge in terms of citations from abroad. When consideration is given to the largeness of the

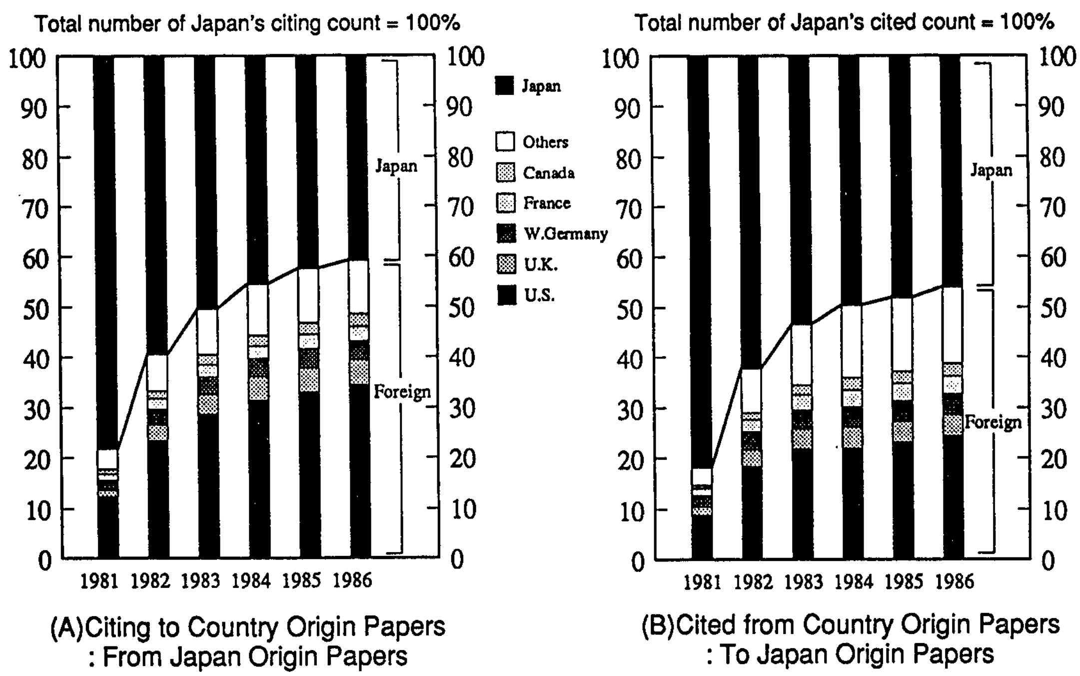
Figure 6-1-6 Citing and Cited Share Counts of Scientific Papers by Country (aggregates for 1984-1986)



Note that (A) = (C)

Source: Computer Horizons, Inc. "Science & Engineering Literature Data Base 1989"
See Table 6-1-6

Figure 6-1-7 Citing and Cited Trends of Scientific Papers to and From Country of Origin



Source: Computer Horizons, Inc. "Science & Engineering Literature Data Base 1989"
See Table 6-1-7

number of Japanese papers contributed to foreign journals (Figure 6-1-4) the number of times Japanese papers are cited by foreign papers is said to be small.

It is difficult to interpret the tendencies shown in Figure 6-1-6 and it is not possible to immediately draw the conclusion that Japan is closed. The study analyzed time trends for the number of times Japanese papers cite others and were cited. Figure 6-1-7 (A) shows the trends of the papers cited by Japanese papers by country. In 1981 nearly 80 percent of the papers cited by Japanese papers were by other Japanese. This ratio had declined to around 40 percent in 1986 hence citing of foreign papers has drastically increased in this short period. In contrast Figure 6-1-7 (B) shows cited trends of which country origin papers cited Japanese papers. In 1981 over 80 percent of Japanese origin were cited by Japanese papers. By 1986 foreign papers had come to account for over half of such citings. As already shown in Figure 6-1-3 the number of times Japanese papers are cited has increased at a pace unprecedented compared with that of other countries. There have been structural changes namely an increase of citations by foreign sources of Japanese papers. It is no exaggeration to say that the change in Japan's international position in the 1980s has been dramatic.

6.2 Patenting, Citations and Registration of Botanical Species

R&D achievements from technologies connected with industries have an important economic value. While such R&D achievements have a proprietary value for the developer it is beneficial that they widely be used. Hence the patent right system has been established to protect owner benefits of technologies having economic value and promote the disclosure of invention contents. The Patent Act calls knowledge which can exclusively be possessed "patent invention" and defines it as comprising a "product of technological ideas which uses natural laws and is of high-level." As compensation for disclosing the contents of the knowledge thus defined, the inventor or developer is guaranteed to exclusively possess the patented invention for a certain period of time. This spreads technology and promotes technological development.

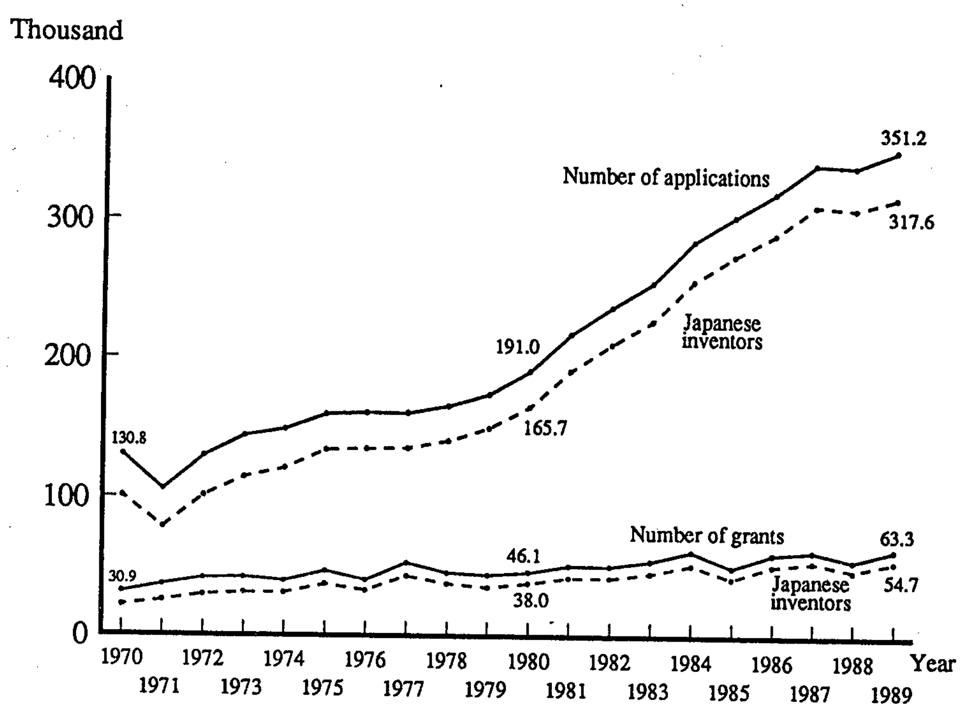
Based on this premise of the patent right system, R&D achievements related to industrial competitiveness can be examined using patent statistics. Such statistics are relatively reliable because the procedures for applying for and registering patents are handled by public agencies (source 2). However the patent system greatly differs across countries so that in conducting international comparisons it is necessary to interpret the findings by fully taking account of such differences. It must also be remembered that there is no one-to-one correspondence between patents and inventions. When these points are Noted patents become an important and indispensable indicator of R&D achievements.

In addition to patents this chapter also discusses the number of registered plant varieties. The said number is indicative of R&D achievements in the area of plants. It is an indicator similar in nature with the number of patents and is important in examining such trends as of the rise of biotechnology in the recent years.

6.2.1 National Patent Applications and Grants

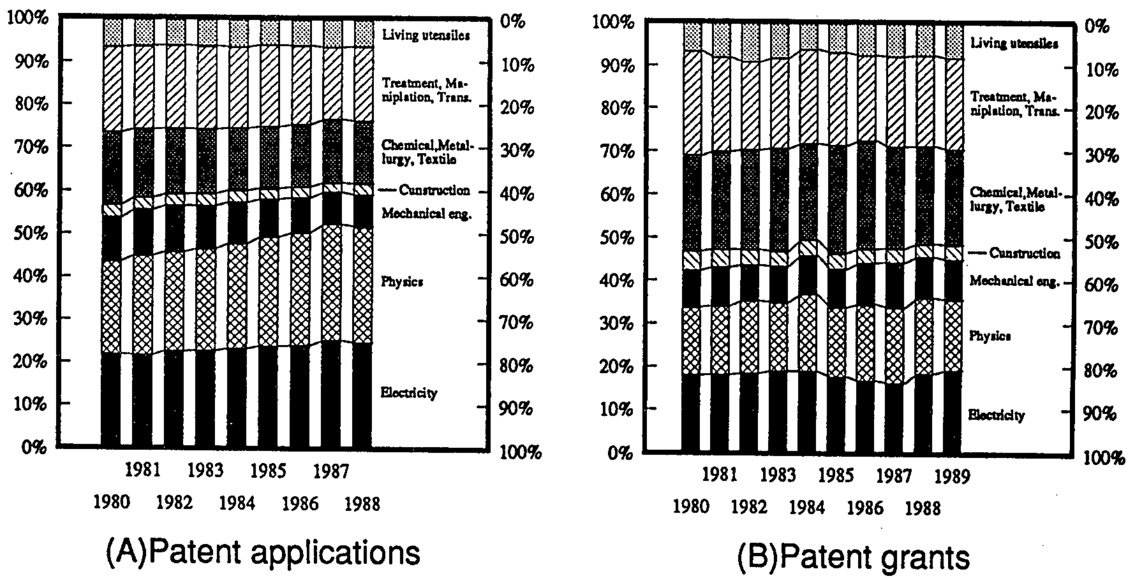
In Japan 351,207 patents were applied and 63,301 were registered in 1989. The number of applications in the major countries is given as reference. To compare country data for the same year, data for 1987 were used. The order for applications was Japan 341,000, the Soviet Union 182,000 (including certificates of inventors), the U.S. 134,000, West Germany 42,000, the U.K. 32,000 and France 19,000. The number of patents registered by country in 1987 were the Soviet Union 85,000 (including certificates of inventors), the U.S. 83,000, Japan 62,000, West Germany 40,000, the U.K. 29,000 and France 30,000 (Note 1). Since patent systems differ across countries these figures should not be interpreted to directly indicate the size of a countries' R&D achievements. However, this background needs to be kept in mind in analysis of patent data.

Figure 6-2-1 Patenting Trends in Japan



Source: Patent Agency, "Patent Agency Annual Report 1989"
See Table 6-2-1

Figure 6-2-2 Patenting Trends in Japan by Sector



Source: Patent Agency, "Patent Agency Annual Report 1989"
See Table 6-2-2

The numbers of national patent applications and grants in Japan are useful indicators in reflecting changes in the size of R&D achievements (Figure 6-2-1). The number of patent applications in Japan has rapidly been increasing particularly in the 1980s. Many of them were applied for by Japanese nationals. Perhaps the increase in the number applied is related to the increase of R&D expenditures in Japan after the latter 1970s. In contrast the number granted has not been increasing as much as the number of applications. The reasons could include insufficient preliminary investigation by applicants so that similar patents are repetitively applied for, applications are not accepted because inventions are obsolete or applications are designed to invalidate identical applications by others. These are believed to be reasons why nearly half of the patents applications in recent years are rejected. Another reason for the large increase might be that the patent screening system has not been able to cope with the rapid increase of applications.

To examine patenting trends by technological area Figures 6-2-2 (A) and 6-2-2 (B) show the number of patent applications and grants by area. The number applied for in 1988 and classified (336,232 cases) were made up of those in the area of physics, (90,954, 27.0 percent), electricity (83,510, 24.8 percent), processing, control and transportation (58,382, 17.4 percent), chemicals, metallurgy and fibers (48,703, 14.5 percent), mechanical engineering (24,978, 7.4 percent), daily commodities (21,269, 6.3 percent) and construction (8,436, 2.5 percent). Comparison with 1980 shows that patent applications in the area of physics have grown drastically by 11 points from 15.7 percent in 1980. In terms of grants, the major areas were chemicals, metallurgy and fibers (13,921, 22.0 percent) and processing, control and transport (13,567, 21.4 percent). Even when consideration is given to the time taken from application to grant the number registered in the areas of physics and electricity must is small compared to the number applied.

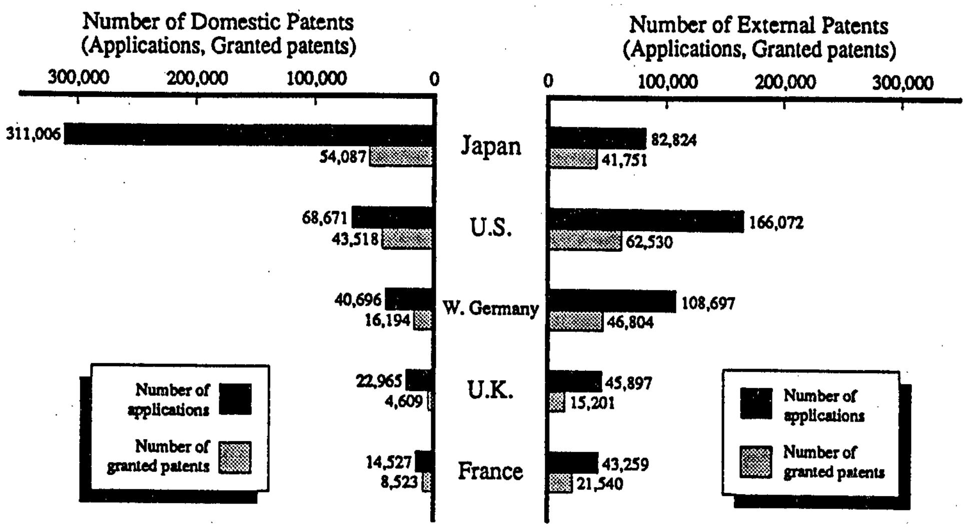
Notes:
(1) The number of national patent applications here means the total number applied in a given country including the number applied for from abroad. Therefore it is not appropriate as an indicator of the size a country's R&D achievements. However since it is easy to obtain it is often used as "number of patent applications". It must also be remembered that this includes the number of countries designated under the European patent application system (EPC application).

6.2.2 Domestic and External Patenting by Country

The number of patent applications by country totals the number of patents for each country accepting and screening patent applications thus by itself it is not appropriate in assessing country R&D achievements. It is necessary to determine the totals of the number of patents by applicant country. Also, to avoid problems resulting from differences in the patent systems across countries it is useful to calculate the number of patents not affected by a country's system by separating those which were applied to foreign countries (externally). Figure 6-2-3 hence shows the number of patents applications by major countries in 1987 by distinguishing between domestic and external applications. The number of patents registered is also shown by distinguishing between domestic and external grants.

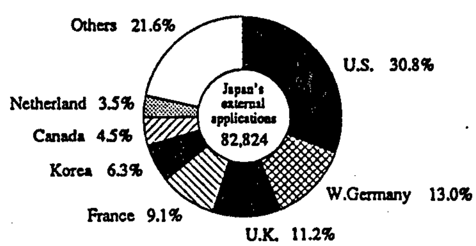
Japan is characterized by a large number of domestic applications (311,000 cases). This has three facets. First, compared with the number of patents applications by U.S., West German, U.K. and French inventors in their own countries more patents are applied by Japanese inventors in Japan. Since inventors first try to apply for patents in their own country the number of patents applied for domestically is believed to be a direct indicator of the level of R&D activity. Indeed, many patent applications are applied for by Japanese inventors in Japan. This pattern of patenting is said to reflect an active R&D system. Secondly, far more patents are applied for in Japan than are granted (54,000). In other words few applications are accepted. Although more patents are granted in Japan than in the U.S. the difference is not as large as the case of applications. Since patents are granted through screening, the number granted is more appropriate as an indicator for qualitatively assessing R&D achievements. Thirdly, more patents are being applied for in Japan than externally. In other countries more are applied externally than in the country. There are cases in which the same invention is applied for patents in a number of countries so it seems that more

Figure 6-2-3 Domestic and External Patenting by Country (1987)

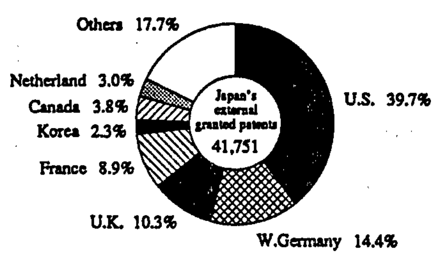


Source: Patent Agency, "Patent Agency Annual Report 1989"
See Table 6-2-3

Figure 6-2-4 Japanese External Patenting (1987)



(A) Japan's external patent applications by country (1987)



(B) Japan's external granted patents by country (1987)

Source: Patent Agency, "Patent Agency Annual Report 1989"
See Table 6-2-4

patents are applied externally because of these overlaps (Note 1). Nevertheless, far more patents are being applied for in Japan than externally. It can be said that there is a tendency for Japanese inventors to emphatically apply for domestic patents. These data delineate R&D achievements in Japan from a global viewpoint without overestimating its influence like the simple and often used "number of patent applications" (to be more accurate, the number of patent applications accepted by countries). While Japan is one of the world's foremost patenting countries it does not have a clear edge over the U.S. or West Germany in terms of international influence but its position can be said to be equal.

As shown in Figure 6-2-3 Japanese inventors applied for 83,000 patents externally of which 42,000 were granted. Figures 6-2-4 (A) and 6-2-4 (B) show the countries. The greatest number of applications were in the U.S. (30.8 percent) followed by West Germany (13.0 percent), the U.K. (11.2 percent), France (9.1 percent) and Korea (6.3 percent). Special notice should be given to the fact that many applications are made in Korea. Japanese applications in Korea are rapidly increasing so much so that that they have come to exceed the number of patents from domestic Korean sources among the patents applied for in Korea. In terms of patent grants many have been granted in the U.S. and West Germany and their shares are larger than those of applications.

Note:
(1) In the case of the European patent application system (EPC application), multiple number of applications were counted by treating a designated number of countries for the same patents in the same way as when applying for patents in all countries.

6.2.3 Patent Applications Accepted and Grants by Patentor Organization

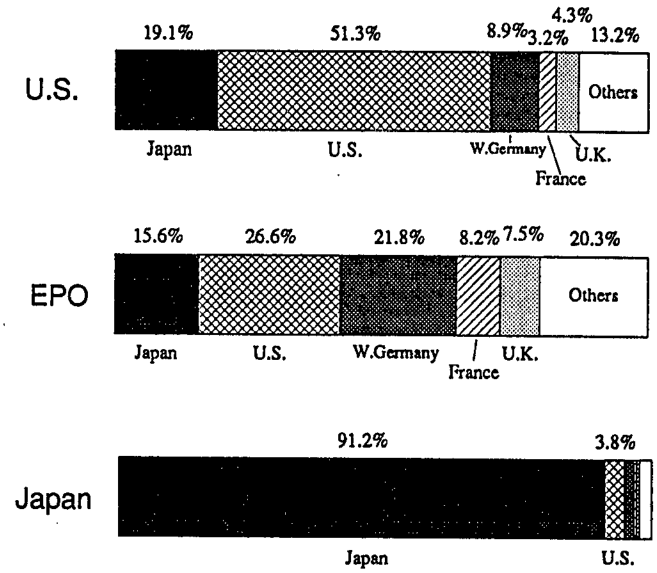
The foregoing section has discussed patents from the point of view of the inventor in a specific country. In examining the flow of patents from inventor country to patentor country, Figure 6-2-3 examines this flow from the side of the inventor country. However, examining this flow from the side of the patentor is also highly suggestive. Hence the study calculates the number of patent applications accepted by Japanese, U.S. and European patent offices and the number of grants by these patentors. These figures are highly significant in that they allow comparison of the number of patents by country under an identical patent system (such as of the U.S., Note 1). This is designed to clarify Japanese patent's position abroad where patenting system is different.

Figure 6-2-5 (A) shows shares by calculating the number of patents applied to the U.S., European and Japanese patent offices by inventor country. As a matter of course the greatest number of patents applied in the U.S. were by U.S. inventors. However nearly 20 percent were applications from Japan which were the most numerous among foreign applications. By region the greatest number of patents applied to the European patent office were from Europe. By country however the most numerous were from the U.S. followed by West Germany, Japan, France and the U.K. In Japan foreign applications did not reach 10 percent even when combined.

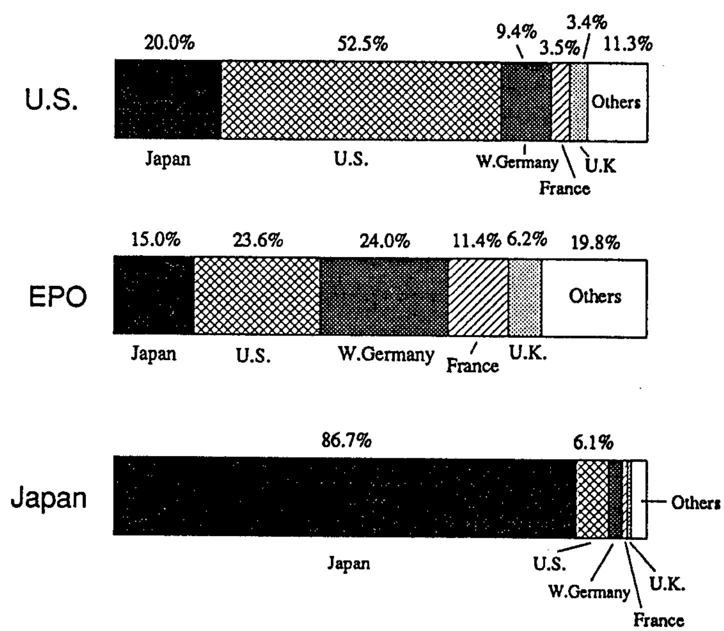
Figure 6-2-5 (B) shows the number of patents grants by calculating the shares by inventor's country. In general it shows more or less the same tendencies as in the case of applications. The share of Japanese patents acquired from the U.S. and European patent offices was slightly larger than the case of applications. The share acquired in Japan was smaller than the case of applications.

Japanese patents applications occupy a increasingly prominent position among those applied to the U.S. and European patent offices. This is indicative of efforts toward international development of patents. However, although their position surpasses that of West Germany, Japan cannot be said to surpass the U.S. In contrast it must be pointed out that external source patents are applied for in Japan.

Figure 6-2-5 Patent Applications and Grants by Organization and Nationality of Inventor (1987)



(A) Patent applications in U.S., EPO and Japan by nationality of inventor



(B) Patent grants in U.S., EPO and Japan by nationality of inventor

Source: Patent Agency, "Patent Agency Annual Report 1989"
See Table 6-2-5

Note:
(1) It must be remembered that this increases patent applications from the domestic country (or region). When comparing Japanese and U.S. patents for example the appropriate method is to compare patents applied to the European patent office. Consideration must also be given to such things as the differences in the progress of economic exchange and in the degree of market internationalization as well as cultural proximity.

6.2.4 Patent Grants and Citations in the U.S.

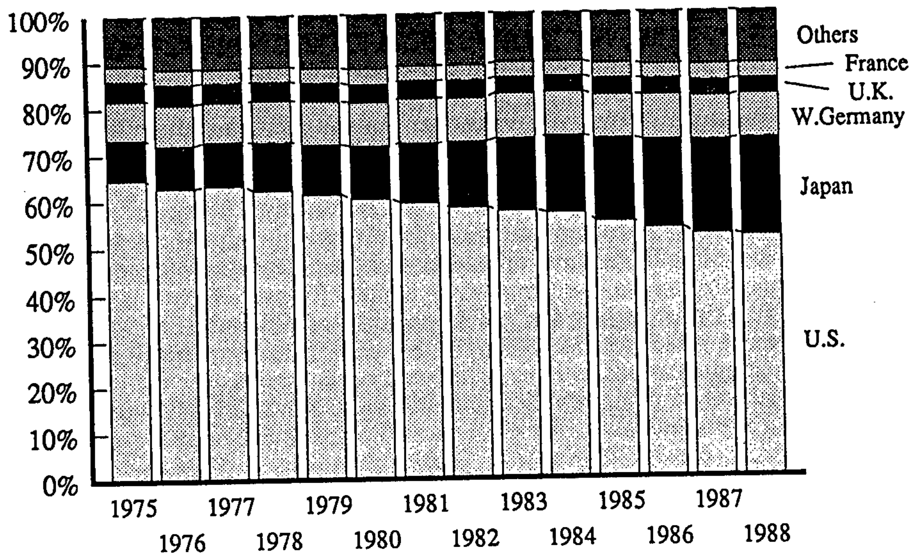
The U.S. comprises the world's largest market and is also the prominent science and technology country. Therefore it is possible that many of the important and high-level patents designed for the global market place are applied for in the U.S. Recent patenting in the US is analyzed (source 3).

Figure 6-2-6 shows country share trends for patents granted in the U.S. The U.S. share has been decreasing every year and that of foreign countries has been increasing. However most of the foreign share increase is ascribable to the contribution by Japan. No other country has greatly increased its share. This clearly shows rapid progress of Japanese R&D in the recent years and efforts to apply for patents in the U.S. Also, while this is not shown in the figure, examining country shares by patent category enables allows a view of which areas of technology Japanese patents have the edge. For example the Japanese share of internal combustion engine-related patents has increased from 16.7 percent in 1975 to 43.9 percent in 1986. During this period the U.S. share in this area has greatly decreased (from 53.7 percent in 1975 to 28.2 percent in 1986). Large Japanese shares are also found in the areas of information and memory, optical technologies and semiconductors.

Examination of patent quality follows. In the U.S. data on patents cited by examiners in the process of patent screening is recorded. These patents are often cited as precedent technologies regardless of the technology's quality evaluation. Hence it cannot be said that the number cited itself is always indicative of patent quality. However it is natural to think that the macro nation-level number of citings reflects the country's technological level. The number of citings per patent registration in particular can be considered as indicative of the quality of R&D achievements. Hence, just as in the case of scientific papers (see section 6.1) Figure 6-2-7 shows trends from 1975 to 1986 by plotting shares of patent registrations on the horizontal axis and those of citings on the vertical axis.

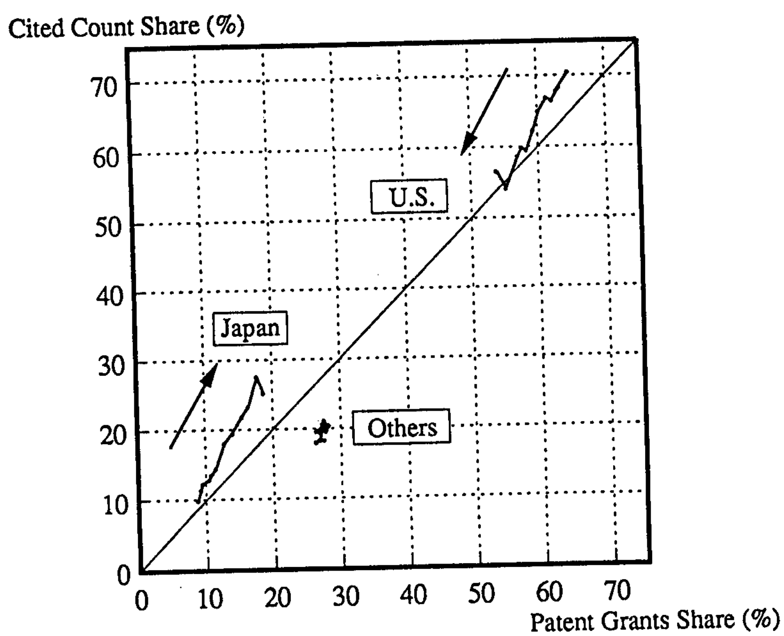
The Japanese share of citings has been greater than the number of patents granted. Therefore the relative citation index obtained by dividing the citing share by the registration share has consistently exceeded 1 during the period covered. Moreover, the citing share has been growing at a pace exceeding the registration share's upping the relative citation index. Given these data it can be said that the Japanese patents granted in the U.S. have rapidly been advancing not just in terms of quantity but also in quality. In contrast, both the U.S. registration share and especially its citing share has been decreasing. As a result, its relative citation index has been declining approaching 1. Countries other than Japan and the U.S. are included in "other". These countries' relative citation indices are below 1 on the average. Even by individually examining them it is not possible to find a country with an index as large as Japan's. These data quantitatively show that Japan is approaching a major technological position in the U.S.

Figure 6-2-6 Patent Grant Share Trends by Country in in the U.S.



Source: Computer Horizons, Inc. "Science & Engineering Literature Data Base 1989"
See Table 6-2-6

Figure 6-2-7 Frequency of Patents Cited in the U.S.



Source: Computer Horizons, Inc. "Science & Engineering Literature Data Base 1989"
See Table 6-2-7

6.2.5 Patents Applications by Industry

When discussing science and technology in Japan it is important to grasp the trends of R&D activities in the industries. This is also clear from the fact that in the recent years the industries account for around 80 percent of all R&D expenditures in Japan. They also have a greater share of patent applications than R&D expenditures. Hence the study examined the present state and trends of R&D by industry using data on patent applications by Japanese companies (source 4).

The data used are the number of patents applied in Japan by Japanese companies in 1985 and 1976. They are analyzed by industry and patent category. Based on the "Quarterly Report of Corporations" (reference 11) and the Management & Coordination Agency statistics' industrial classification (reference 12), companies are divided into approximately 20 categories and patents into 118 categories according to the three-digit international patent classification (reference 13). Companies covered are listed Japanese firms which applied for over 20 patents or utility models in 1985. A total of 640 firms applied for 90,021 patents in 1976 and 212,308 in 1985. These accounted for 66 percent (1976) and 78 percent (1985) of all patents applied by Japanese. It can be seen that the patent applications in Japan which are so numerous are mainly being made by these firms. The analysis of patent applications in 1985 shows the following regarding the present state of patent applications.

(1) In terms of the number of patents applied for by industry the electric machinery industry has the overwhelming edge followed by the transport machinery, precision equipment and general chemicals industries.
(2) The electric machinery industry has considerable shares in almost all of the patent categories, the applications by the transport machinery and general chemicals industries have concentrated in specific areas.
(3) Most of the patent categories in which industries have large shares are core business areas. Applications by industries such as other chemicals and precision equipment have concentrated their patenting in electricity-related patent categories.
(4) In all industries a number of high-ranking capitalized firms account for a majority of the patent applications. In the electric machinery industry for example the top five capitalized firms (4 percent of the firms) account for 51 percent of all patents applied for by the industry.

Changes in patenting trends is shown by comparison of the number of patents applied for in 1985 and 1976.

(1) The number of patents applied for in 1985 by industry was more or less proportional to the number applied in 1976.
(2) In pharmaceuticals, other manufacturing and fibers there have been changes in patent categories applications. Such changes have been small in other chemicals and electric machinery.
(3) Recently differences in patent application policies among firms within the same industry has increased. This tendency has been particularly marked in as the pharmaceuticals, oils and fats, fibers, steel, foodstuffs, general chemicals, other manufacturing and general machinery.
(4) Large capitalized firms in fibers, steel and general machinery which have formed the core of patent applications have been taking the lead in changing their patent application fields.
(5) In industries which are increasing patent applications there has been small difference in the policies among firms within the same industry.

The following can be said in summarizing industrial patenting activities in Japan.

(1) Electricity-related technologies, mainly electronics, have become the main current of technological development in recent years. Supporting these industries are the electric machinery, precision equipment, other chemicals and nonferrous metals industries. In general these industries are markedly increasing their patent applications and there have been

small changes in the direction of their R&D. In addition to electricity-related areas they are often applying for patents in such areas as of photography and printing.

(2) Along with the electricity-related technologies, patents for chemicals-related technologies have become a major technological current common to many industries such as general chemicals, fibers, pharmaceuticals and oils and fats and paints. In recent years however there have been changes in the direction of R&D in all of these industries and such direction has been considerably different across firms. There have also been many patent applications in areas non-core business areas such as the fibers industry into medicine and the general chemical industry into electric devices.

(3) Transport machinery and rubber show strength in machinery-related technologies such as related to vehicles and engines but are not markedly entering other areas. In the general machinery industry companies are oriented toward diverse R&D directions such as agricultural machinery, machine tools and electricity-related.

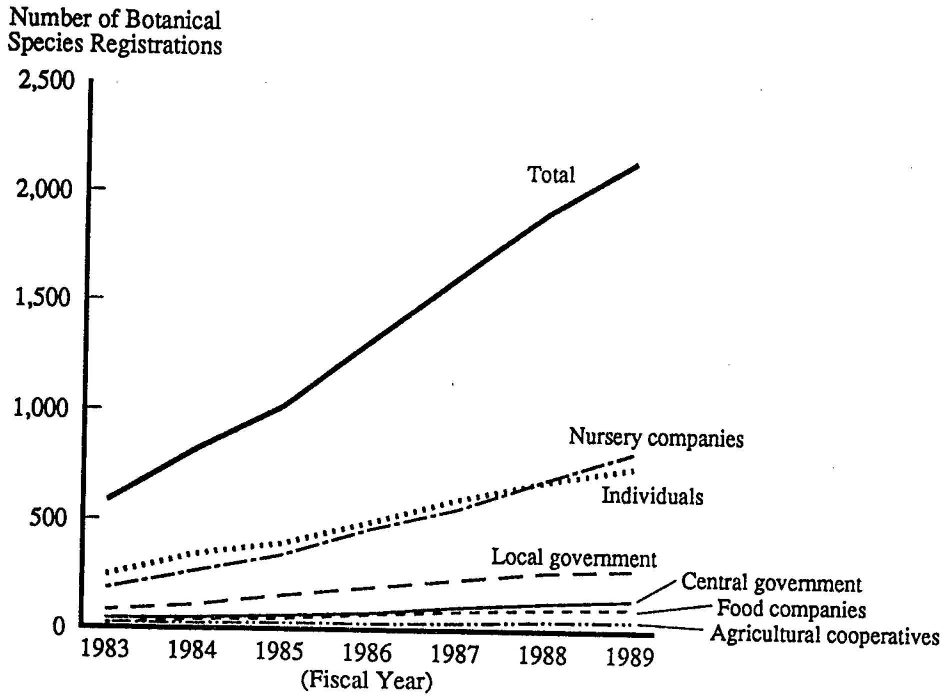
(4) At least until 1985 the steel industry patent applications have grown in such areas as metallurgy and metal processing but there have not been marked changes in the direction of its R&D. Major firms however have been showing signs of change.

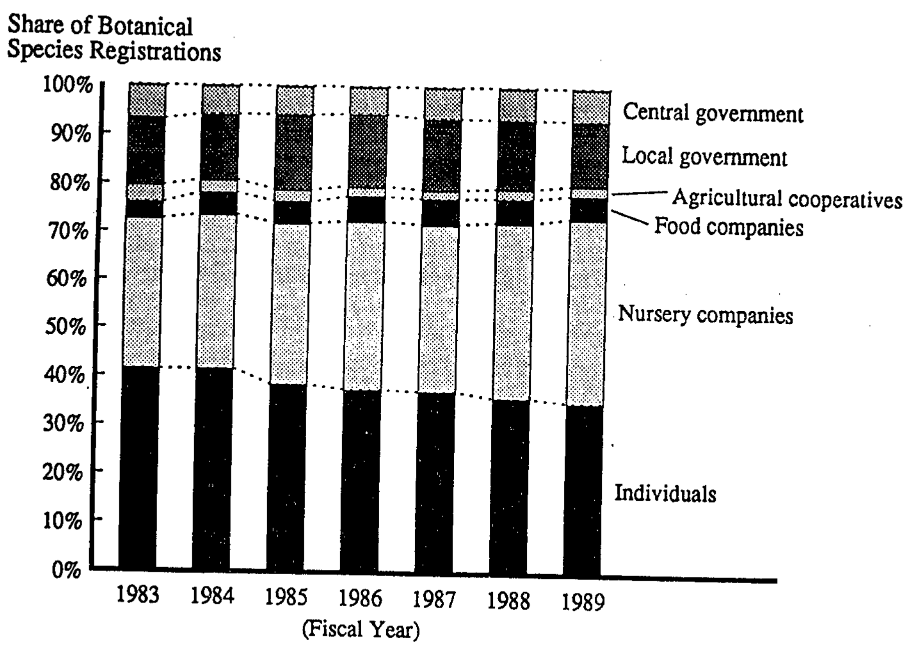
6.2.6 Registration of Botanical Species

In protecting the rights of developers of new plant varieties Japan has established a system for registering varieties based on the Seeds and Saplings Law. Registration application of newly developed varieties are applied for by the developer and granted through screening process. The number of botanical varieties granted through this system is a result of variety development activities against the backdrop of technical knowledge and experience and can be considered as an indicator of R&D activities in the area of plants. Registration requires that the new variety's character (shape, quality, resistance to diseases, etc.) can clearly be distinguished from existing varieties and is stable within the same generation and after propagation. Also required is that the varieties are not marketed prior to application and their names are distinct from those already in existence.

A variety of 430 plants can be granted in areas such as rice, wheat, vegetables, fruit trees, flowers, appreciative trees, mushrooms and laver. As of August 1990 2,388 varieties were granted. Trends of plant varieties granted from 1984 to 1990 show a 200-300 yearly increase. The main registrants are individuals, nursery firms and local self-governing bodies. In the recent years the shares of individuals and agricultural cooperatives, etc., have been decreasing and while those for nursery firms are increasing. These organizations are believed to have advanced technical and organizational R&D systems (Figure 6-2-8). 50 percent of the registered species are flowers followed by appreciative trees and vegetables. Development of botanical species in the past was made principally through classical crossbreeding methods. In recent years however, bio-technology methods such as cell and tissue culture, embryo and ovule culture and cell fusion are more frequently utilized and could result in an even larger number of registered species in the foreseeable future.

Figure 6-2-8 Trends in the Number of Botanical Species Grants





Source: Ministry of Agriculture, Forestry and Fisheries, and NISTEP
See Table 6-2-8

6.3 Industrial Standards

Academic papers and patents are generally used as direct indicators of R&D achievements. This section also examines industrial standards as an indicator of the public property value of R&D achievements. From the viewpoint of production in an industrial society, it is very important to maintain uniform quality. For this reason standards play an important part in scientific and technological activities. Unified standards aid in smooth industrial production activities while concurrently, the achievements of scientific and technological activities in turn enrich industrial standards. Standards can be therefore said to reflect the level of scientific and technological activities.

6.3.1 Industrial Standards in Japan

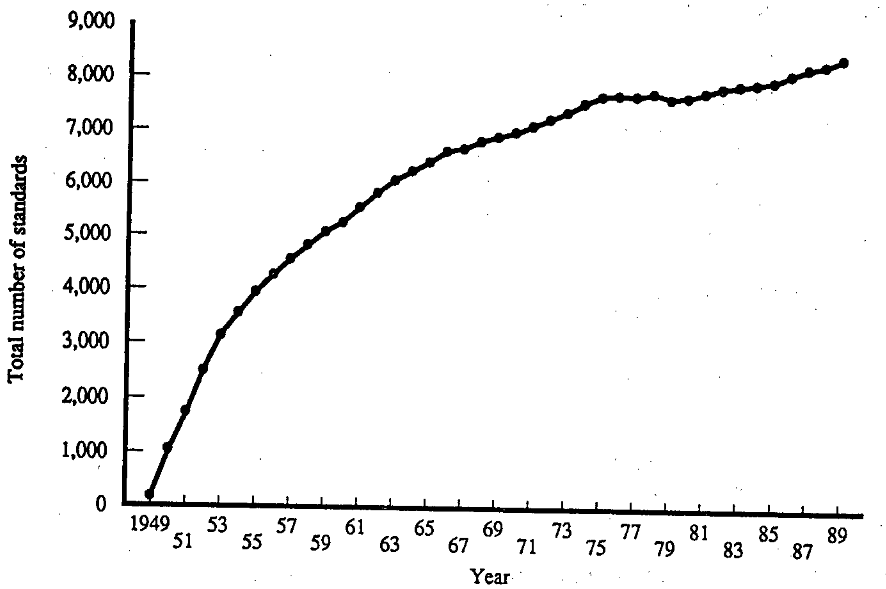
There are five objectives in standardization of scientific and technological activities: (1) unification of terms, symbols and drawings to ensure mutual understanding, (2) ensuring of safety of man and materials, (3) ensuring of commonness and interchangeability to assure system compatibility, (4) development of the product quality and performance for fit and use and (5) simplification of products to limit their kind. Achieving these objectives generates many effects such as rationalization of production, distribution and consumption, quality development and cost reduction.

The history of industrial standardization systems in Japan goes back to the Taisho Era (1912-1926). However Japan Industrial Standards (JIS) are based on the Industrial Standardization Law enacted in 1949. As of the end of fiscal 1989 there were 8,414 standards (Figure 6-3-1). Since 1949 a total of 11,656 standards have been enacted, 19,749 revised and 3,242 abolished. Examining the number of standards over time shows a striking increase from around 1949 to 1950. This increase in the initial period is believed to have been due to development of the standard system itself. Afterwards the pace of increase has gradually slowed down. The number however is still increasing due to technological progress and social demand.

Examining the number of standards by sector is useful in seeing technological trends (Figure 6-3-2). As of the end of fiscal 1989 the sectors having a large number of standards were chemicals 1,654 (20 percent), general machinery 1,266 (15 percent) and electronics and electric equipment 819 (10 percent). These are all standards in technological areas comprising the basic infrastructure of Japanese industry. The fact that there are many standards in the chemicals and electronics and electric equipment sectors is believed to be related to the fact that the chemical and electric machinery industries form the core of Japan's manufacturing along with the transport machinery industry. On the other hand, the number of standards in the general machinery area is believed to be a reflection of the nature and technology than of industrial structure. This is because the technology related to general machinery is used in diverse industries. For example many machinery-related standards are applied to directly to motor vehicles in addition to those related to motor vehicles. The fact that the number of automotive standards is not so large compared to the industry's size is believed to support this view.

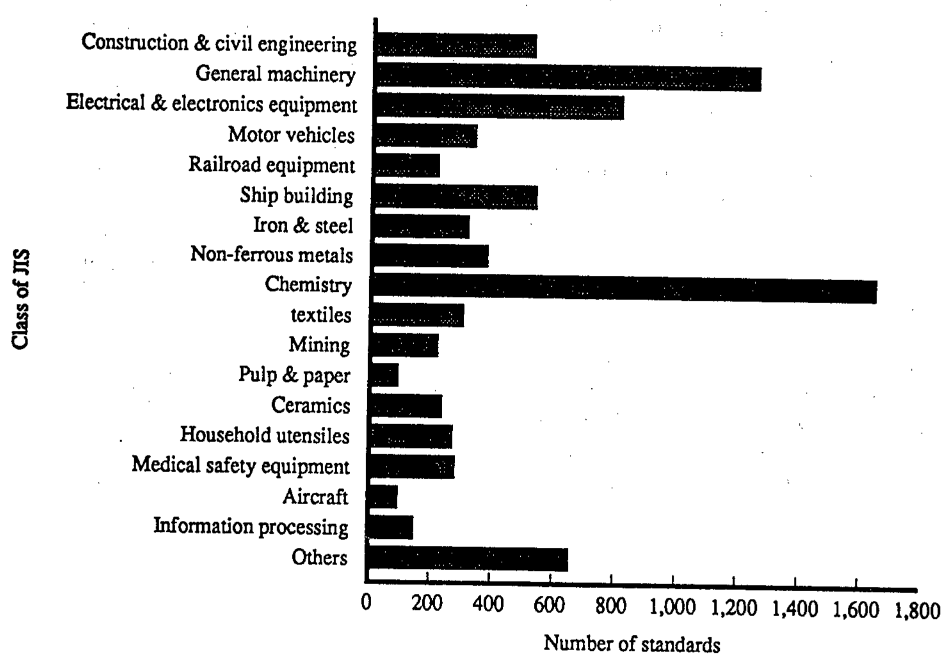
The year in which the standards were enacted by sector is also instructive to examine. Many standards in the chemical sector were enacted in the first half of the 1950s. In contrast the year of standards enactment in the general machinery and civil engineering and construction sectors was dispersed. Many of the standards in the electronics and electric equipment and the information processing sectors were enacted in the 1980s. This can be interpreted as an indirect indication of the rapid changes in the industrial production patterns centering around electronics. Many of the standards in the medical safety equipment sector were enacted in the latter 1980s. It is possible to infer a situation in which the demand increased for technologies related to safety as being a social requirement for harmony between science and technology and human living.

Figure 6-3-1 Trends in the Number of Japan Industrial Standards (JIS) (cumulative)



Source: JIS Directories, 1990
See Table 6-3-1

Figure 6-3-2 Number of JIS Standards by Sector (end of FY 1989)



Source: JIS Directories, 1990
See Table 6-3-2

6.4 Evaluation of Japanese Scientific and Technological Achievements through the Award for Persons of Scientific and Technological Merit

It is said that scientific and technological developments in Japan after World War II have chiefly and greatly been due to introduction of technologies from the Western countries. However Japanese industries and other sectors have also made efforts to develop their own technologies. Japan has already caught up with the developed countries in many areas of science and technology. There is now increasing calls for Japan to conduct R&D which can make global contributions. To do so it is necessary to evaluate the results of the past efforts to develop technologies domestically. In doing so useful is an indicator which qualitatively assesses the R&D achievements which have provided significant impacts on science and technology. An example of evaluation of scientific and technological achievements based on the Award for Persons of Scientific and Technological Merit rewards system is reviewed (source 5).

6.4.1 Evaluation of Japanese Scientific and Technological Achievements through the Awarding System

A system for awarding scientific and technological achievements is designed to select outstanding R&D achievements using uniform evaluation standards. If it has wide coverage and the evaluation standards are highly reliable the award system is suitable in providing a glimpse of scientific and technological trends. As one example this study analyzed scientific and technological achievements which were granted the Award for Persons of Scientific and Technological Merit. This is one of the Minister of State for Science and Technology Agency awards. During the 31 years from 1959 when the system was inaugurated to 1989, 637 scientific and technological achievements were selected and awarded. Often awarded achievements are those related to organic chemicals (47 cases, 7.4 percent), transport machinery (45, 7.0 percent), precision machinery (45, 7.0 percent), steel (38, 6.0 percent), electronics and communications parts (38, 6.0 percent), wire and wireless communications equipment (31, 4.9 percent) and ceramics (27, 4.2 percent).

Time trend data for the 1960s indicate 193 items were awarded. By technological category the most numerous were related to precision machinery (17 cases, 8.8 percent) followed by organic chemicals (16, 8.3 percent), transport machinery (13, 6.7 percent), steel (11, 5.7 percent) and pharmaceuticals (11, 5.7 percent). The decade was characterized by numerous awards in precision machinery, organic chemicals, transport machinery and steel which are indicative of science and technology efforts aimed at heavy industry, mainly the heavy chemical industry.

In the 1970s 154 items were awarded. By technological category the most numerous were those related to electronics and communications parts (14 cases, 9.1 percent), followed by organic chemicals (12, 7.8 percent), chemical machinery and equipment (11, 7.1 percent), steel (10, 6.5 percent) and construction (10, 6.5 percent). Compared to the previous decade electronics and communications parts ranked at the top supporting the steady progress of development in the electronics technology.

290 items were recognized with awards in the 1980s, up 88.3 percent from the previous decade's 154. By technological category the most numerous were related to transport machinery (24 cases, 8.3 percent) followed by precision machinery (21, 7.2 percent), electronics and communications parts (21, 7.2 percent), organic chemicals (19, 6.6 percent), steel (17, 5.9 percent) and ceramics (17, 5.9 percent). In this decade chemistry-related science and technology awards decreased in number.

Sources:

The data on academic papers in section 1 were calculated using (1). Those on patents in section 2 were based on (2) except for the number of patent applications by industry. The said number was quoted from (3). (4) is the source of the data on the number of plant varieties registered. The data in section 3 were calculated using (5). The source of section 4 is (6).

(1) Computer Horizons, Inc., "Science & Engineering Indicators Literature Data Base," 1989.
(2) Patent Agency, "Patent Agency Yearbook," yearly editions.
(3) Toshiya Nanahara and Fujio Niwa, "Patent Applications and Japanese Firms' R&D Trends," (March 1990, National Institute of Science and Technology Policy, Science and Technology Agency).
(4) Study by Seeds and Saplings Division, Agricultural Production Bureau, Ministry of Agriculture, Forestry and Fisheries and National Institute of Science and Technology Policy, forth research group.
(5) Japan Standards Association, "JIS Catalog," April 1990.
(6) Akio Nishimoto and Hajime Nagahama, "Awarding System and Japanese Science and Technology Trends," (March, 1990, National Institute of Science and Technology Policy, Science and Technology Agency).

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(1) Institute for Scientific Information, "Science Citation Index."
(2) Institute for Scientific Information, "Science Citation Index Data Base."
(3) Science and Technology Agency, "Report on International Distribution of Science and Technology Information."
(5) National Science Board, "Science & Engineering Indicators - 1989," U.S. Government Printing Office, 1989.
(6) Hamilton, D.P., Science. 250, 1331-1332 (1990).
(7) Hamilton, D.P., Science. 251, 25 (1991).
(8) F. Narin and J.D. Frame, "The Growth of Japanese Science and Technology," Science, Vol. 245, pp. 245-605, 1989.
(9) Fujio Niwa, Hiroshi Suzuki and Toshiya Nanahara, "Diversification of R&D Activities in Japanese Companies Using Patent Statistics," The 2nd International Conference on Management of Technology at Miami, USA, 1990.
(10) Fujio Niwa, "The Measurement of Technology Diversification Using Patent Application - Trunk Technologies for Comprehending Technological Activities," The 2nd International Conference on S&T Policy Research, Oiso, Japan, 1991.
(11) Quarterly Report of Corporations - Vol. 4, 1988, Autumn," Toyokeizai Shinposha, 1988.
(12) Management & Coordination Agency Statistics Bureau, "Report on the Survey of Research & Development," yearly editions.
(13) Patent Agency, "Search Guide for International Patent Classification (4th Edition)."
(14) Science and Technology Agency, "White Paper on Science and Technology," yearly editions.

CHAPTER 7

INTERNATIONALIZATION OF RESEARCH AND DEVELOPMENT

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In 1989 Japan's Gross National Product, in nominal terms, reached $2,834,500 million, accounting for as much as 14 percent of the total world GNP. Accompanying such remarkable economic growth have been strong demands for Japan to make a more significant contribution to world development. In research and development, Japan spent a total of ¥11,815,500 million in 1989, and is second only to the United States. Japan is expected to take a more active and appropriate role in basic research, and should make efforts to ensure reasonable access to its R&D activities. With these expectations as a backdrop a steady increase of research exchange with other countries are expected.

This chapter looks mainly at R&D by private companies in terms of internationalization. With the rapid progress of socioeconomic globalization in recent years, competition within the corporate sector is growing more fierce as companies are staking their very survival on expanding R&D activities that extend beyond national boundaries. Internationalization of R&D can thus be said to be moving ahead at an unprecedented pace.

This chapter comprises two sections, "Exchange of R&D Personnel" and "Cross-border Flows of R&D". The first section discusses the present state of exchanges of research engineers in Japan and overseas. It also describes the special features of international seminars, which are an important arena for exchanges among researchers. The second section examines trends of research laboratories established by overseas affiliates of Japanese companies and by Japan-based affiliates of overseas companies, and describes the difference in their R&D activities. This chapter also looks at technological trade and how it has altered international technological development capabilities in terms of overseas expansion by Japanese companies.

7.1 Exchange of R&D Personnel

7.1.1. Exchange of Research and Engineers

It has been pointed out that in Japan basic research funds account for a smaller percentage of total R&D funds than those in the United States and Europe (this is what has become known as "Japan's free ride on basic research"). It has also been pointed out that for the past few years there has been an imbalance in researcher exchanges between Japan and many other countries. Specifically, Japan sends vast numbers of R&D S/E to the United States and Europe to acquire new knowledge, and then uses this in the development of manufactured products back in Japan. In contrast, it has been pointed out that Japan is closed to R&D S/E from the United States and Europe, and has done little to create a structure to accept overseas R&D S/E. When discussing an imbalance in researcher exchanges, we must first take a quantitative look at the present situation. But since there is no statistical survey from which a precise understanding of the present researcher exchange situation can be had, it is not always possible to describe these issues in quantitative terms.

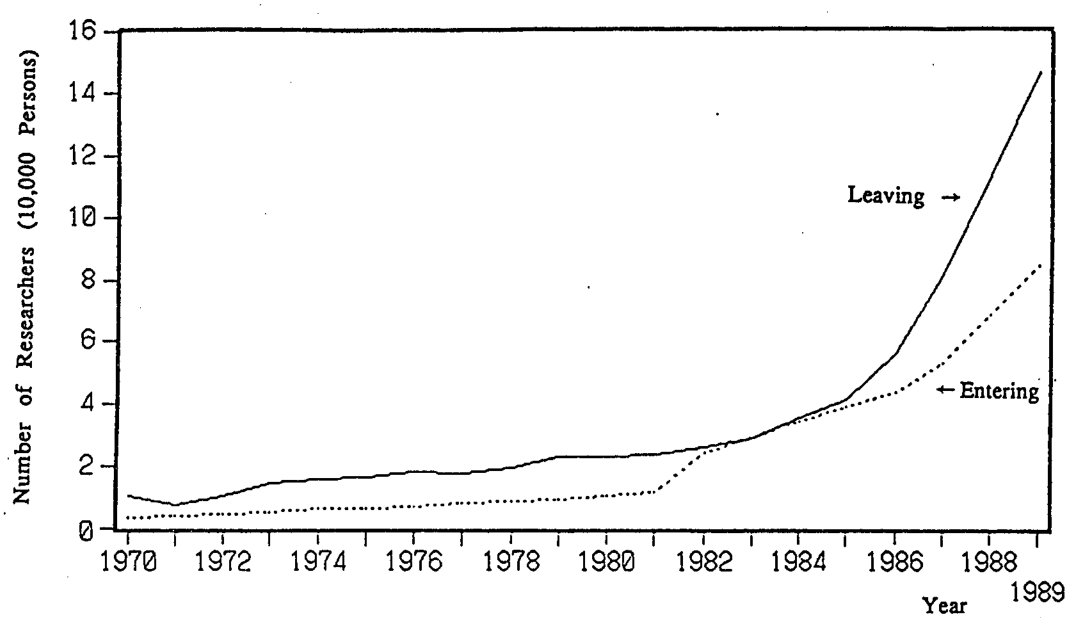
The state of researcher exchanges between Japan and other countries is analyzed using the data in the "Immigration Statistics" published by the Ministry of Justice as the basic data. Since it was difficult isolate data related specifically to R&D S/E in these statistics, the analysis covers those engaged in research in natural sciences, humanities and social sciences, and also those associated with learning or teaching industrial technologies or skills. The Immigration Control and Refugee Recognition Law classifies purpose of overseas travel into eleven items, and of these, this analysis on R&D S/E dispatched overseas from Japan was restricted to those who had been sent overseas with the aim of either "academic research or studies" or "overseas studies, training or skills acquisition". As for acceptance of overseas R&D S/E, from among the eighteen kinds of residential status those entering Japan for the purpose of "study", "training", "teaching", "artistic or academic activities" or "provision of high-grade technology" are taken up in the data base. The term "research engineers" is applied to all of these people.

(1) Overall Trends

In 1989 146,488 research engineers left Japan to other countries (personnel leaving), accounting for 1.5 percent of all Japanese who departed Japan. In the same year, 84,295 overseas research engineers came to Japan (entering personnel), accounting for 2.8 percent of all foreigners entering Japan. From the 1970s until the mid 1980s the number of leaving and received personnel showed a steady increase (Fig. 7-1-1), but from the latter half of the 1980s it rose sharply, particularly the number of those leaving, which in 1989 was 3.6 times as great as in 1985. This hints at the remarkable progress made in the internationalization of science and technology exchanges from the latter half of the 1980s.

In 1982 "training" was added to the classifications for residential status in Japan, accounting for the sharp increase in entering personnel. If this this "training" status is not taken into account, then the number of those entering showed only a moderate rise.

Figure 7-1-1 Number of Research and Engineers Leaving and Entering Japan



Ministry of Justice, "Statistics on Immigration Control"

(2) Japanese Research Engineers Leaving Japan

The number of Japanese sent overseas under the category of "academic research or studies" or "overseas studies, training or skills acquisition" continued to increase steadily until about 1985, and the ratio between the two stood at 1:1.4. The number of those leaving increased sharply, and in 1989 33,254 Japanese travelled overseas for "academic research or studies", while 113,234 left Japan for "overseas studies, training or skills acquisition". The ratio thereby expanded to 1:3.4. It can be seen that in 1989 almost 80 percent of all Japanese research engineers going overseas went for the purpose of acquiring knowledge and skills in the host country by studies or training. From this it is evident that more and more Japanese research engineers are travelling overseas to gain an insight into science and technology in other countries.

Most people who left Japan for the purpose of "academic research or studies" or "overseas studies, training or skills acquisition" went to the United States or Europe. In fact slightly more than 50 percent of the people who left Japan for "overseas studies, training or skills acquisition", and one third of those who left for "academic research or studies" went to the United States, making it by far the most popular destination (Fig. 7-1-2).

By region, over the past 20 years the vast majority of Japanese research engineers have gone to North America, Europe or Asia. The number going to North America increased sharply from the latter half of the 1980s, and in 1989 stood at more than half of all leaving personnel: 74,554 were sent to North America, while 34,287 were sent to Europe, and 30,225 to Asia. More than 90 percent going to North America went to the United States, while more than 70 percent of those sent to Europe went to three countries: United Kingdom, France and West Germany. There was also a sharp increase in the number heading to the United Kingdom during the mid 1980s. In 1989, 69,556 research engineers (almost 50 percent) were sent to the United States, followed by the United Kingdom with 13,511 and China with 8,606. Together, these three countries accounted for more than 60 percent of all research engineers sent overseas from Japan.

(3) Foreign Research Engineers Entering Japan

Every year since 1970 most research engineers entering Japan have done so for the purpose of "study", and since 1982, this has been followed by "training". Since the late 1980s both categories have shown the same high rate of increase. In 1989, 45,424 research engineers came to Japan for the purpose of "study", and 32,512 came for "training", and together these two categories accounted for more than 90 percent of all the personnel entering the country. In contrast, less than 10 percent came to Japan for "artistic or academic activities", "teaching" or "provision of high-grade technology" (Fig.7-1-3). From this it can said that research engineers are entering Japan to acquire knowledge and skills from Japan through study and training, while an extremely small number are entering to provide Japan with knowledge through teaching activities. Almost 90 percent of those entering Japan for "studies" and three-quarters of those who entered for "training" came from Asia.

In fact, since 1970 those entering from other Asian countries have consistently accounted for the majority of research engineers entering Japan. In 1989 there were 67, 248, or 80 percent of all received personnel, followed by 6,255 from North America, and 4,640 from Europe. By country, 20,286 came from South Korea (about one-quarter of the total), 15,015 from Taiwan and 11,763 from China; and together these three countries accounted for 60 percent of all received personnel, and 70 percent of those from the Asian region. It can be seen that most overseas research engineers entering Japan have come from the Asian region to acquire scientific and technological knowledge and skills.

(4) Research Engineer Exchanges

When analyzing the state of researcher exchanges, the issue of whether the statistical survey used here will give an accurate understanding of researcher movements is necessary. For example, there is a need to ascertain whether research engineers that come to Japan for the purpose of "studies" (who account for more than 50 percent of all received personnel) are R&D S/E in the true sense, and to differentiate between R&D S/E and technicians (it is thought that most entering Japan for "training" are technicians). However from the viewpoint of clarifying the sate of exchanges, it is believed that provided these points are taken into account there is sufficient meaning in examining researcher exchanges based on the number of received and leaving personnel.

Figure 7-1-2 Research Personnel Leaving by Purpose of Travel (1989)

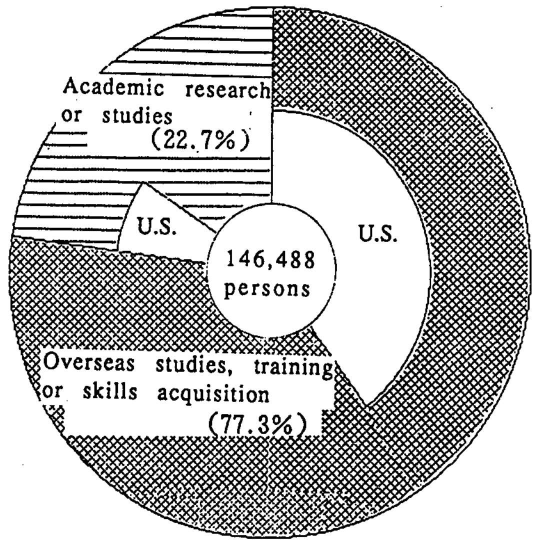
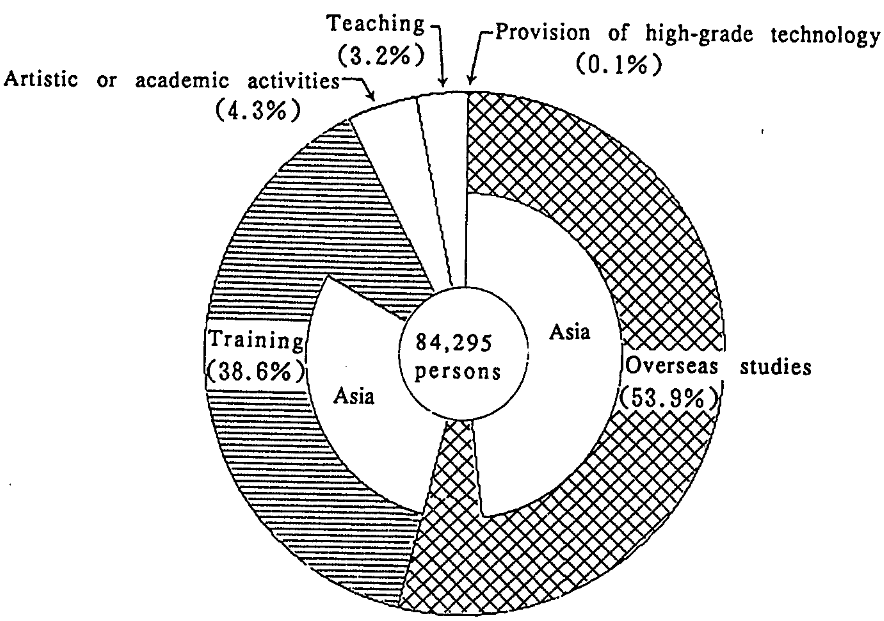
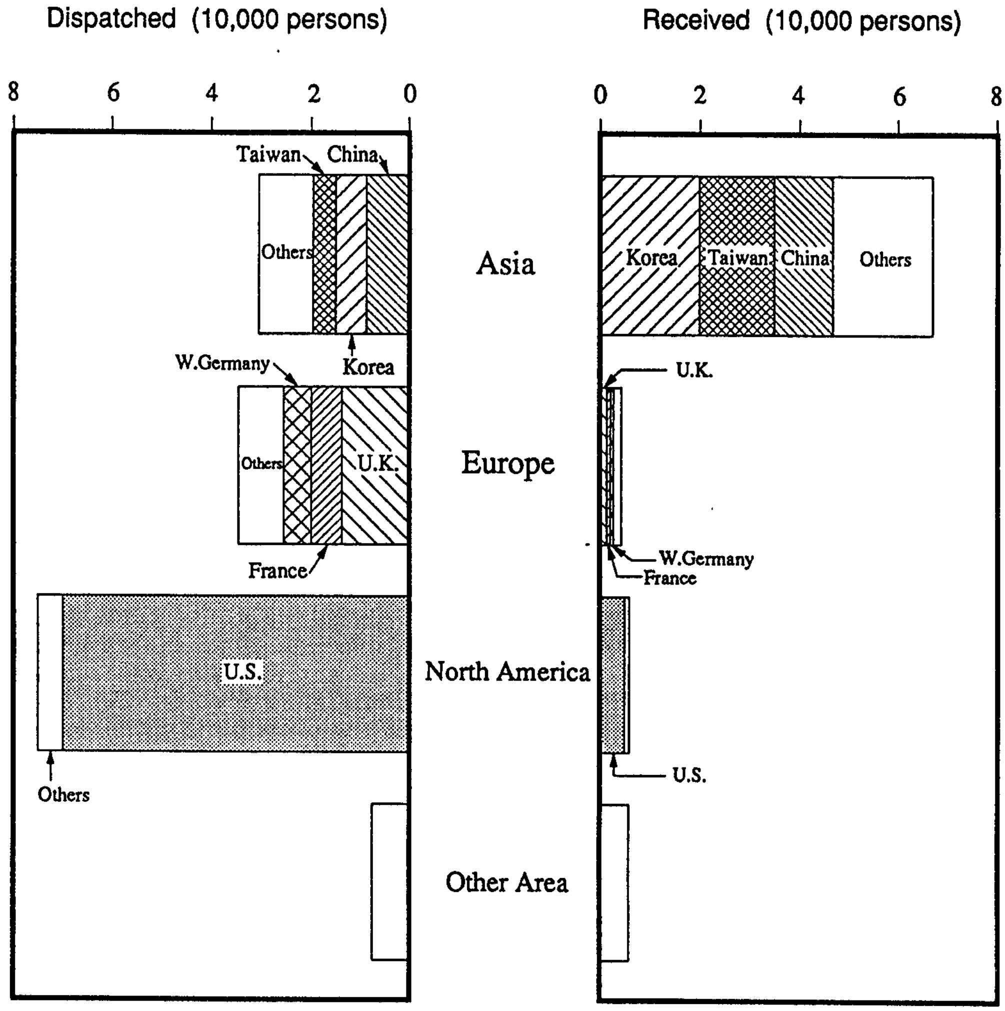


Figure 7-1-3 Research Personnel Received by Purpose of Travel (1989)



Ministry of International Trade and Industry, "Statistics on Foreign Investment"
See Table 7-1-1, Table 7-1-2.

Figure 7-1-4 Regional Breakdown of Researchers and Engineers Leaving and Entering Japan



Source: Ministry of International Trade and Industry, "Statistics on Foreign Investment"

See Table 7-1-1, Table 7-1-2

First, as mentioned earlier, in the latter half of the 1980s the number of research engineers sent overseas from Japan increased dramatically. The numerical gap between leaving and entering personnel widened during this period from 1:1.1 in 1985 to 1:1.7 in 1989. By region, Fig. 7-1-4 shows that there is a considerable imbalance between region and number of those leaving and entering the country: in 1989 three-quarters of the Japanese research engineers sent overseas went to North America or Europe, whereas 80 percent of overseas research engineers accepted into Japan came from the Asian region. This imbalance stands out even more if when looking at these figures by country. Whereas about half of all Japanese research engineers sent overseas went to the United States, a mere 6 percent of foreign research engineers accepted into Japan came from the United States. In only the United States and Europe, more than 60 percent of research engineers from Japan went to the United States, while almost 50 percent of foreign research engineers accepted into Japan came from the United States. Among North American and European countries, the United States has the most active exchanges with Japan in terms of flows of research engineers.

From this it is clear that Japan is still sending many Researchers and Engineers to the developed countries, particularly the United States and Europe in an effort to absorb knowledge, while working to transfer knowledge by accepting many overseas research engineers, particularly from the Asian region.

7.1.2 International Conferences in Japan

One way for researchers and engineers to exchange information with colleagues from other countries is by attending international conferences.

From the 1970s through to the mid 1980s, the number of international conferences held in Japan (Note 1) grew from a fairly constant level to a more gradual increase, but from the latter half of the 1980s, the number increased substantially (Fig. 7-1-5). It is thought that a fluctuation appears because most conferences are held every second or third year, and many were held during the year of the international exposition or the commemorative year of the world organizations, and the year before and after the exposition.

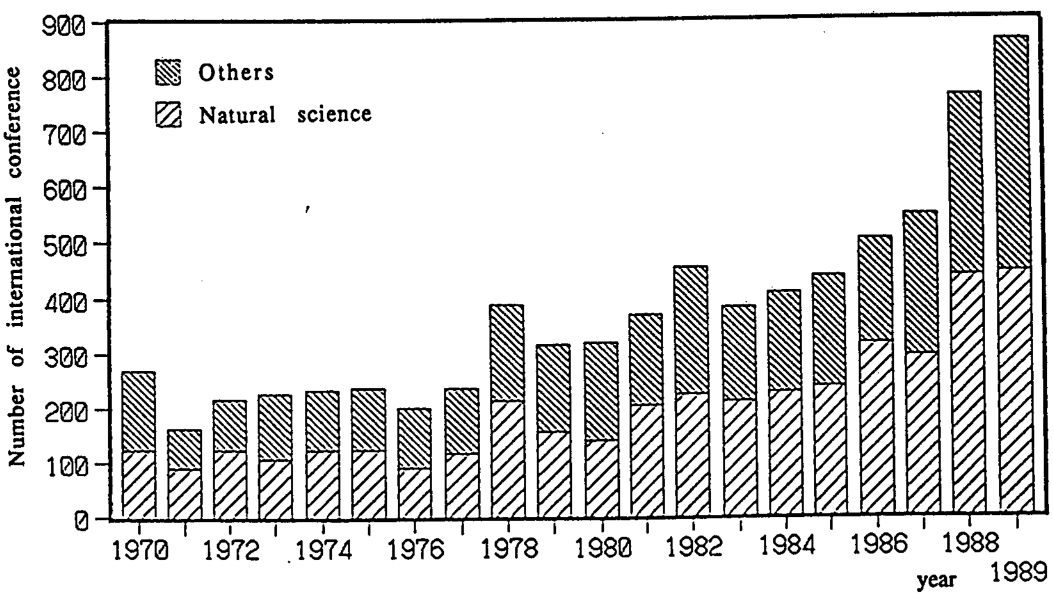
More than half the international conferences in both decades were associated with the "natural sciences (science and technology, medicine and industry)", followed by those on "politics, economics and law" and "arts, culture and education". A special feature of international conferences over the past few years is that an increasing number are held in regional centers as a result of the enthusiastic efforts to attract these conferences by local governments and convention organizers.

Notes:

1. As well as international conferences attended by representatives from two or more countries including Japan, international seminars and symposiums are also included. We have not included sales promotion conferences by private companies and intra-firm training conferences.

2. 1970: World Expo (Osaka); 1978: Conferences by The Lions Clubs and Rotary International; 1982: was peak year of the anti-nuclear and arms reductions movements.

Figure 7-1-5 Number of International Conferences Held in Japan



Source: Japan Travel Promotion Association
See Table 7-1-3.

7.2 Cross-border Flows of Research and Development

7.2.1 R&D Facilities of Japanese Affiliates Abroad

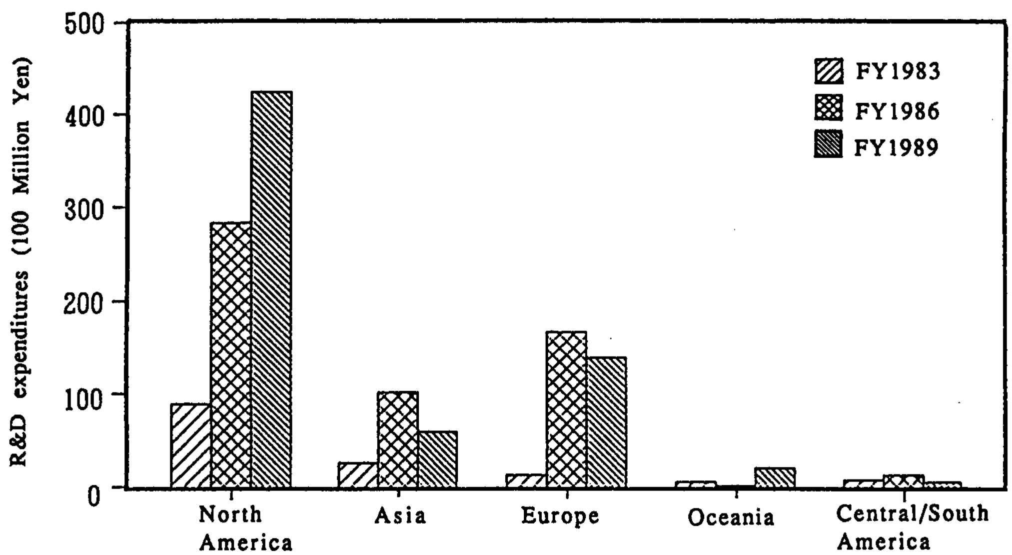
Research and development is becoming more and more internationalized as research activities by overseas affiliates of Japanese companies continue to expand year after year.

According to a survey by the Ministry of International Trade and Industry, as of the end of fiscal 1989, 367 Japanese overseas affiliates (Note 1), or 5.8 percent, were undertaking research and development. This represents a 2.4-fold increase over fiscal 1986. Companies undertaking research and development abroad are refereed to as as "overseas research affiliates".

In fiscal 1989 R&D expenditures by overseas research implementation affiliates amounted to ¥64,646 million. The electric machinery industry had the largest R&D expenditures with ¥19,886 million, followed by general machinery with ¥9,557 million, chemical industry with ¥6,016 million, and precision machinery with ¥1,757 million. These four industries accounted for almost 60 percent of total R&D expenditures by overseas affiliates. As for average R&D expenditures per company (Note 3), the same four industries were ranked the highest, headed by electric machinery, and followed by general machinery, precision machinery and the chemical industry. A comparison between the 1986 survey and the 1989 survey reveals that total R&D expenditures in fiscal 1989 were about ¥7,000 million more than in fiscal 1986. Broadly dividing the various industries into manufacturing and non-manufacturing, R&D expenditures by the manufacturing industries increased about 20 percent from ¥43,553 million in fiscal 1986 to ¥52,939 million in fiscal 1989; while R&D expenditures by the non-manufacturing industries dropped by about 20 percent over the same period. As a result, manufacturing share of R&D expenditures rose from 76 percent in fiscal 1986 to 82 percent in fiscal 1989. By region, R&D expenditures in North America showed the biggest increase, rising from 49 percent of total R&D expenditures in fiscal 1986 to 66 percent in fiscal 1989.

At the end of fiscal 1989 there were 222 research laboratories operated by overseas affiliates of Japanese firms. By region, there were 98 in North America (of which 95 were in the United States), 81 in Asia, and 25 in Europe; thus about 90 percent of research laboratories were gathered in these three regions. By industry type, 170 research laboratories, or about three-quarters of the total, were operated by the manufacturing industries, including 42 chemical laboratories, 36 electric machinery laboratories and 27 general machinery laboratories. More than 90 percent of the research laboratories in Asia and more than 70 percent of those in Europe are operated by the manufacturing industries. On the other hand, in fiscal 1986 about half of the research laboratories in North America were operated by the non-manufacturing industries, such as commerce and the service industry, but in fiscal 1989 the manufacturing industries' share rose sharply to about 70 percent.

Figure 7-2-1 R&D Expenditure by Overseas Affiliates of Japanese Companies



Ministry of International Trade and Industry, "Statistics on Foreign Investment"
See Table 7-2-1.

R&D expenditures as a percentage of sales by overseas affiliates in the manufacturing industries dropped from 0.4 percent in fiscal 1986 to 0.2 percent in fiscal 1989, while the corresponding figures for the parent companies in Japan rose from 3.0 percent to 3.4 percent. Proportionally, overseas affiliates spend considerably less on R&D than their parent companies in Japan (Note 4). However, as mentioned before, R&D expenditures by overseas affiliates of Japanese companies, particularly those in the manufacturing industries, is increasing, so it would seem that as the need for researcher exchanges with other countries becomes greater, research and development will continue to become more and more internationalized.

Notes:
1. In this section, overseas affiliates of Japanese companies are overseas-based corporations in which a Japanese company holds at least a 10 percent capital share. These are referred to as overseas subsidiaries
2. R&D expenditures do not include capital investment for research and development.
3. The average R&D expenditures per company was obtained by dividing the total R&D expenditure for each industry type by the number of companies undertaking research and development within each industry type.
4. For Japan-based subsidiaries of overseas companies in the manufacturing industries, these figures were 1.1 percent in fiscal 1986, 0.9 percent in fiscal 1987, and 1.3 percent in fiscal 1988 (Source 5).

7.2.2 R&D Facilities of Foreign Affiliated Firms in Japan

Globalization sees competitors grow from local companies to international corporations, and along with this, the need for technological expertise has become greater than ever before. For this reason, companies from all over the world are staking their survival on unfolding R&D activities that extend beyond national boundaries. As mentioned earlier, overseas R&D activities by Japanese companies have been expanding in recent years, and at the same time, overseas companies have been developing more and more research and development bases in Japan.

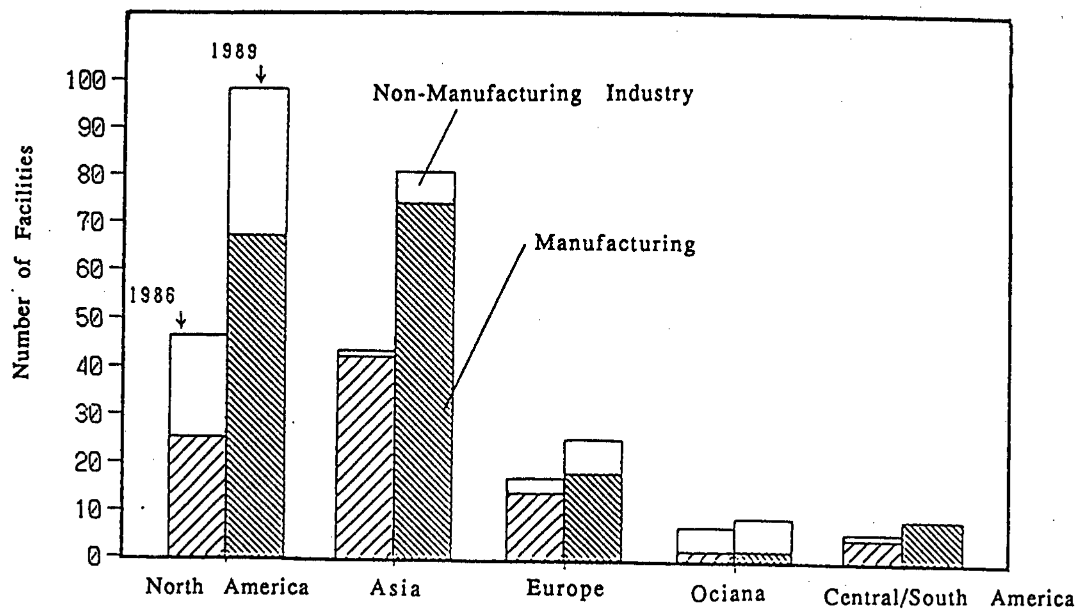
NISTEP carried out a survey on the R&D activities of 132 foreign-owned subsidiaries based in Japan as of 1989 that reported conducting research and development activities. Companies surveyed included 50 chemical companies and 16 medical supplies companies, which together account for half of all companies surveyed, and if we add to this the 19 electronics companies and the 12 machinery companies, this equals about three-quarters of all companies surveyed. Of the subsidiaries surveyed, the parent companies of 78, or 60 percent, are located in the United States, while 12 are in West Germany, 11 in Switzerland, 7 in the United Kingdom and 5 in France.

Figure 7-2-3 shows the changes in the number of research laboratories operated by the foreign-owned subsidiaries that responded to the survey.

The development of research laboratories by foreign-owned subsidiaries has been centered on two periods: the first period was from the mid 1960s to the start of the 1970s; while the second has been from the early 1980s. For Japanese companies, the first research laboratory establishment boom started in the first half of the 1960s, while the beginning of the 1980s saw the start of the second boom (Reference 2). As can be seen, these tie in closely with the laboratory development periods for the foreign-owned subsidiaries.

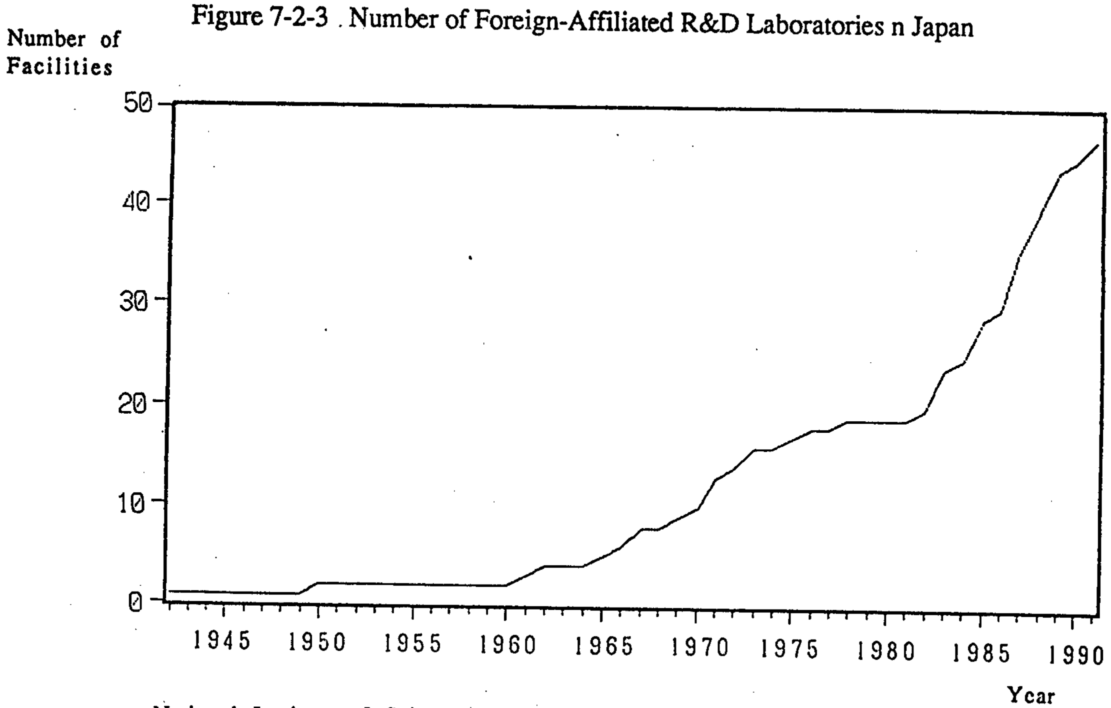
The major feature of the second period is that foreign-owned subsidiaries established in the mid 1970s set up research laboratories relatively a while after establishment. Many of the subsidiaries that established research laboratories in the first period leant towards market development aimed at the import and sale of manufactured products and finding market openings, and later engaged in full-scale research and development. In contrast, a greater number of foreign-owned subsidiaries established after the mid 1970s leant towards research and development from the very beginning of their Japan operations.

Figure 7-2-2 Number of R&D Facilities of Japanese Affiliates Abroad



Ministry of International Trade and Industry, "Statistics on Foreign Investment"

Figure 7-2-3 . Number of Foreign-Affiliated R&D Laboratories n Japan



National Institute of Science and Technology Policy

About half of the foreign-owned subsidiaries that currently have research laboratories and that were established before the beginning of the 1970s set up their research laboratories during the second period. Adding to this the research laboratories set up by subsidiaries established from the mid 1970s, there were many more laboratories established in the second period than in the first.

Note: 1. Research laboratories include technical and design centers.

7.2.3 Technological Trade

Patents, utility models, know-how and so on are the fruits of a company's research and development programmes, and are important elements in its production operations. But they are not used exclusively by the company that developed them; rather they are traded as a commercial commodity both domestically and internationally for an appropriate market price. These international transactions are called technological trade. The extent of this technological trade - the amount imported or exported - reflects a segment of the science and technology level of a country, so it is important to examine this when looking at scientific and technological activities.

(1) Technological Trade by Industry and Region

Japan's technological trade trends by industry and region are observed according to the "Report on the Survey of Research and Development" by the Management and Coordination Agency.

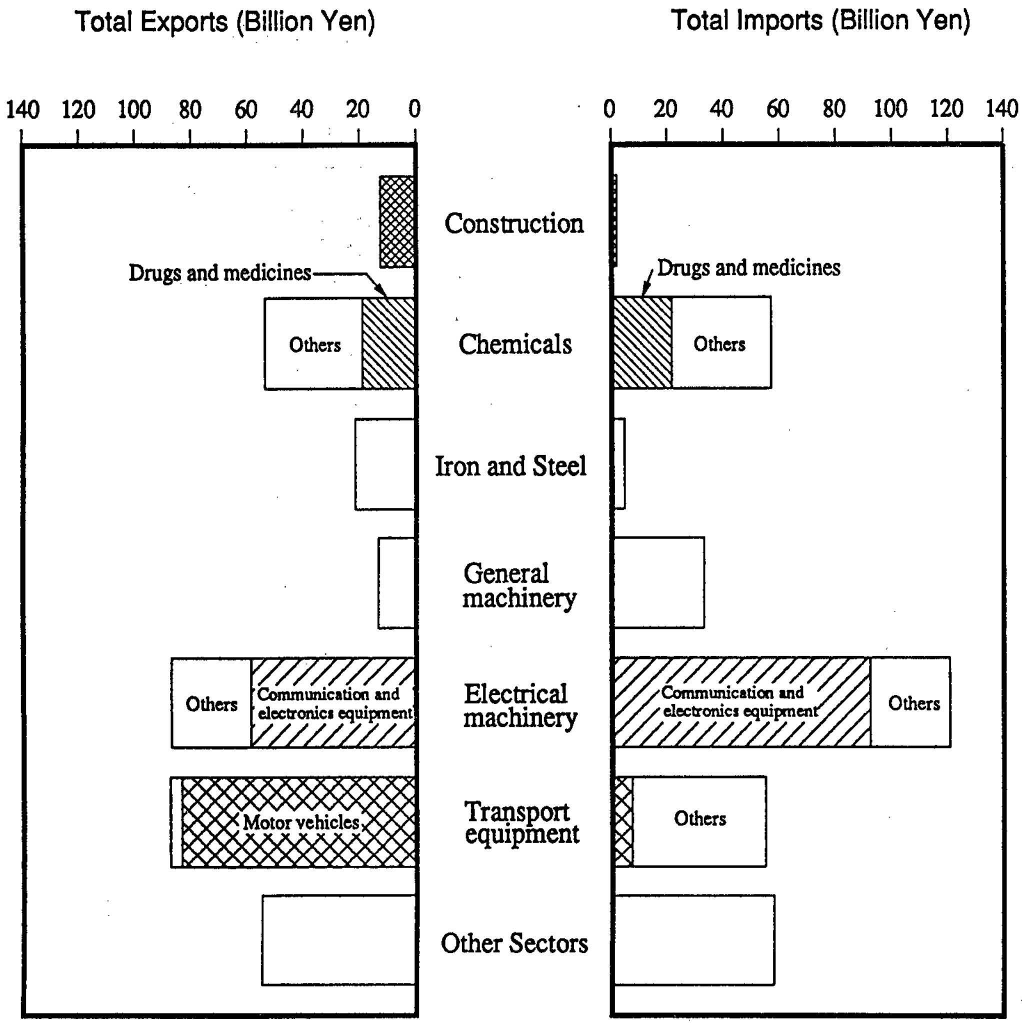
In fiscal 1989 Japan's technological exports amounted to ¥329,300 million (value received), while imports amounted to ¥329,900 million (value paid). In fiscal 1980 imports and exports were ¥159,600 million and ¥239,500 million respectively, while in fiscal 1985 they were ¥234,200 million and ¥293,200 million respectively, and from this we can see that the ratio of Japan's technological trade revenue and expenditure (exports/imports) is drawing closer to 1 each year. Changes in the total amount of technological trade from fiscal 1975 will be discussed later.

Fig. 7-2-4 breaks down the technological trade for fiscal 1989 by industry (Note 2), while Fig. 7-2-5 give a regional breakdown. The three top technology exporting industries for fiscal 1989 were the transport machinery manufacturing industries with ¥87,100 million (of which the motor vehicle industry accounted for ¥83,000 million); electric machinery manufacturing industries with ¥86,700 million (communication equipment and electronic/electrical equipment industry - ¥58,500 million); and the chemical industry with ¥53,600 million (pharmaceutical industry - ¥18,900 million). The three top technology importing industries were electric machinery manufacturing industries with ¥120,600 million (communication equipment and electronic/electrical equipment industry - ¥92,000 million); the chemical industry with ¥56,900 million (pharmaceutical industry - ¥21,500 million); and transport machinery manufacturing industries with ¥54,900 million (motor vehicle industry - ¥7,200 million).

Characterization of industries into the following three groups based on changes in the amounts of technological trade. One group comprises the industries that for the past 15 years have exported more technology than they have imported. This trade surplus has been the case for the iron and steel industry since fiscal 1974, and for the construction industry since fiscal 1975. The construction industry enjoys a particularly high technological trade surplus, and since fiscal 1980 its technology revenue has been around ten times as great as its technology expenditure. In fiscal 1989 the construction industry exported technology to the value of ¥12,400 million, 80 percent of which went to Asia (excluding West Asia).

Another group comprises industries whose technology revenue-expenditure ratio has increased sharply over the past few years. The motor vehicle industry began exporting more technology than it was importing at the beginning of the 1980s, and from around the middle of the decade its technology export amount increased rapidly, while the import amount continued to fall. Between fiscal 1985 and fiscal 1989 the technology revenue-expenditure ratio rose from 2.3 to 11.5.

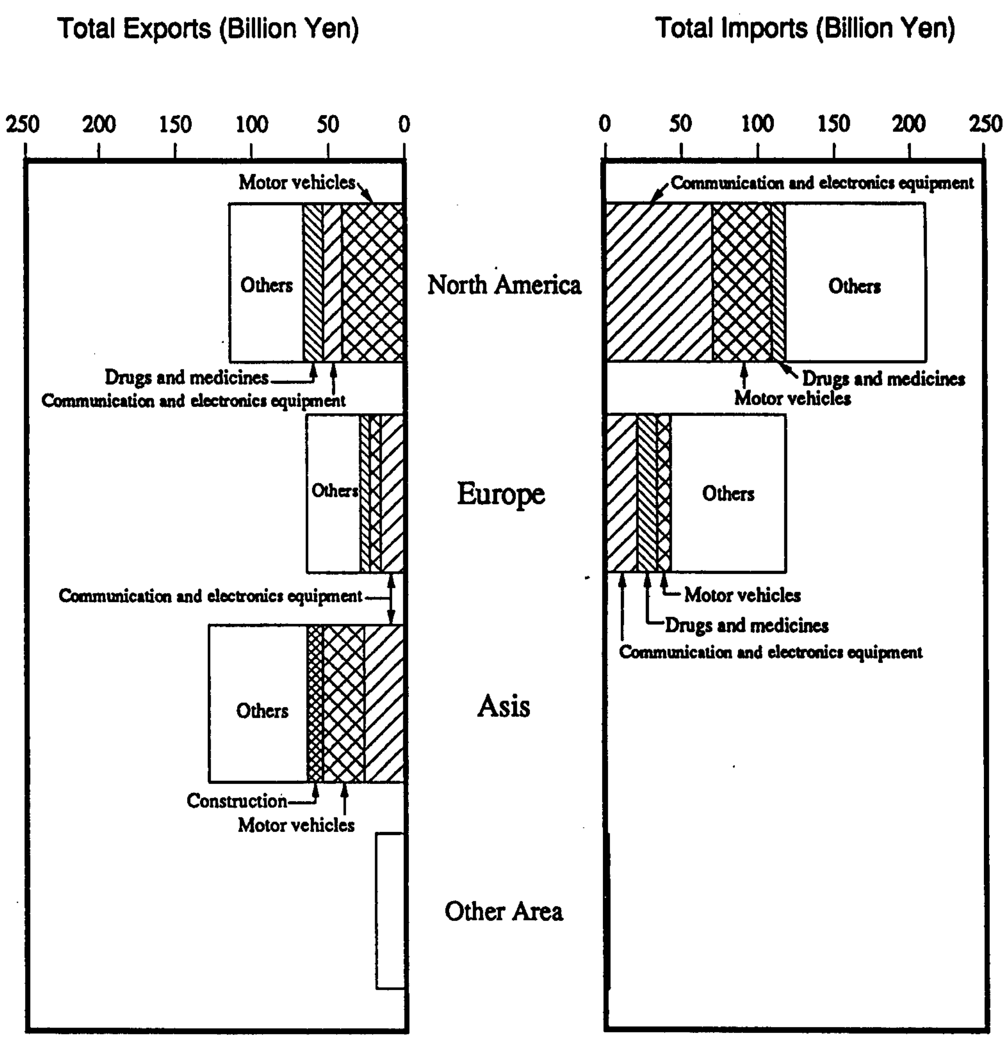
Figure 7-2-4 Japan's Technological Trade by Industry (Fiscal 1989)



Source: Statistics Bureau, Management and Coordination Agency,Japan,

"Report on the Survey of Research and Development"

Figure 7-2-5 Japan's Technological Trade by Region (Fiscal 1989)



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

Between the latter half of the 1970s and the early 1980s 60-70 percent of the motor vehicle industry's technology imports were from North America, while about 80 percent of its technology exports were to Asia. This started to turn around in fiscal 1984 with technology exports to North America increasing rapidly to exceed exports to Asia. Thus the rapid rise of the technology revenue-expenditure ratio is due to the industry's large technology trade surplus with North America. Technological trade with Europe was fairly balanced in the mid 1980s, but in fiscal 1988 and 1989 exports were far in excess of imports. From the mid 1980s the motor vehicle industry pushed ahead with its policy of local production (U.S.A, Canada and U.K.), and a large part of the technological trade is now between the main company back in Japan and the local Japanese affiliates. Therefore, the motor vehicle industry's large technology trade surplus is considered to be attributable to its greater R&D expertise, but also to the growing number of overseas production bases. In fiscal 1989 65 percent of technology imports were from Europe, while the technology export distribution was 55 percent to North America, 36 percent to Asia, and 9 percent to Europe.

The third group consists of industries where the technology revenue-expenditures ratio has been close to 1 each year (pharmaceutical industry; and communication equipment and electronic/electrical equipment industry). Technological trade by the pharmaceutical industry has been virtually balanced (revenue-expenditure ratio almost 1) since the mid 1980s, and from this period industry's R&D capabilities have risen to world standards. Technology exports to North America have exceeded imports since the mid 1980s and are continuing to increase year after year. On the other hand imports from North America have generally remained the same (although there was a large increase in fiscal 1989), so the technological trade surplus has followed the increase in technology exports. Technological trade with Europe was fairly balanced between fiscal 1984 and fiscal 1986, but from fiscal 1987 imports again greatly exceeded exports, similar to the period up to the early 1980s. In technology imports, the pharmaceutical industry has placed great importance on its relationship with Europe at least from the mid 1970s.

As for the communication equipment and electronic/electrical equipment industry, from the mid 1970s through the 1980s, technology exports grew slightly more than technology imports. The revenue-expenditure ratio exceeded 0.5 in the mid 1980s, and

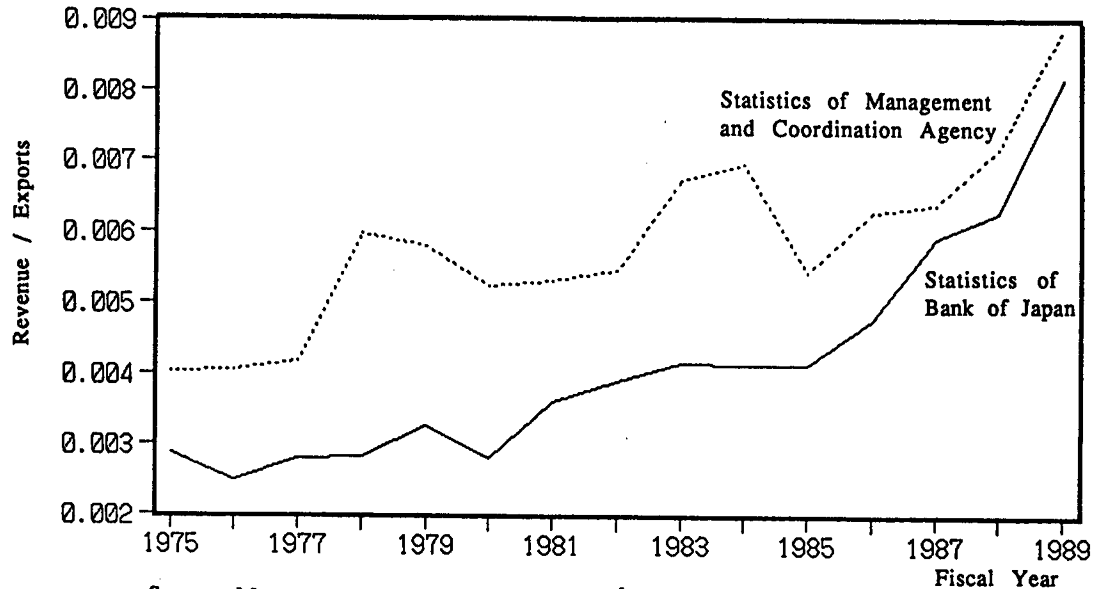
by fiscal 1989 it had grown to 0.64. The value of technology exports by the communication equipment and electronic/electrical equipment industry was more than any other industry in fiscal 1984 and 1985, and since fiscal 1986 it has been second only to that by the motor vehicle industry. The rise in the revenue-expenditure ratio for the communication equipment and electronic/electrical equipment industry has contributed significantly to Japan's overall technological trade balance.

(2) Changes in Technological Trade

While it is important to look at changes in the absolute value of technological trade when examining trends in Japan's technological trade over the past 15 years, sudden fluctuations in the exchange rate in recent years mean that the situation is considerably different depending on whether one looks at it in yen terms or dollar terms. Two kinds of graphs are used which are adjust for fluctuations in the yen-dollar exchange rate.

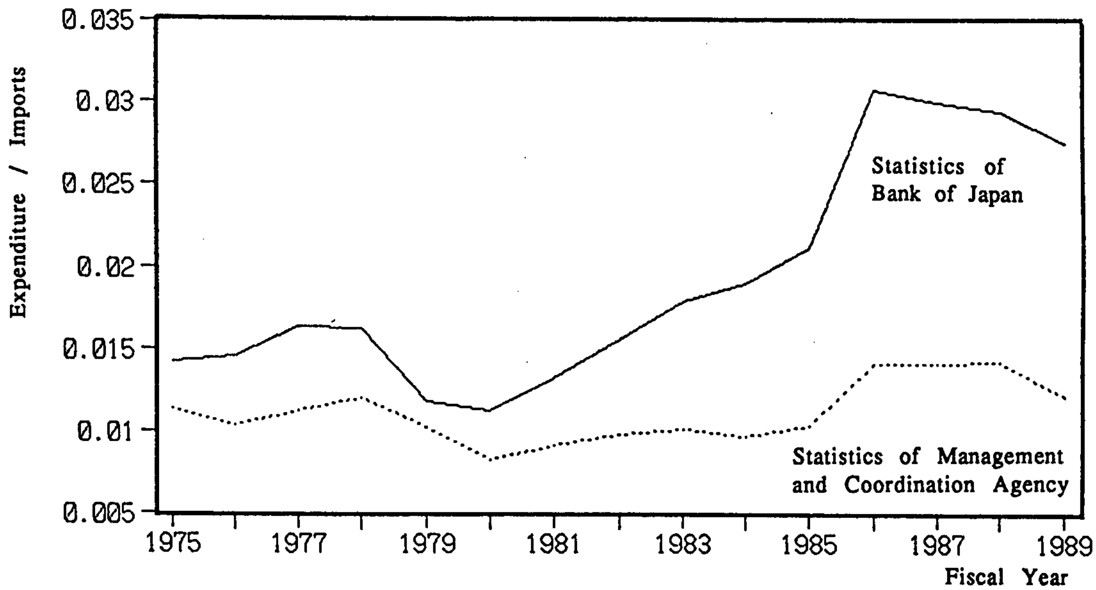
The first shows the value obtained by dividing the amount of technology exports (value received) and the amount of technology imports (value paid) by, respectively, the amount of general exports and the amount of general imports (Figs. 7-2-6 and 7-2-7). This value is significant when we examine the importance of technological trade in Japan's overall trade. Over the past 15 years both revenue and expenditure are showing an increasing trend, and that technological trade is becoming an increasingly important part of Japan's overall trade. It is thought that the drop in both revenue and expenditure between 1979 and 1980 is due to the effects of the second oil crisis, and technological trade declines during a period of economic turbulence. The difference between the Bank of Japan statistics and the Management and Coordination Agency statistics shown in the figure is due to the different survey methods (Note 1).

Figure 7-2-6 Technological Trade Revenue (Compared with General Trade Revenue)



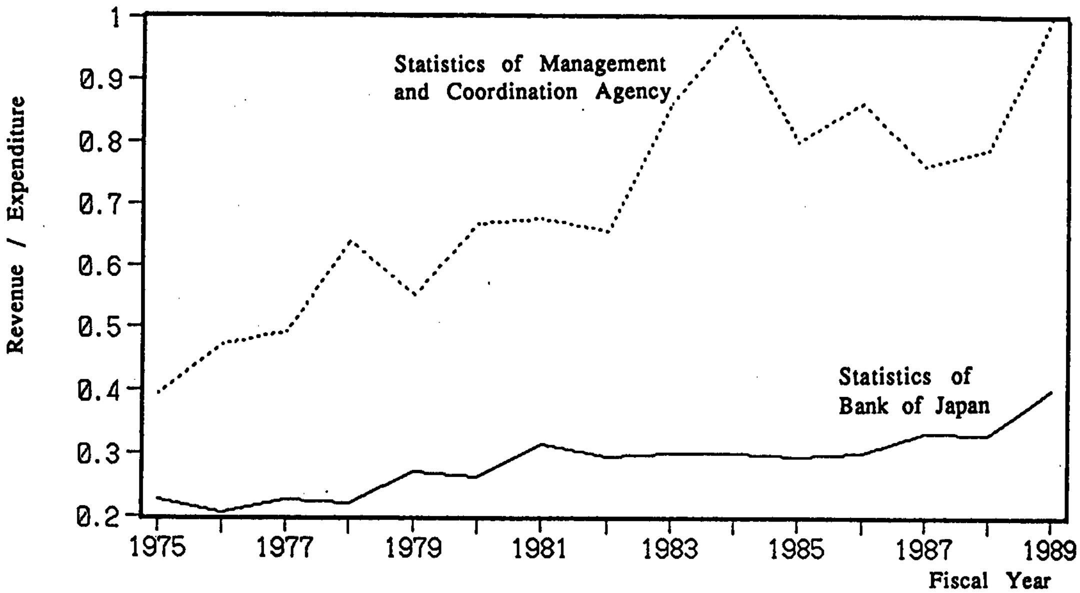
Source: Management and Coordination Agency, and Bank of Japan
See Table 7-2-5.

Figure 7-2-7 Technological Trade Expenditures (Compared with General Trade Expenditure)



Source: Management and Coordination Agency, and Bank of Japan
See Table 7-2-5.

Figure 7-2-8 Japan's Technological Trade Revenue-Expenditure Ratio



Source: Management and Coordination Agency, and Bank of Japan
See Table 7-2-5.

The second figure shows the value obtained by dividing technological trade revenue by expenditure (Fig. 7-2-8). This value represents the technological trade revenue-expenditure ratio, and is an important indication of a country's science and technology level. In Japan's case, this has shown a steadily increasing trend for the past 15 years, but Japan's fiscal 1988 revenue-expenditure ratio of 0.33 by the Bank of Japan is still lower than the U.S.A. with 5.24, the U.K. (1987) with 0.92, France with 0.51, and West Germany with 0.49.

Note:
1. Main causes of the difference between the Bank of Japan statistics and the Management and Coordination Agency statistics.

(a) Calculation Method
Bank of Japan statistics: Totals only the amount of foreign exchange directly connected with payment or receipt of royalties. Management and Coordination Agency statistics: Totals amount of money in all cases where surveyed companies provide to or receive from overseas companies patents, know-how, or technical guidance.

(b) Scope of Survey
Bank of Japan statistics: Cover all companies and organizations that remit money overseas or receive money from overseas. Management and Coordination Agency statistics: Covers all companies except wholesalers, retailers, restaurants, finance companies, insurance companies, the real estate industry and the service industries (the statistics do, however, cover the
broadcasting industry), and also covers special corporations, public corporations, and special companies.

2. See Table 4-A (pp125).

(3) Introduction of Technology from Abroad

Other major statistics on technological trade in Japan apart from the previously mentioned "Survey of Research and Development" by the Management and Coordination Agency and the "Balance of International Payments Statistics" by the Bank of Japan include the "Outline of Overseas Technology Introduced by Japan" by NISTEP (Source 8). This outline only covers the introduction of overseas technology, so we are not able to obtain Japan's technological trade revenue and expenditure, an indicator of our technological strength (Note 1). The outline is, however, very useful as a supplement to Management and Coordination Agency and Bank of Japan data, for it provides otherwise unavailable data classified into the various technological fields. The following is an outline of the totals and analysis results obtained by NISTEP.

To grasp the overall flow of overseas technology into Japan, annual changes in flows of technology into Japan are looked at (Fig. 7-2-9). Although fluctuations could be seen from the latter half of the 1950s to 1973, generally the number of cases of new technology being introduced into Japan was on a fairly steep upward trend. It then dropped significantly, but from 1976 the number started to increase again, and since then, it has continued a steady climb. In 1987 the number of cases showed a sharp rise, after which it again continued a steady increase.

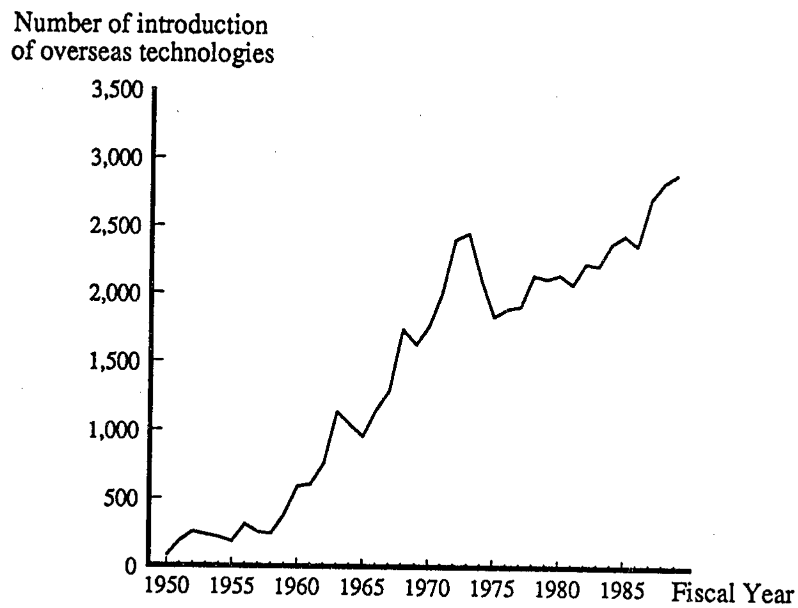
As for the various technological fields, a breakdown of the 2,898 cases of new technology introduced into Japan in fiscal 1989 reveals that the "electrical" field had the largest number of cases with 1,604 (55.4 percent), followed by "machinery" with 383 cases (13.2 percent), "chemical" with 308 (10.6 percent), "metals" with 60 (2.1 percent), while there were 543 cases (18.7 percent) for "Others". And Figure 7-2-10 shows that the "electrical" field's share of newly introduced technology has increased considerably over the past five years.

As for the number of cases for each technology classification (Note 2) in fiscal 1989, the highest number of cases was for level 2 classification was "electric machinery and appliances" with 1,604 cases, followed by "general tools and machinery" with 283 cases, "chemical products" with 240, "clothing and textiles" with 182, "other products" with 134, and so on. In level 3 classification, first was "electronic equipment" with 1,322 cases (of which 1,268 were in "computers"), followed by "communications equipment" with 132, "pharmaceuticals" with 121, "outer garments" with 117, and so on.

As for the regions from which Japan imported technology in fiscal 1989, North America with 1,868 cases (64.5 percent) and Europe with 909 cases (31.4 percent) together accounted for 95.8 percent of all new technology entering Japan. Other regions were Asia with 95 cases (3.3 percent), Oceania with 23 (0.8 percent), U.S.S.R. with 2 and South America with 1. By country, the overwhelming majority of new technology came from the U.S.A. (1,808 cases, 62.4 percent), followed by the U.K. with 196 (6.8 percent), West Germany with 191 (6.6 percent), France with 187 (6.5 percent), and Switzerland with 81 (2.8 percent). These five countries account for 85.0 percent of all new technology introduced into Japan. Next were the Netherlands with 79 cases (2.7 percent), Italy with 78 (2.7 percent), Canada with 49 (1.7 percent), and Singapore with 47 (1.6 percent). A look at the changes in the number of cases by country over the past five years reveals that the introduction of technology from the U.S.A. and the countries of Asia is in a rising trend, whereas introduction from the European countries is declining.

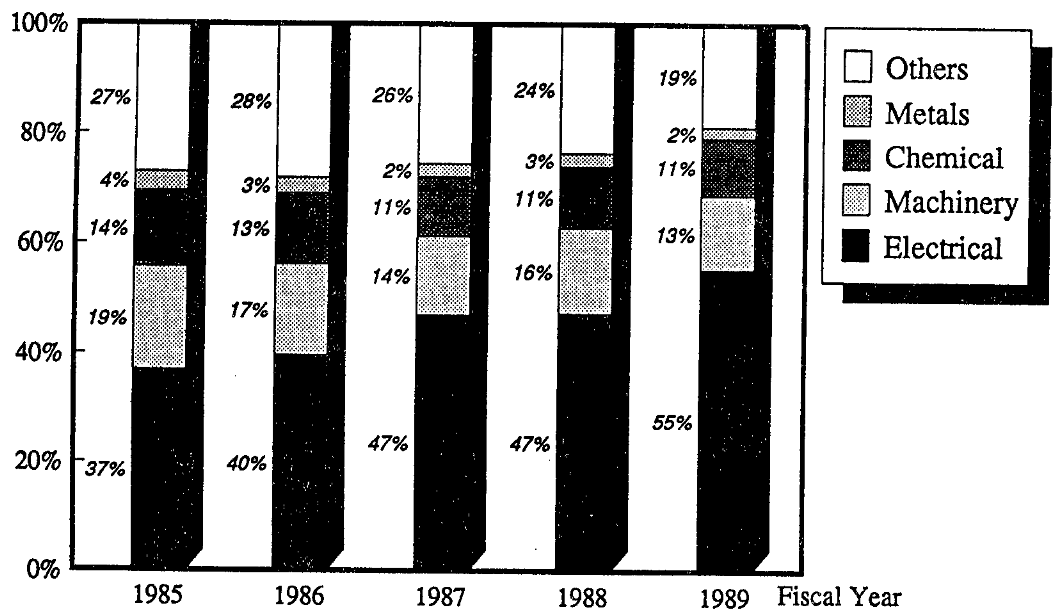
Notes:
1. The following is an outline of the survey conducted by NISTEP. NISTEP based its figures for overseas technology introduction on notifications submitted to the Bank of Japan in accordance with the Foreign Exchange and Foreign Trade Control Law when concluding contracts for the introduction of technology. The number of cases represent the number of technology introduction contracts.
2. The "Annual Report on the Introduction of Overseas Technology" uses "technology classifications", which is different from "technology fields". Corresponding tables for these two kinds of classifications are contained in Source 8.

Figure 7-2-9 Trends in Technology Transfer to Japan



Source: NISTEP
See Table 7-2-6

Figure 7-2-10 Trends in Technology Transfer to Japan by Technological Field



Source: NISTEP
See Table 7-2-7

7.2.4 International Co-authorship of Scientific Literature

In an attempt to quantify R&D internationalization, international co-authorship of scientific literature is examined. The data were obtained from the CHI data base, which is widely used for macro indicators related to scientific literature (Source 9).

The numbers that scientific literature is written under international co-authorship is reviewed. In 1981 5.5 percent of the scientific literature included in the CHI data base was written under international co-authorships. In 1986 this rose to 7.5 percent, which shows an increasing trend (Note 1). This indicates that internationalization is progressing on a world scale.

Next as an indicator of internationalization in each country, the percentage of scientific literature each country has in international co-authorships is tabulated (referred to here as the international co-authorship percentage). Changes in the international co-authorship percentage are shown in Fig. 7-2-11 (Note 2). The international co-authorship percentage for all countries increased between 1981 and 1985. Countries with a particularly high percentage are France, West Germany and U.K. The percentage increase shown by West Germany has been striking. On the other hand, the percentage increase for the U.K. has not been as large as the other two countries. Following these major European countries, the United States also has a high percentage, and this is increasing steadily. Although Japan's international co-authorship percentage is higher than the Soviet Union's, it is the lowest of the other major countries shown in the figure. It is, however, slightly higher than the increase shown by the world as a whole. The international co-authorship percentage of the Soviet Union is low, and is increasing only very slowly.

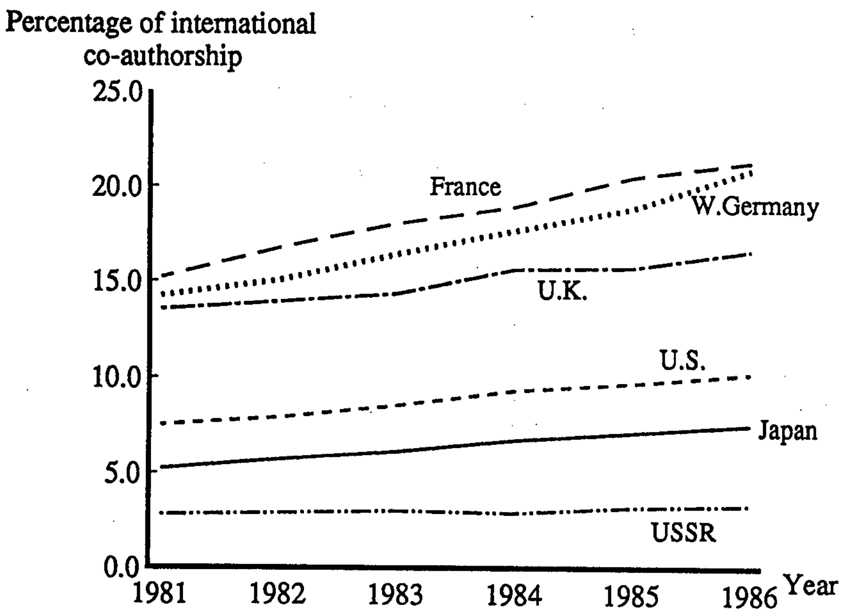
Japanese researchers co-authorships of scientific literature by country is shown in Fig. 7-2-12 (Note 3). The vast majority are with researchers from U.S.A., followed by West Germany, U.K., Canada and France. All are major countries, and all produce a large quantity of scientific literature. Over the period 1981-6 the amount of co-authored literature with researchers from West Germany, France and the other European countries, and from the Asia-Pacific region (excluding Australia) increased significantly.

Although care must taken in keeping in mind differences in language, social structure, and geographical and historical circumstances between the various countries when interpreting the above data, it does give an idea of how far internationalization has progressed in basic research, which is the main subject of internationally co-authored scientific literature.

Notes:

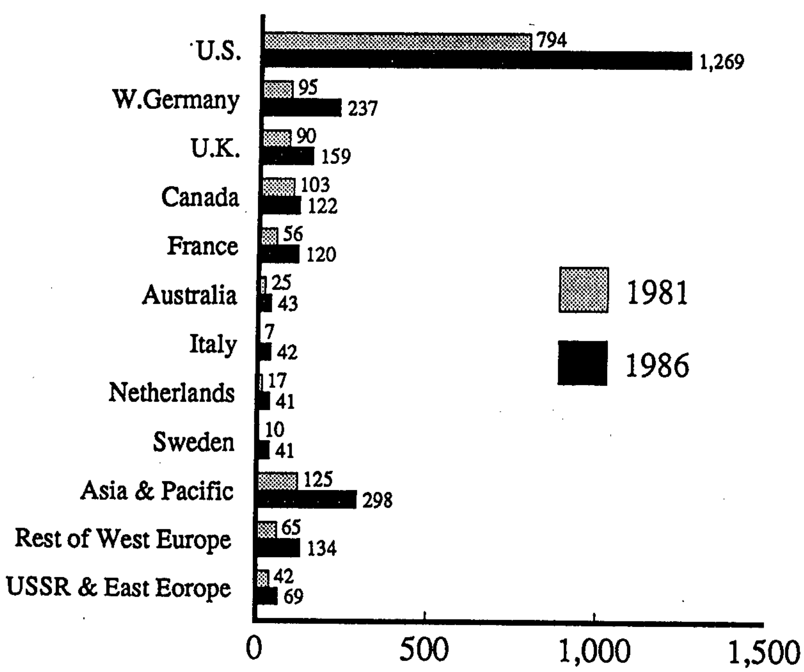
1. Internationally co-authored scientific literature is scientific literature that has been written by two or more researchers from different countries. The country of the co-author is determined not by nationality, but by the location of the institute etc. to which he/she belongs.
2. Values are calculated as follows:
   The number of scientific papers by country A includes all scientific papers written by researcher of country A. The number of country A's internationally co-authored scientific papers are the number of scientific papers that have been written by a researcher of country A and at least one researcher from another country. The international co-authorship percentage for country A is then calculated by dividing the number of country A's internationally co-authored scientific papers by the total number of country A's scientific papers. This method of calculation is different from the method used in Section 1 Chapter 6 in the aspect that papers are not divided proportionally among countries according to the number of authors. Therefore, a single internationally co-authored paper will be counted at least twice, for under this method it will belong to more than one country.
3. This shows the number of scientific papers co-authored by Japanese researchers . The number of papers for country A is all papers that have been written by researchers of Japan and country A. Therefore, papers written by researchers of Japan, country A and country B are allocated to both country A and country B.

Figure 7-2-11 Share Trends in Co-authorship by Country



Source: Computer Horizons, Inc. "Science & Engineering Literature Data Base 1989"
See Table 7-2-8

Figure 7-2-12 Co-authorship by Co-author's Country



Source: Computer Horizons, Inc. "Science & Engineering Literature Data Base 1989"
See Table 7-2-9

Sources:

1. Ministry of Justice, "Annual Report of Immigration Statistics"
2. Japan Travel Promotion Association, "International Conference Statistics 1977"
3. Japan Travel Promotion Association, "Convention Statistics 1989"
4. Ministry of International Trade and Industry, Industrial Policy Bureau, International Companies Section, "International Investment Statistics"
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CHAPTER 8

SCIENCE, TECHNOLOGY AND SOCIETY

CHAPTER 8

SCIENCE, TECHNOLOGY AND SOCIETY

R&D activities are important elements of science and technology, but they cannot alone indicate the overall state of science and technology. The reason for this is that the purpose of science and technology is to create an affluent society and make life more comfortable, and while R&D is one means to that end, it normally does not contain any element that has a direct connection with community life. These days for various activities in society to succeed, they must first gain societal acceptance. Exactly the same can be said about activities connected with science and technology. There is a growing awareness about science and technology and enjoyment coming from the subsequent benefits.This chapter therefore describes the important elements that are both the beginning and end of scientific and technological activities.

This chapter comprises four sections: "Science, Technology and Industry", "Impact on Life-styles", "Contribution to Preservation of the Global Environment", and "Science & Technology and Culture", and describes the relationship between science & technology and society, from the viewpoint of industry and people's lives.

8.1 Science,Technology and Industry

8.1.1 Value Added Productivity

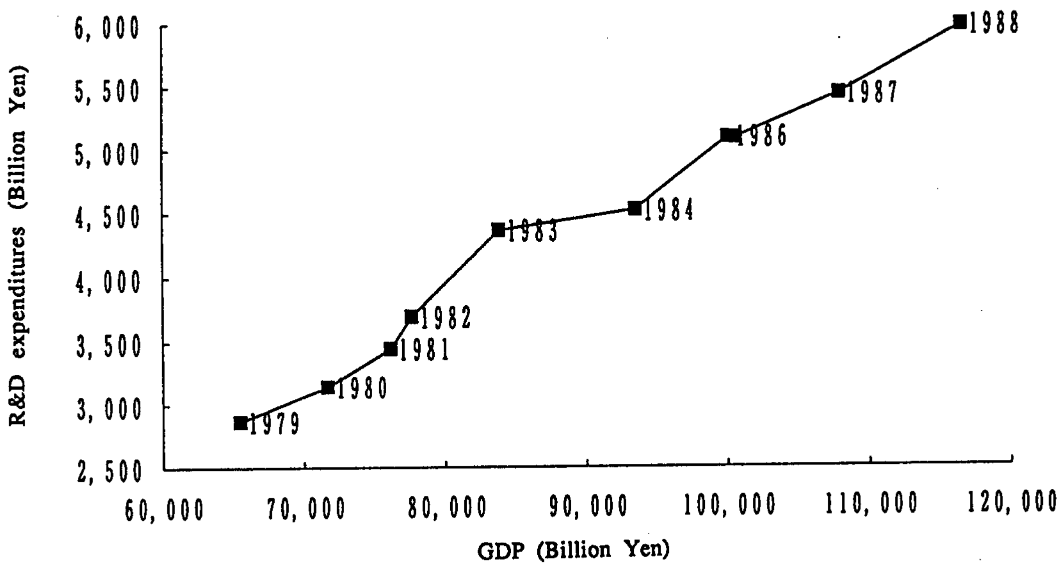
The fruits of R&D are returned to society through an increase in intellectual assets, personal wealth or public wealth. These tangible and intangible assets will ultimately be reflected with added value in our lives. If production gives rise to added value in a narrow sense, then science and technology is a process of creating a high level of added value in a wide sense. The relationship between science & technology and industry must therefore be analyzed through value added production. We can analyze the relationship between science & technology and industry as a science and technology indicator by type of industry or from a macro-level viewpoint by country. Here we shall analyze the relationship between science & technology and industry at the macro-level by country.

Value added for a country is indicated by Gross National Product (GNP) or Gross Domestic Product (GDP). GNP includes the value added that a country's industry can obtain overseas, while GDP is the total value added that a country's industry can obtain domestically. One of the structural characteristics displayed by Japanese R&D is that industry spends an extremely small amount on R&D overseas (less than 0.2 percent of total industry R&D expenditures). So it is proper to examine GDP and R&D expenditures in a comparison between Japan's value added production and industry.

What part has R&D played in the growth of Japan's value added production? An attempt was made to analyze the real growth rate into the factors that contribute to technological progress, namely capital, labour, and R&D achievements (Reference 1). It is clear that along with capital and labour, overall factor productivity, which indicates technological progress, has contributed a great deal to Japan's real growth rate. In recent years, there has been a growing number of companies invest more into R&D than into plant and equipment (Reference 2). This trend has contributed to companies' diversification through the development of R&D activities in other industrial fields, and also to Japan's growth through an overall move towards high value added. To show this point, this section clarifies the relationship between R&D expenditures and GDP in the manufacturing industry over time.

As indicated in Fig. 8-1-1, R&D expenditures by Japan's manufacturing industry and GDP show an almost rectilinear trend (against GNP, total R&D expenditures by Japan shows virtually the same rectilinear trend; refer to Chapter 4 Section 1). Total corporate sales are reflected in GDP, so R&D expenditures are set proportionate to GDP. Consequently, the fact that Japan's R&D expenditures and GDP are in a rectilinear relationship indicates that a determining factor in R&D

Figure 8-1-1 R&D Expenditures and GDP in Japan (Manufacturing)

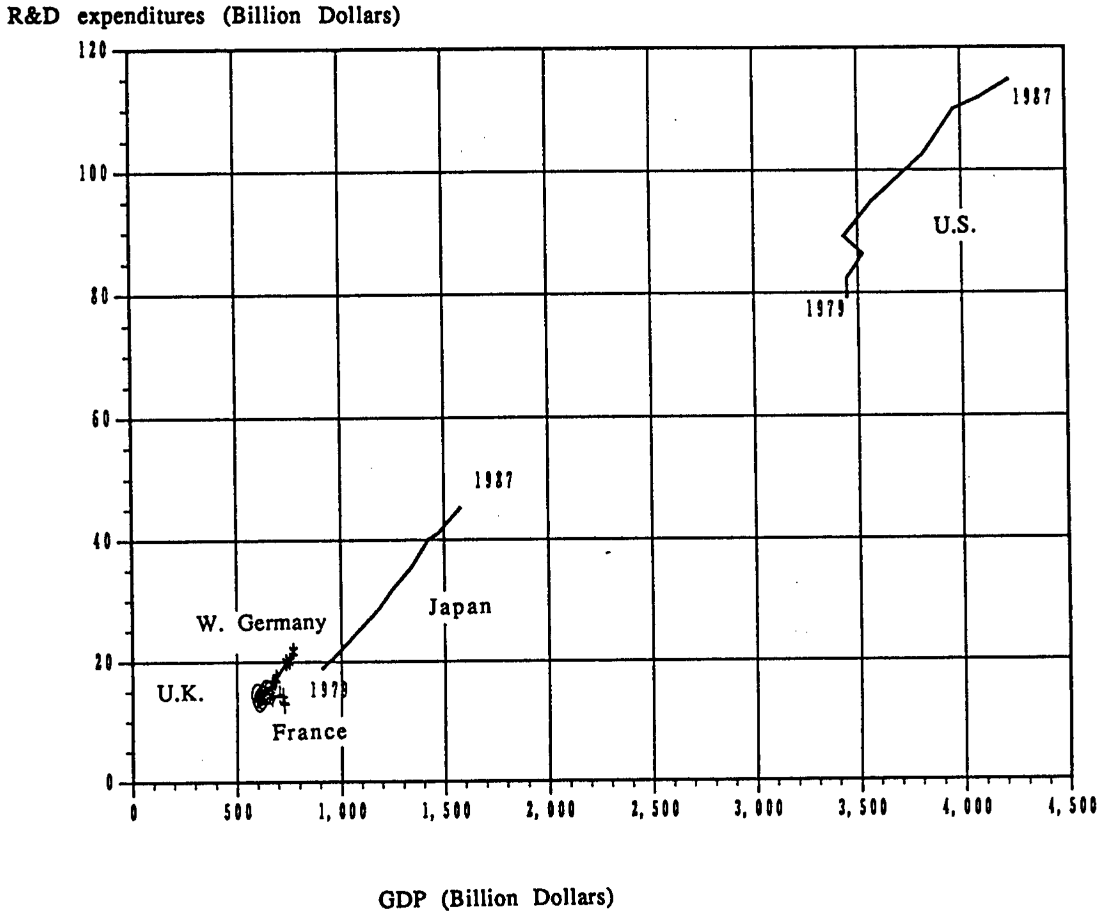


Source: Economic Planning Agency
Management and Coordination Agency
See Table 8-1-1.

expenditures by Japanese companies is the amount of corporate sales. R&D success will increase intermediate investment or the value added of the end product, and this should be linked to an increase in sales. This dynamic process is directly indicative of the relationship between R&D and industry.

Figure 8-1-2 compares R&D expenditures in countries and their respective GDP. In U.S.A. both R&D expenditures and GDP are much greater than in Japan. As for R&D expenditures trends, the contribution R&D makes to GDP in U.S.A. is gradually decreasing, whereas in Japan, R&D expenditures are beginning to influence GDP, although very gradually. Japan is therefore heading in the opposite direction as the U.S. is.

Figure 8-1-2 R&D Expenditures and GDP in Selected Countries



OECD, "Main Science and Technology Indicators"
See Table 8-1-2.

8.1.2 Energy Efficiency

Energy efficiency can be considered throughout various stages ranging from energy production (generation) through to distribution and consumption. Technology to raise energy efficiency in all processes is continually being developed, and an improvement in energy efficiency is one indicator of technological progress.

(1) International Comparison of Energy Conservation

Energy efficiency comparisons are made among several countries based on the primary energy basic unit (GDP ratio), which is used to ascertain the state of energy conservation (Fig. 8-1-4). Between 1973 and 1988 the basic unit of primary energy showed an average annual drop of 1-2 percent for all countries, and their respective basic units are finally approaching Japan's level at about the time of the first oil crisis.

During the ten years from 1973, Japan's basic unit of primary energy decreased by an average of almost 3 percent per year, greatly exceeding that shown by the other countries in Fig. 8-2-4, but from the mid 1980s, this gradually slowed down, and in 1988 actually showed an increase over the preceding year. Nevertheless, Japan has experienced an average decrease of around 2.5 percent per year between 1973 and 1988, and with still quite a considerable gap between Japan and the other countries, it is clear that energy conservation in Japan is well advanced.

As for the United States, the annual decrease between 1973 and 1988 was the largest, after Japan's, and over the past five years has been greater than all other countries. However the basic unit in the United States at the start of the 1970s was the largest of all the countries, and even with the significant decrease over the years, in 1988 it was still the largest among the countries shown in the figure. Nevertheless, the gap between U.S.A. and all other countries except Japan has narrowed considerably, and from this it is clear that U.S.A. has put a great deal of effort into raising energy efficiency (energy conservation).

(2) Energy Efficiency in the Industrial Sector

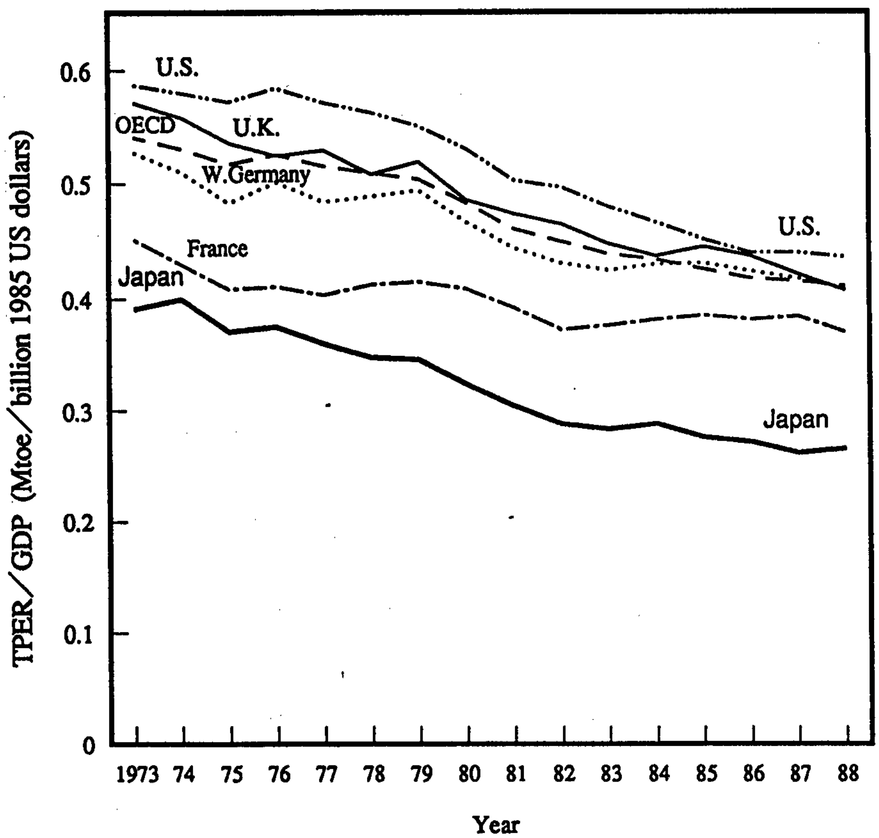
Among the consuming sectors (Note 1), the industrial sector accounted for 65.5 percent of all energy consumed in Japan in fiscal 1973, but the progress of energy conservation precipitated by the oil crises saw this percentage steadily drop to 52.8 percent in fiscal 1989.

The manufacturing industry accounts for about 90 percent of all energy consumed by Japan's industrial sector. Using the basic unit of energy consumption (GNP ratio) as an indicator to observe the energy efficiency in each industrial category within the industrial sector (Fig. 8-1-5), it is clear that the absolute value for the iron and steel industry and the chemical industry decreased significantly. The basic units for the paper and pulp, non-ferrous metals, food, textiles and ceramics industries all decreased considerably until fiscal 1982. It is evident that the manufacturing industry pushed towards a decrease in energy consumption for about ten years from 1973, and during this time, production efficiency in the industrial sector rose markedly.

Energy efficiency in the transportation sector decreased over a 15-year period from the mid 1970s, although the change was not a great as in the industrial sector. Transportation refers to the basic unit of energy consumption for motor vehicles, especially private-use trucks and vans and had a higher basic unit than railways and marine transport, which indicates that the energy efficiency of motor vehicles is low (Fig. 8-1-6). In the early 1980s, the basic unit of consumption for passenger cars decreased (higher energy efficiency), while that for private-use trucks and vans increased (lower energy efficiency).

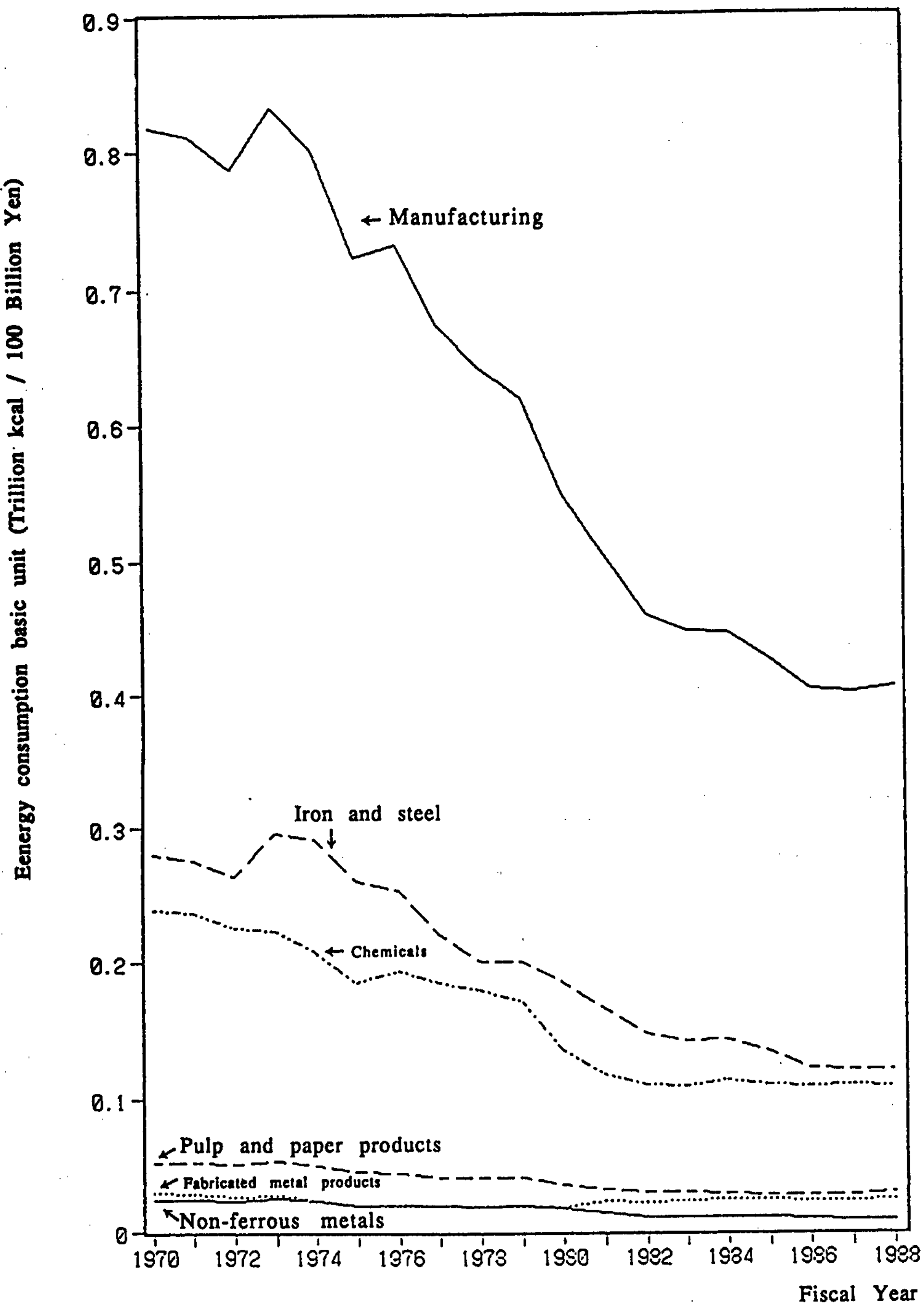
Note:
1. Source 5 classifies Japan's energy consuming sector: industrial, domestic and commercial, and transportation.

Figure 8-1-4 Basic unit of Primary Energy of the Major Developed Countries (GDP Ratio)



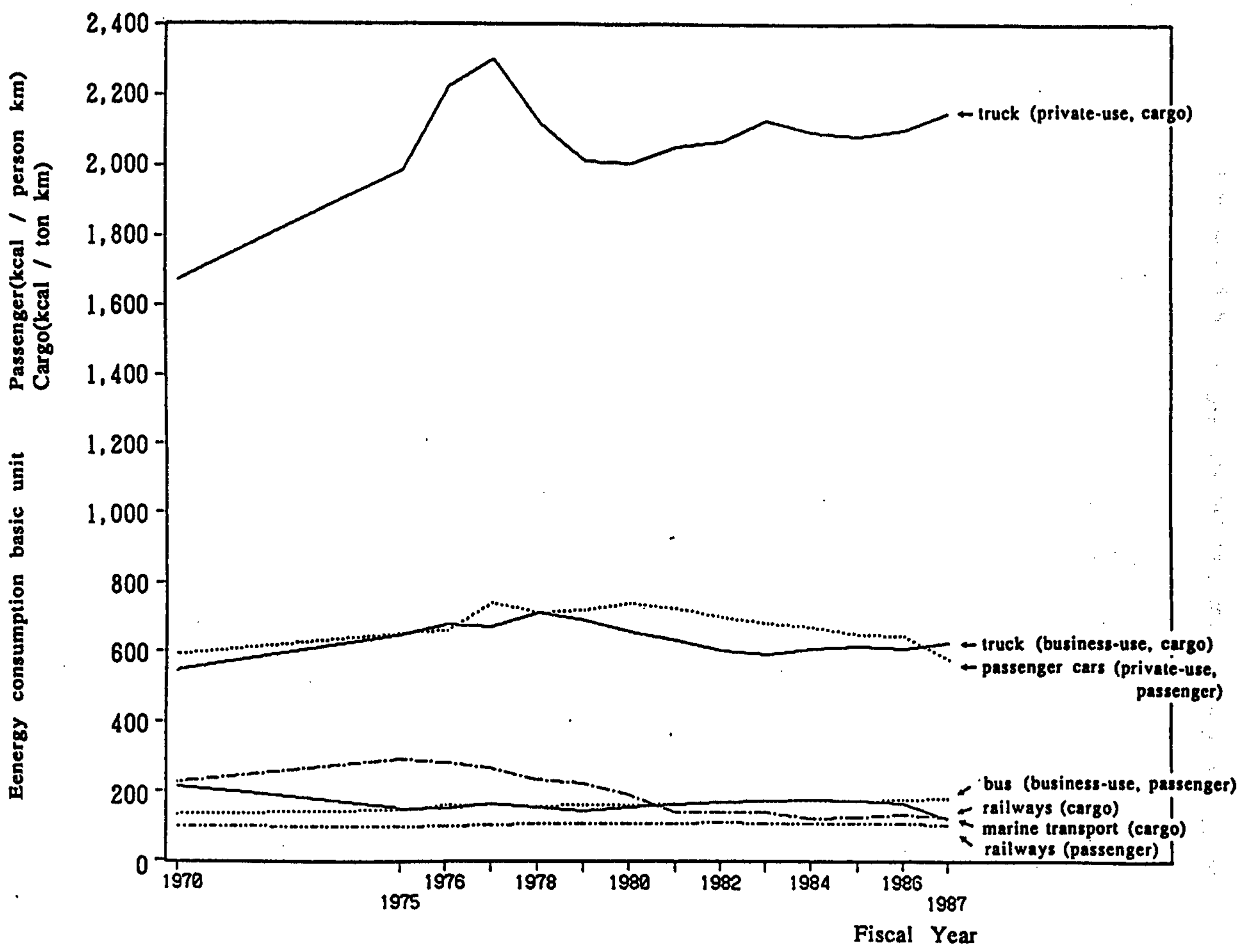
Source: OECD, "Energy Balances of OECD Countries 1987-1988"
See Table 8-1-4

Figure 8-1-5 Manufacturing Industry Energy Consumption in Japan



Source: MITI
See Table 8-1-5.

Figure 8-1-6 Energy Consumption by Major Means of Transportation in Japan



Source: Ministry of Transport

See Table 8-1-6

8.1.3 Robot Usage

Industrial robots have made major contributions to greater productivity and higher product quality in Japan's manufacturing industry. To date there has been much debate about the effects of industrial robots and other new production technologies. According to R.U. Ayres (Reference 3), the merit of new production technologies are in the following five points: (1) substitute for labour; (2) increase of production capacity; (3) improvement in the rate of facility operation; (4) improvement in product reliability and quality; (5) promotion of technological innovation.

This section examines usability of data on industrial robots, and discusses the state of robot usage and the background to the development of robot technology.

(1) Robot Usage in Japan

The Japan Industrial Robot Association (JIRA) has extremely detailed data on the domestic production and shipment of industrial robots (Sources 7 and 8). Every year since 1979 JIRA has compiled tables showing shipment number and value for industrial robots by robot type, industry type, and usage. Data on shipment value by robot type and industry type have been available since 1974. Besides these, estimations of shipment value by robot type have been available since 1970, but their accuracy is questionable. Since 1979, data on both shipment number and shipment value for robots, and consignees have been classified by industry and robot usage.

IRA uses the following classifications for industrial robots.

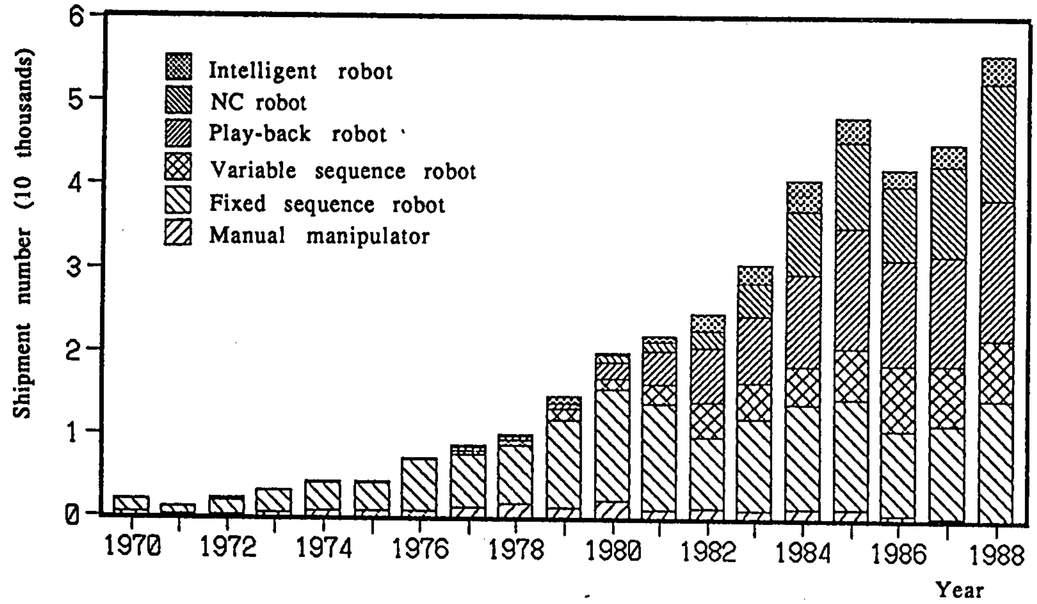
1). Manual manipulator: Robots that are remotely controlled by humans.
2). Fixed sequence robot: Robots which carry out fixed predetermined operations, and whose movements cannot be altered.
3). Variable sequence robot: Fixed sequence robots with an additional function which makes a change of operations possible.
4). Play-back robot: Robot which repeats a programmed series of movements.
5). NC robot: Robots whose movements are numerically controlled.
6). Intelligent robots: Robots which are equipped with visual sensors and which can control their own movements.

It should be Noted that there each country's definition of industrial robot differs. In Japan manual manipulators and fixed sequence robots are classified as robots; however they are not covered by the definition agreed upon by the International Organization for Standardization (ISO). There are also differences according to industrial robot capability and function.

Industrial robots are not specified in trade statistics, so import figures are not available. And although JIRA has in the past frequently conducted surveys on the number of robots in stock and state of usage, they are unable to cover the whole of Japan, so our only option is to estimate the total number of industrial robots in use based on some kind of assumption.

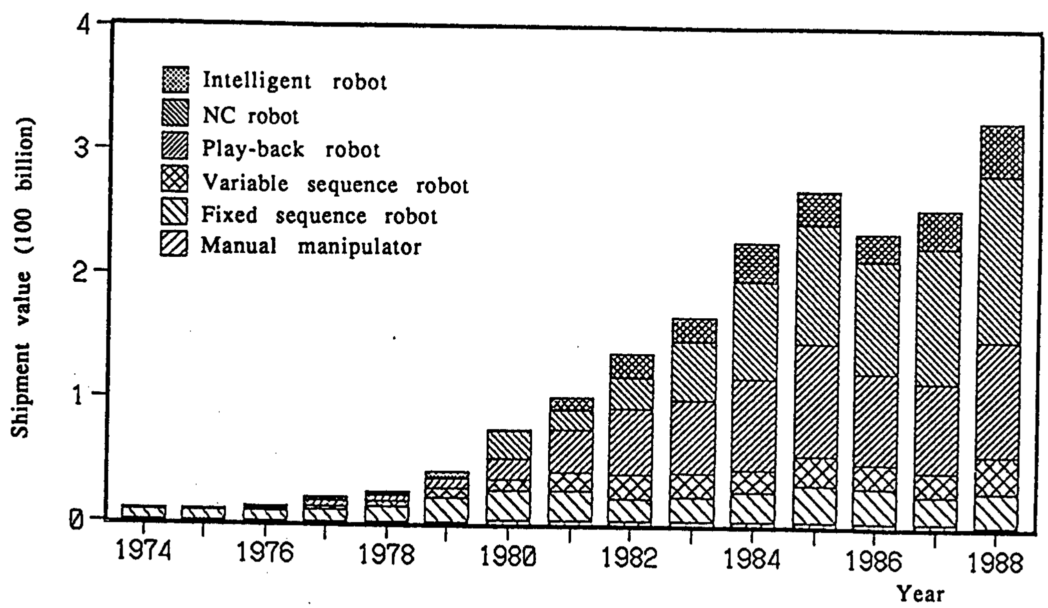
Keeping this in mind, shipment number and value are looked at. Figs 8-1-7 and 8-1-8 give a good picture of the growth in robot usage.

Figure 8-1-7 Changes in Number of Industrial Robots Shipped



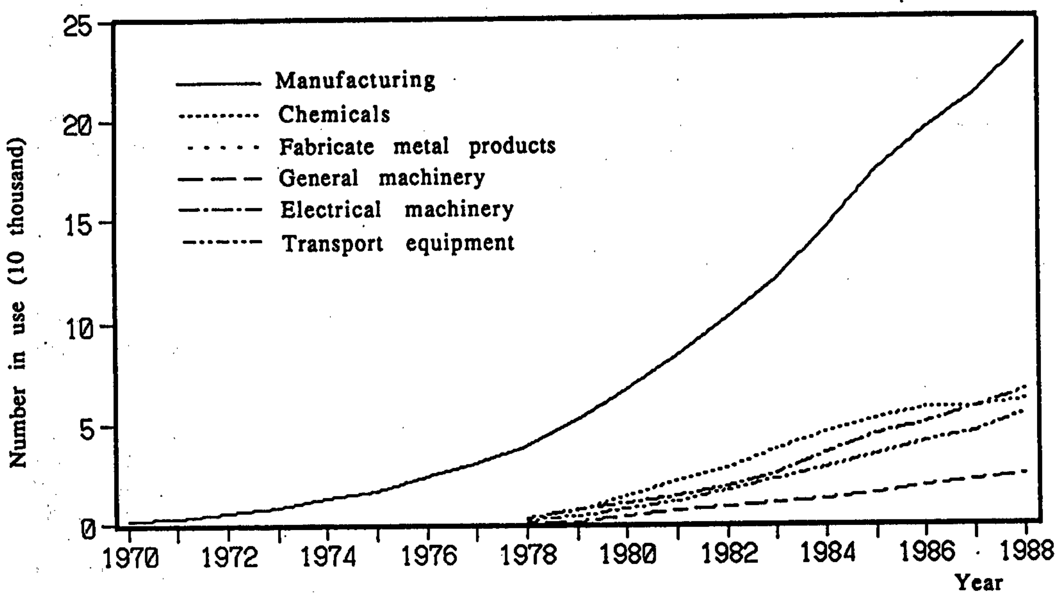
Source: Japan Industrial Robot Association
See Table 8-1-7

Figure 8-1-8 Changes in Industrial Robots Shipment Value



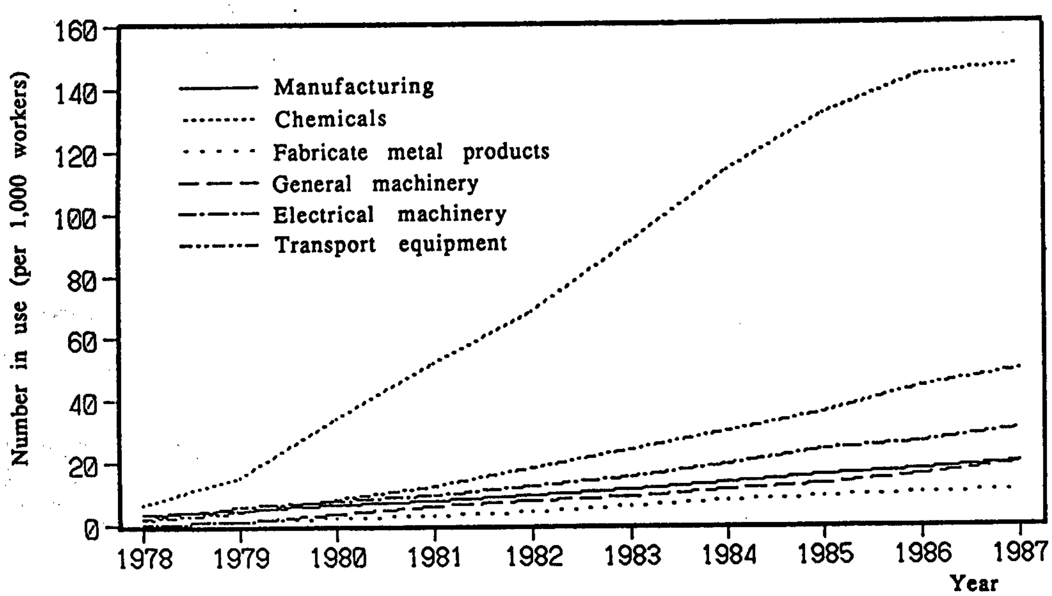
Source: Japan Industrial Robot Association
See Table 8-1-8

Figure 8-1-9 Changes in the Number of Industrial Robots in Use



Source: Japan Industrial Robot Association
See Table 8-1-9

Figure 8-1-10 Changes in the Number of Industrial Robots Per 1,000 Workers



Source: Japan Industrial Robot Association
See Table 8-1-10

The number of industrial robot in use is looked at next. Industrial robots are said to have an average life span of seven years, but according to JIRA surveys, the range is from two to ten years depending on the industrial field. Fig 8-1-9 shows the number of robots in use in manufacturing. Based on estimations assuming a robot life expectancy of seven years.There are a significant number in industries such as chemicals, metal products, general machinery, electric machinery and transport machinery industries.

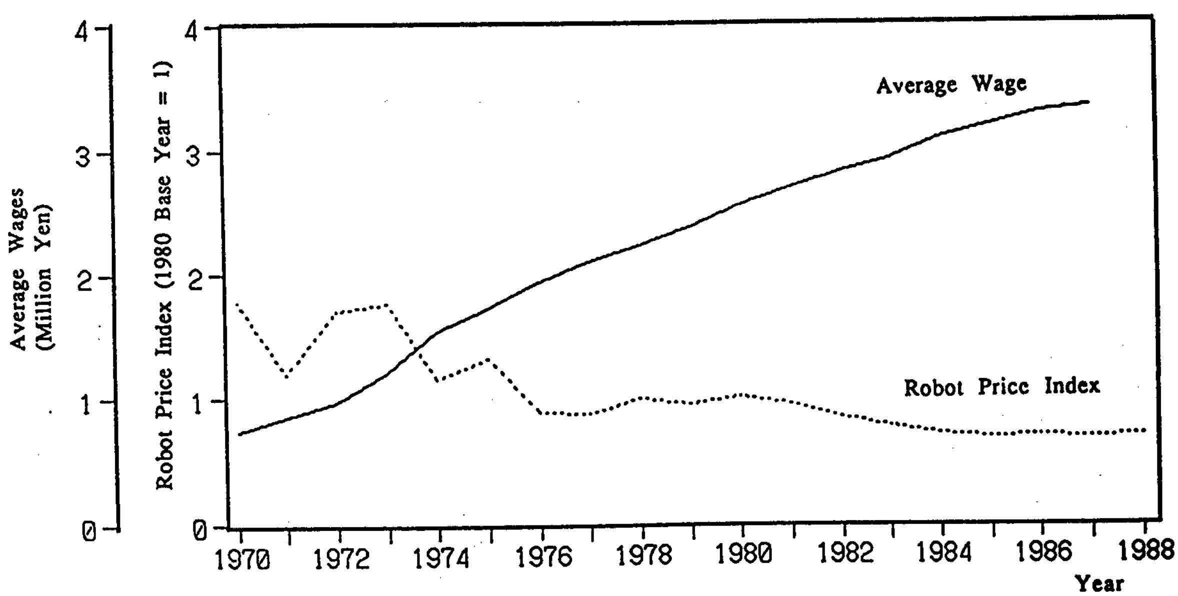
Fig 8-1-10 shows the number of industrial robots per 1,000 workers.The chemical industry has by far the most industrial robots, and this is thought to be mainly due to their use as extractors in the injection moulding processes. Almost all robots used in the chemical industry are variable sequence robots.

(2) Progress and Background of Robot Technology

A major factor in the rapid increase of industrial robot usage is the lowering of prices brought about by the progress of robot technology (Fig. 8-1-11). The price index used here is a type-based averaged price index weighted by shipment value.

According to surveys by JIRA and others, Japan's manufacturing industry has now reached the stage where introduction of robots is largely determined by economical efficiency. It no longer looks to the effectiveness of robots in raising product quality or promoting technological innovation to the same extent as in the United States and Europe. In fact, it is pointed out in Reference 4 that the earning rate of investment in robots has become set despite their growing sophistication. This indicates that the industrial robot market in the manufacturing industry has matured.

Figure 8-1-11 Changes in Wage Index and Robot Price Index



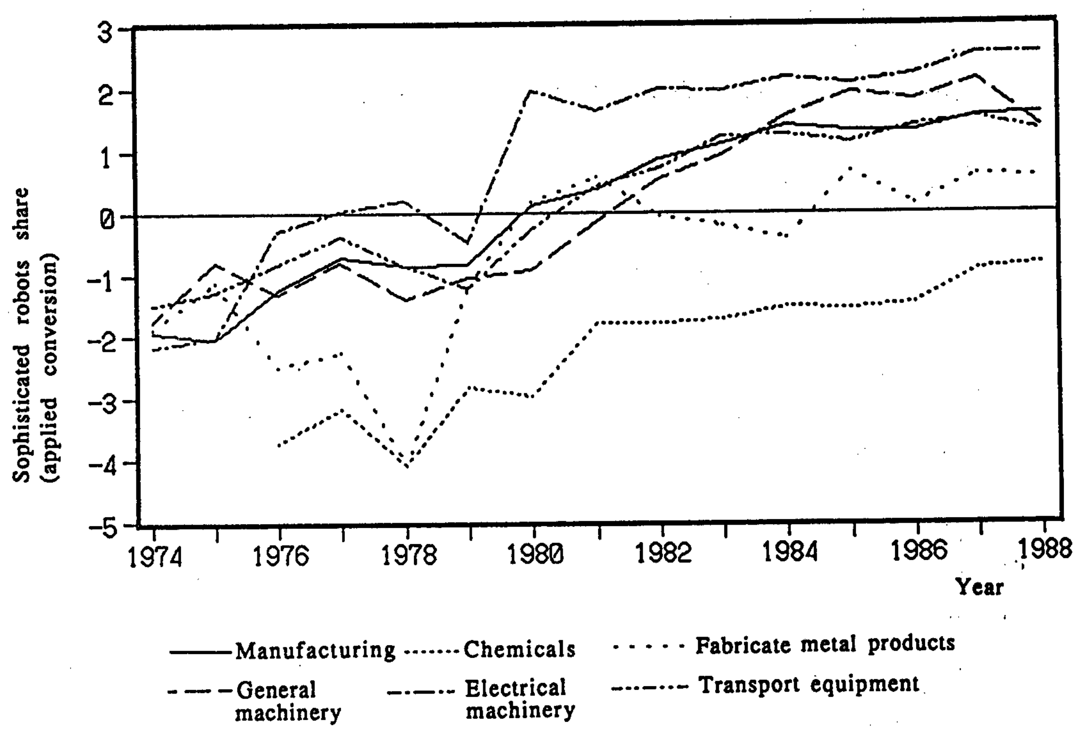
S. Mori, "Macroeconomic Effects of Robotization In Japan"

Of great interest is the question whether industry is heading towards a greater use of sophisticated robots. To examine this, changes in the share of the overall robot shipment value for sophisticated robots (play-back, NC, and intelligent robots), is looked at and plotted on a growth curve. A conversion of ln{s/(1-s)} (s = sophisticated robots' share) is applied; the results are shown in Fig. 8-1-12.

The zero line in this graph represents a 50 percent share held by sophisticated robots. The results show there is a clear shift towards sophisticated robots. The graph also shows that the chemical industry's switch over to sophisticated robots is slower than the other industries.

There is a need to develop new forms of robot usage in both the manufacturing and non-manufacturing industries, especially robots for extreme kinds of work, and medical and welfare service robots Also robots are needed to undertake wide-ranging analysis on the effect they will have on society and the economy.

Figure 8-1-12 Changes in the Share of Sophisticated Robots



S. Mori, "Macroeconomic Effects of Robotization In Japan"
See Table 8-1-12

8.1.4 Company Directors With an Academic Backgrounds in Science and Engineering

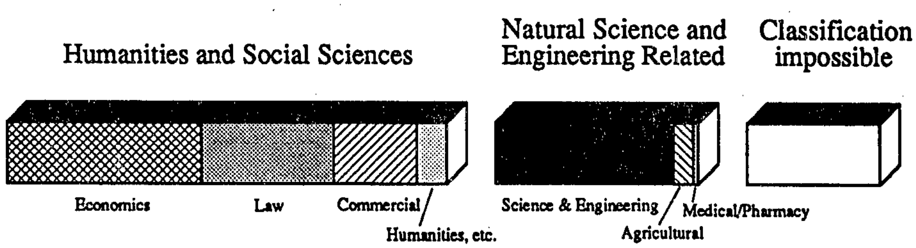
The percentage of company directors involved in formulating company management policy who have graduated from a science and engineering related faculties is an indicator of the extent to which people with technical backgrounds are used effectively, and also highlights the characteristics of Japanese corporate management.

Of the 38,485 directors in the 2,064 companies listed on the stock exchange, the academic backgrounds of 6,598 are not clear or cannot be classified. Figure 8-1-13 shows the academic backgrounds of the remaining 31,887. Economic departments had the highest share with 30 percent, followed by law faculties. It is thought that engineering departments have about the same share as law faculties, but science and engineering are difficult to differentiate in these data, so percentages for engineering by itself are not clear. The academic backgrounds are divided into science and the arts. 31.6 percent of the directors have an academic background in science and engineering (this is referred to below as the S/E percentage).

Figure 8-1-14 shows the S/E percentage by industry. First, industries are divided into manufacturing and non-manufacturing; the S/E percentage for the manufacturing industries was 40.9 percent, and for the non-manufacturing industries it was 20.6 percent. The only industry with a S/E percentage exceeding 50 percent was the construction industry with 60.7 percent. Industries with a percentage higher than 40 percent were transport machinery (49.2 percent), electric machinery (48.6 percent), precision machinery (47.4 percent), chemical (43.8 percent), non-ferrous metals (43.0 percent), iron and steel (42.4 percent), machinery (42.3 percent), and agriculture, forestry and fisheries (40.9 percent). It is worth noting that the science percentage is relatively high in the transport machinery, electric machinery and chemical industries, all considered Japan's major manufacturing industries.

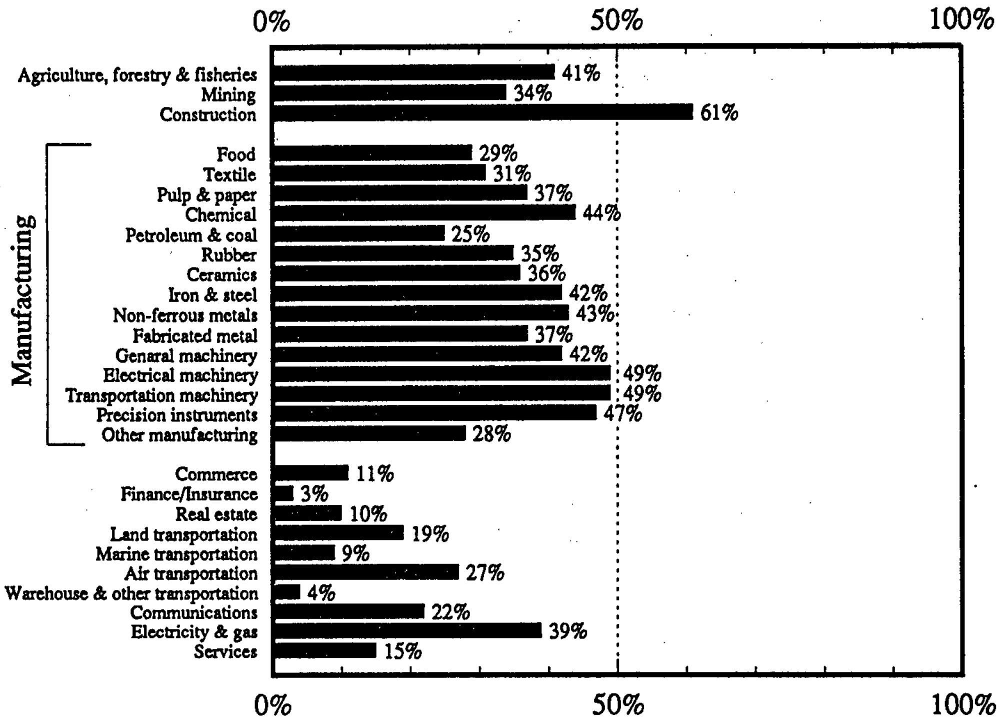
Although not shown in the figure, analysis was also carried out based on the size of company, on the company presidents only, and on changes in the S/E percentage over a set period. For company size capital investment is used as the basis for classification. The science percentage for the 707 companies with capital of more than ¥10,000 million was 29.4 percent, which was slightly lower than the overall average of 31.6 percent. These data indicate that the extent to which people with an academic backgrounds in S/E. Next, the S/E percentage for company presidents only was 32.8 percent, which was higher than the average for all directors. As for changes in the S/E percentage over a set period, it is difficult to come up with any reliable data, for statistics only go back to 1986 and this is not sufficient to observe any change. Moreover, the number of companies that come into calculation is increasing year after year, and it is impossible to determine whether the number of directors with S/E backgrounds is indeed increasing, or simply whether companies with a low S/E percentage are coming into calculation for the first time. For reference, the S/E percentage in 1986 was 33.7 percent, so it would appear that the S/E percentage has decreased.

Figure 8-1-13 Corporate Director Academic Backgrounds (Companies Listed on the Tokyo Stock Exchange)



Source: Toyou Keizai Shinpou-sha, "Executive Quarterly Database" 1990
See Table 8-1-13

Figure 8-1-14 Share of Company Directors With Academic Backgrounds in Science and Engineering



Source: Toyou Keizai Shinpou-sha, "Executive Quarterly Database" 1990
See Table 8-1-14

8.2 Impact on Life-styles

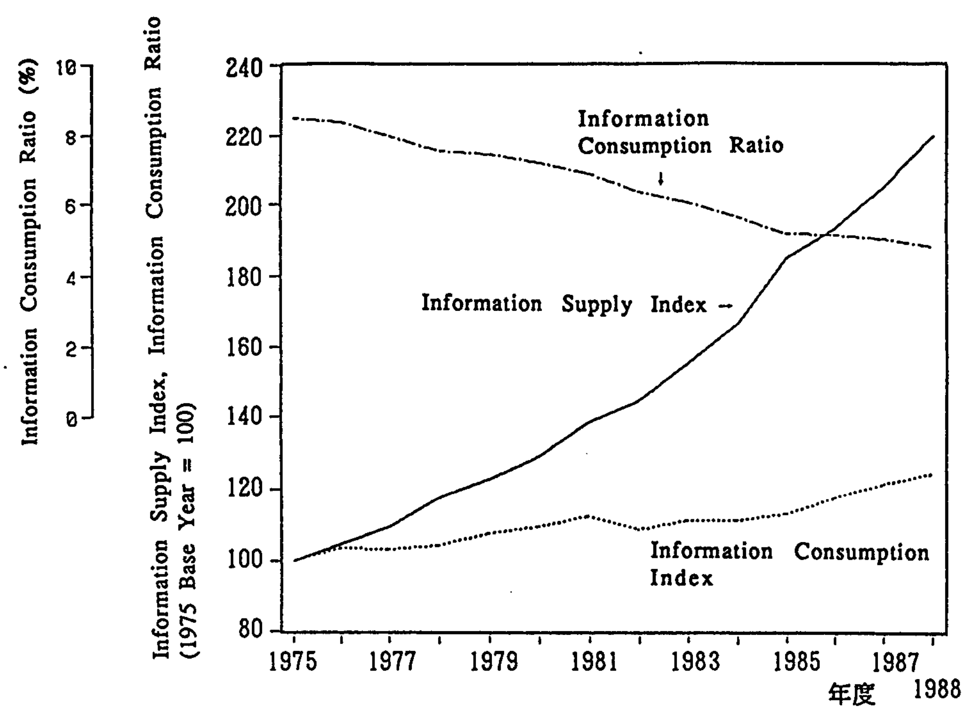
8.2.1 Changes in the Degree of Use of Information Media

The information and communication field has developed remarkably in recent years. Many new forms of information media have appeared, particularly in the early 1980s, and are contributing greatly to society. This section examines the degree to which information media are being used as means of determining the relationship between the achievements made by science & technology and life styles.

A general view of information media is first. The volume of information supplied (Note 1) has continued to grow each year as well as the rate of growth; but the volume of information consumed has not grown to the same extent. Each year the volume of information supplied is much greater than the volume of information consumed, so each year the information consumption rate (volume of information consumed/volume of information supplied) is dropping. As for the information indices for fiscal 1988 (fiscal 1975 = 100), the information supply index was 219, while the information consumption index stood at only 124. The information consumption rate dropped from 8.5 percent in fiscal 1975 to 4.8 percent in fiscal 1988 (Fig. 8-2-1).

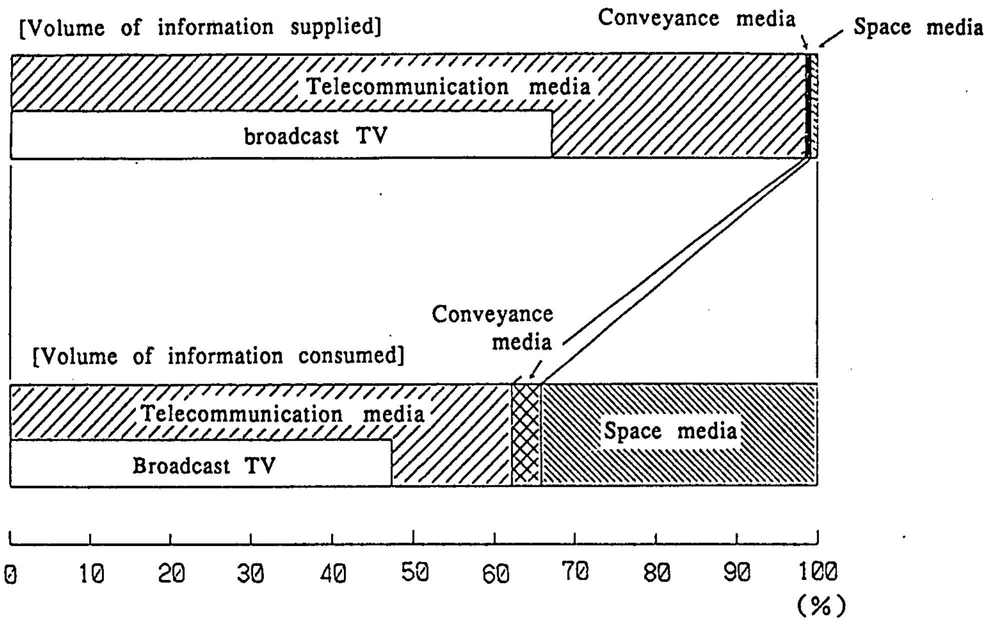
Information media is divided into three media groups: telecommunications, conveyance and space. As can be seen in Fig. 8-2-2, in fiscal 1988 the telecommunications media accounted for about 99 percent of all information supplied (broadcast TV - 67 percent; others - 32 percent), and more than 60 percent of all information consumed.

Figure 8-2-1 Changes in Information Supplied and Information Consumed



Ministry of Posts and Telecommunications, "Census on Information Flows 1988"

Figure 8-2-2 Media Group Share of Information Supplied and Consumed (Fiscal 1988)



Ministry of Posts and Telecommunications, "Census on Information Flows 1988"
See Table 8-2-2 to Table 8-2-7.

(1) Volume of Information Supplied

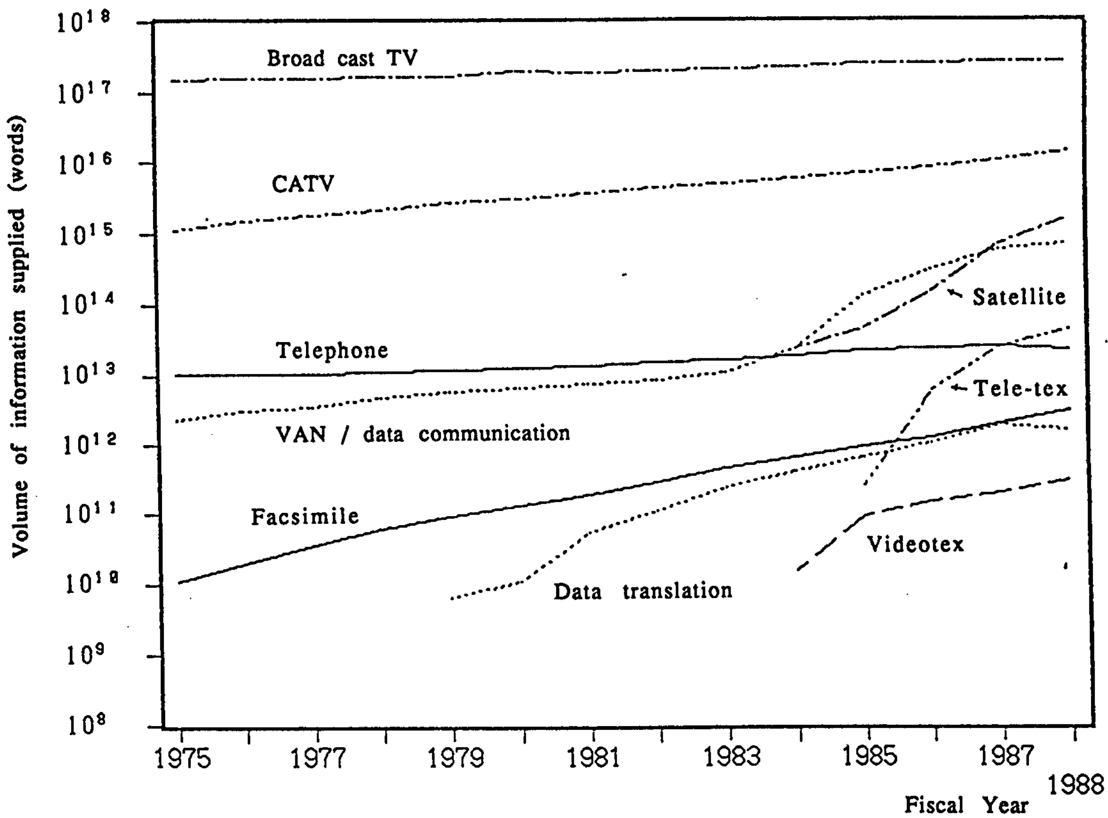
Each year the volume of information supplied by telecommunications media is increasing at a greater rate than that supplied by the other two media groups. In fiscal 1988 the information supplied indices for the three groups were telecommunications - 221, conveyance - 173, and space - 124; telecommunications accounted for 98.9 percent of all information supplied, conveyance for 0.5 percent, and space for 0.6 percent (Fig. 8-2-2). Both the volume and growth rate of information supplied by the telecommunications media is significant, and this media group in particular has contributed much to the growth in the volume of information supplied by the information media as a whole.

Changes in the volume of information supplied by the information media is examined. Between fiscal 1975 and fiscal 1988, the volume of information supplied by conventional media, including telephone, broadcast TV, letters and postcards, newspapers, and magazines and books, increased at almost the same rate each year. However the volume of information supplied by these media over this period grew less than two-fold, so in terms of information supplied, it is said that these are mature media.

New communications media, on the other hand, enjoyed significant growth. The volume of information supplied through facsimiles increased markedly during the 1980s (Fig. 8-2-3 shows this as a rectilinear increase), and VAN/data communications expanded rapidly from about 1984. Other new media such as satellite broadcasting, tele-tex broadcasting, word processors, and video software came into being in the early 1980s, and all have shown steady growth (Fig. 8-2-3, Fig. 8-2-4).

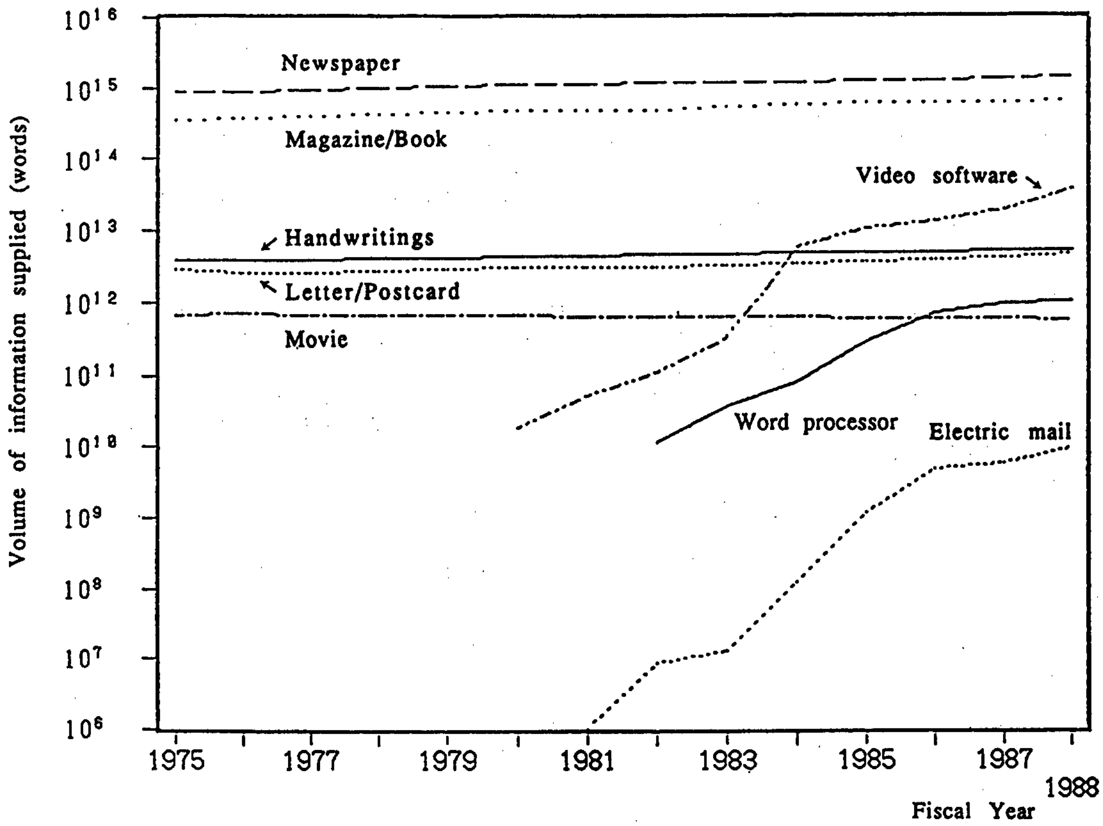
A comparison of some of these new media with the more traditional media shows that. Ownership of word processors increased rapidly from the mid- 1980s (in 1988 word processors could be found in 20 percent of all households), and in fiscal 1988 the volume of information supplied through documents prepared on word processors had reached 10 percent of that supplied through hand-written documents. Although the volume of information supplied through electronic mail also grew rapidly between fiscal 1981 and fiscal 1988, it is a mere 0.2 percent of the volume of information supplied through letters and postcards. It is clear that the new media have not yet reached the levels of the traditional media.

Figure 8-2-3 Volume of Information Supplied Through the Telecommunications Media



Ministry of Posts and Telecommunications, "Census on Information Flows 1988"
See Table 8-2-2

Figure 8-2-4 Volume of Information Supplied Through the Conveyance Media and Space Media



Note: in Table 8-2-4 and Table 8-2-6, Conveyance media includes letter, postcard, electric mail, handwritings, writing by word prcessor, newspaper, magazine, book and video software, on the other hand, Space media includes movie.

Ministry of Posts and Telecommunications, "Census on Information Flows 1988"
See Table 8-2-4, and Table 8-2-6.

(2) Volume of Information Consumed

The volume of information consumed through conveyance media has grown at a greater rate than through the other two media. The growth in video software has been particularly strong. In fiscal 1980 only 0.9 percent of information consumed through conveyance media was done so through video software, but by fiscal 1988 this had grown to 16.7 percent, putting it on the same level as newspapers, magazines and books. Growth of the conveyance media stands out from the others: in fiscal 1988 the information consumed indices for the three media groups were telecommunications - 124, conveyance - 142, and space - 124. However, the telecommunications media account for the majority of information consumed with 62.1 percent, followed by the space media with 34.2 percent and the conveyance media with 3.7 percent (Fig. 8-2-2).

In all cases, the volume of information consumed through such media as telephone, letters and postcards, newspapers, and magazines and books grew less than two-fold between fiscal 1975 and fiscal 1988. Since the early 1980s the volume of information consumed through broadcast TV has decreased, though only slightly, and in terms of information consumed, it can be said that these are mature media.

Although the volume of information consumed through new media - satellite broadcasting, teletex broadcasting and video software - has not increased as much as the volume of information supplied, there has been steady growth (Fig. 8-2-5, Fig. 8-2-6).

Comparing some of these new media with traditional media, the volume of information consumed through word processor documents and electronic mail has not yet reached the same level as through volume consumed through the traditional media. On the other hand, the volume of information consumed through video software first exceeded the volume consumed through the cinema in about 1983, and has continued to increase. Considering that in fiscal 1988 movies accounted for about 60 percent of the video software sales amount, video software is a new medium that is taking the place of cinema. It certainly stands out that while the other new media have yet to reach the same level as the traditional media, video software has gone beyond the traditional cinema medium and is continuing to grow.

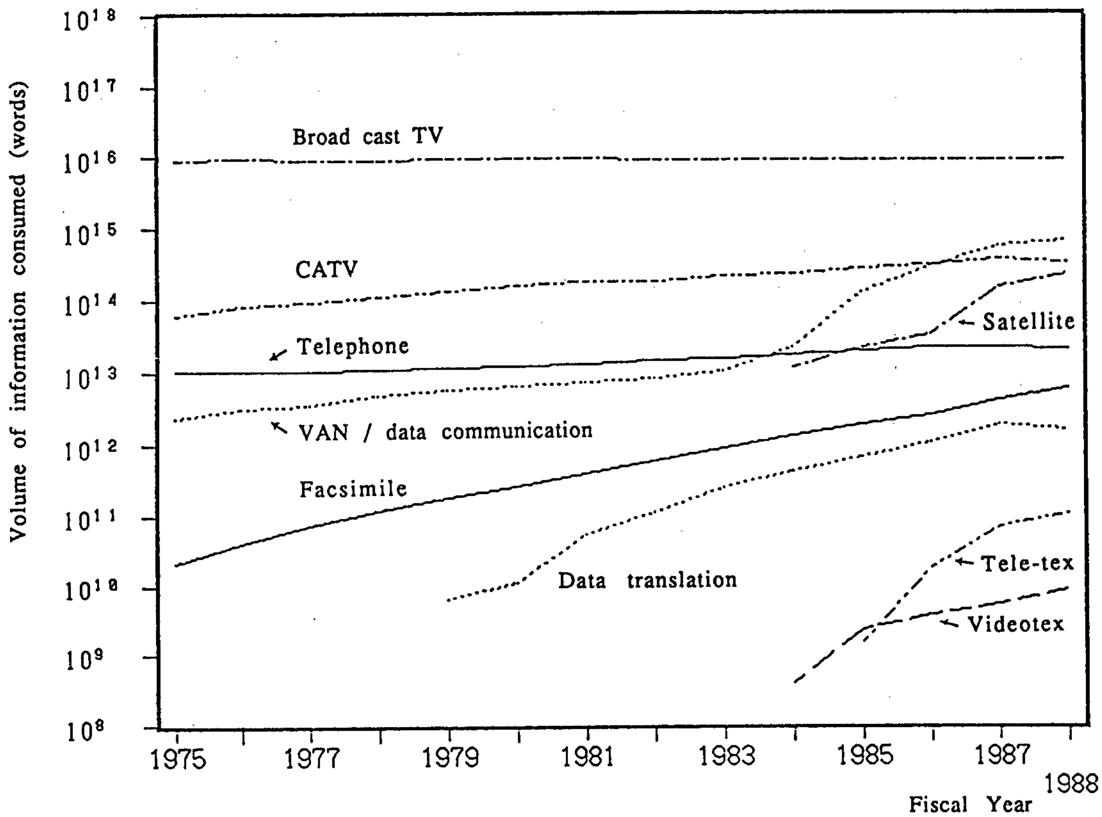
(3) Information Consumption

In fiscal 1988 information consumption percentages were: telecommunications - 3.0 percent (communications - 100.4 percent, broadcasting - 2.9 percent), conveyance - 34.8 percent, and space - 296 percent. For the space media, it is normal for more than one person to come into contact with the same piece of information at the same time, so the volume of information consumed exceeds the volume supplied.

The information consumption percentage reflects the efficiency of information consumption (or efficiency of information use), of the telecommunications media, broadcasting in particular, through which a large volume of information is supplied and consumed, has an extremely low consumption efficiency of 2.9 percent. This can be attributed to the fact that the non-broadcasting media for the most part provide information according to the needs of the information consumers, whereas broadcasting is a one-way supply of information without regard to the number of information consumers (eg. the number of television viewers).

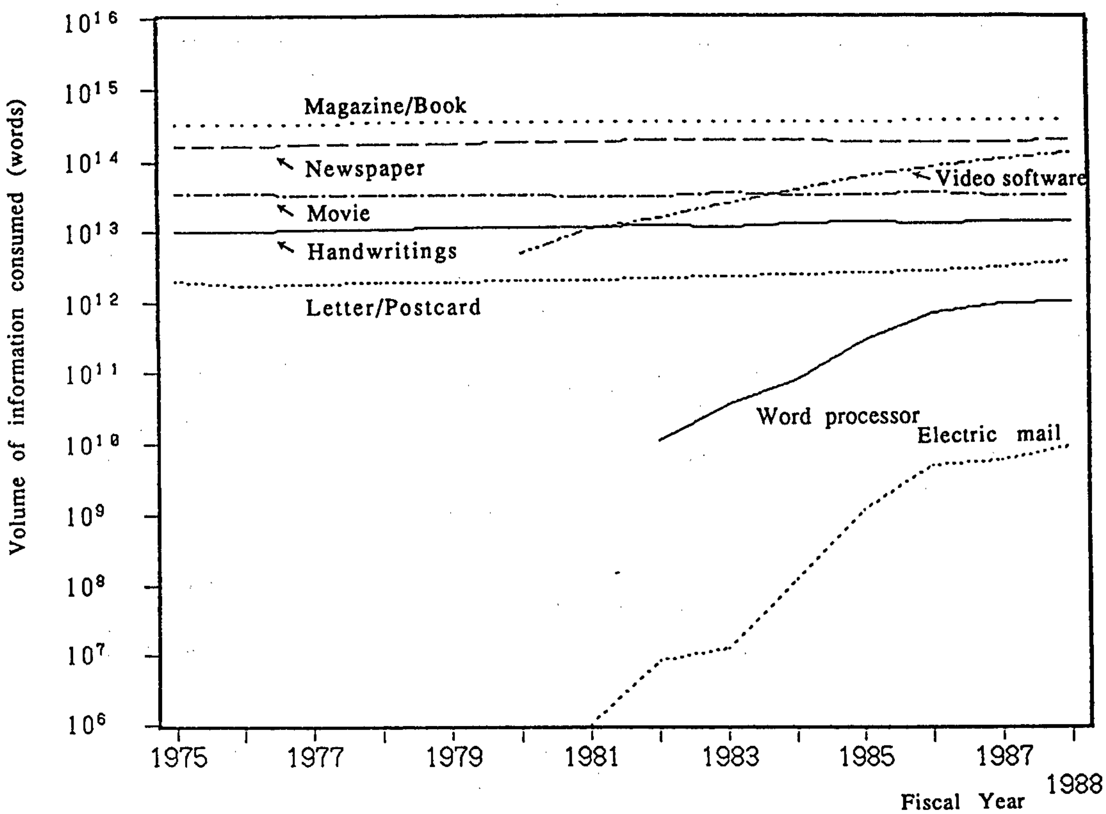
Note:
The volume of information supplied refers to total volume of information supplied in a form that can be received by information receivers at the point of receipt for each piece of information. The volume of information consumed is the total volume of information that is actually consumed by the information receiver from the information provided to the market by the information suppliers.

Figure 8-2-5 Volume of Information Consumed Through the Telecommunications Media



Ministry of Posts and Telecommunications, "Census on Information Flows 1988"
See Table 8-2-3

Figure 8-2-6 Volume of Information Consumed Through the Conveyance and Space Media



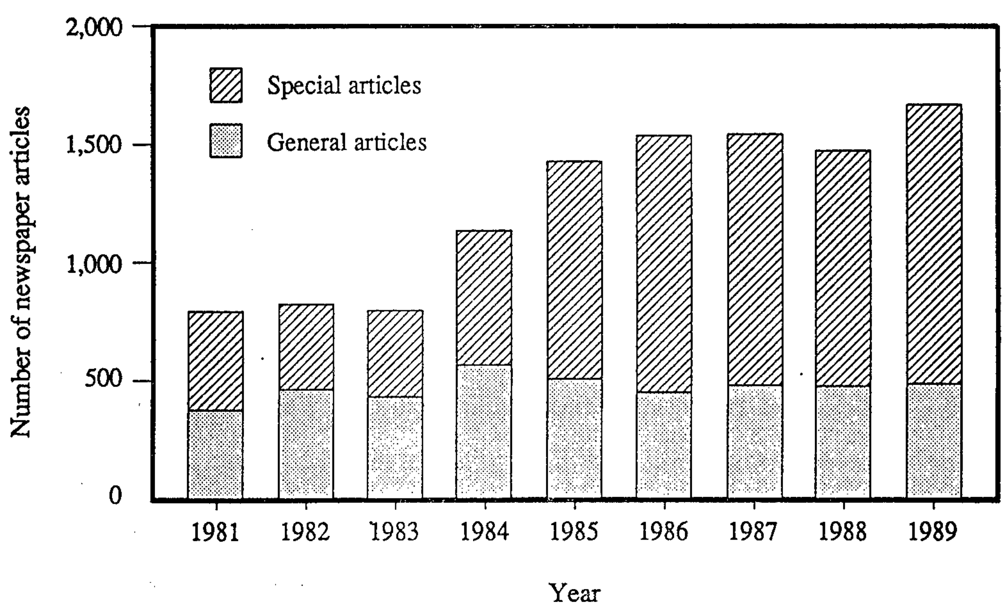
Ministry of Posts and Telecommunications, "Census on Information Flows 1988"
See Table 8-2-5, and Table 8-2-7.

8.2.2 Scientific and Technological Information

The information supplied and consumed, looked at in the preceding section, covers all fields. the contrasting focus in this next section is on information connected with science and technology. People normally come into contact with scientific and technological information through broadcast programmes and newspaper articles. It is important to look at changes in the information connected with science and technology when discussing scientific and technological activities.

First, as can be seen in Fig. 8-2-7, newspaper articles on science and technology (Note 1) increased dramatically in the mid 1980s. But whereas the number of special articles increased rapidly, the number of general articles stayed at much the same level. This is due in part to reader demand for more detailed information on science and technology matters, and also to the newspaper company belief that the size of the role fulfilled by the mass media regarding science and technology requires them to provide sufficiently detailed information to their readers.

Figure 8-2-7 Changes in the Number of Newspaper Articles on Science and Technology



Source: Asahi Sinbun *(Asahi Newspaper)*

See Table 8-2-8

As can be seen in Chapter 9 "Public Opinion on Science and Technology" the percentage of people interested in science and technology, which had been dropping from the latter half of the 1970s to the early half of the 1980s, began to rise from the latter half of the 1980s. It is generally thought that this change has been brought about by the increased opportunities for people to come into contact with science and technology through newspapers. Another view is that reader changing awareness is being reflected in newspaper editing. In either case, Fig.8-2-7 shows changing approaches and views for both reader and mass media regarding science and technology. Also surveyed are radio and television programmes and books, but no significant changes are evident.

According to a public opinion surveys conducted by the Prime Minister's Office (Note 2), there is a view that "articles or news about science and technology have increased in recent years," but as yet "are not provided with sufficient opportunities or information to find out everything needed to know about science and technology." There was a large response, especially among people interested in science and technology, that not enough information is being provided.

Notes:

1. Number of scientific and technical articles in the Asahi Shimbun.

2. The data from the "Public Opinion Poll Regarding Science & Technology and Society (January 1990)" by the Prime Minister's Office used in this section is as follows.
Responses to the poll were multiple choice, and unless indicated otherwise, the percentage shown is the percentage of the 2,239 people who were surveyed.

(1) "Are you interested in news or discussions concerning science and technology?"
(a) Interested (55.9 percent)
(b) Not interested (41.7 percent)
* "Interested" includes "very much interested" and "somewhat interested". "Not interested" includes "Not particularly interested" and "Not interested at all"

(2) "From where do you normally obtain information about science and technology?" (Multiple response)
(a) Television, radio, newspapers, general magazines (90.0 percent)
(b) Conversations with family members and friends (23.8 percent)
(c) Technical magazines and books (10.9 percent)

(3) "Do you think that 'articles or news about science and technology have increased in recent years'?"
(a) Yes, I think so (74.7 percent)
For this question, the percentage of the 1,252 people whose answer to Q1 was "interested" was 8.0 points higher than the overall percentage of 74.7 percent; similarly the percentage of the 934 people whose answer was "not interested" was 8.9 points lower.
(b) No, I do not think so (11.9 percent)
* "Yes, I think so" includes "Yes, I definitely think so" and "Yes, I think so". "No, I do not think so" includes "No, I definitely do no think so" and "No, I do not think so".

(4) "Do you think that you are provided with sufficient opportunities or information to find out everything you want to know about science and technology?"
(a) Yes, I do think so (26.5 percent) For this question, the percentage of the 1,252 people whose answer to Q1 was "interested" was 3.8 points higher than the overall percentage of 26.5 percent; similarly the percentage of the 934 people whose answer was "not interested" was 4.0 points lower.
(b) No, I do not think so (53.9 percent). The percentage of the 1,252 people whose answer to Q1 was "interested" was 5.8 points higher than the overall percentage of 53.9 percent; similarly the percentage of the 934 people whose answer was "not interested" was 6.1 points lower.

8.2.3 Spare-time Activities (Video Tape Recorders, Personal Computer Use)

(1) Spread of Domestic-use Video Tape Recorders

While color television was spreading rapidly throughout Japan between the late 1960s and early 1970s, development of domestic-use video tape recorders (VTR) (Note 1) was progressing steadily, and in the mid 1970s, VTR production began.

As VTR production gained momentum the unit price dropped, and this, coupled with an expanding range of video software, the VTR market grow at an annual rate of more than 80 percent in the early 1980s (Reference 5) (Fig. 8-2-8). Video software rental accelerated the spread of the VTRs, as can be seen by the dramatic increase in video software sales (Note 2) following the opening of the first video rental shop in 1984 (Fig. 2-8-9), and in 1989, two out of every three households owned a VTR.

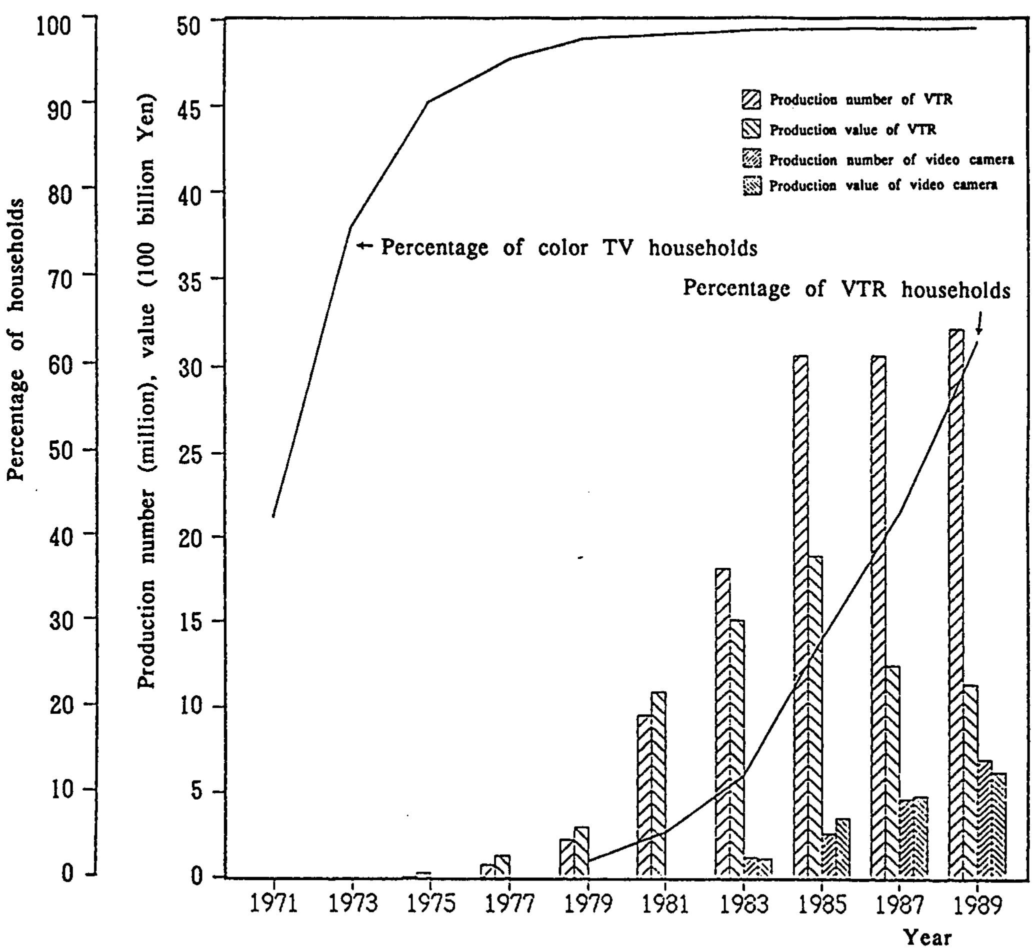
The VTR has brought about a significant change to life-styles which can be referred to as a time-shift from television to movie viewing. As for genre, movie software accounted for almost 60 percent of video software sales in 1989. Of this, foreign movies accounted for about 80 percent of retail sales, while Japanese movies accounted for almost 60 percent of rentals. This shows that the spread of the VTR has brought about a change in viewing habits regarding foreign movies; that is, more people are viewing foreign movies at home rather than at movie theaters. This also indicates that Japanese movies are not viewed as much as foreign movies. Although accounting for less than 1 percent of the rental sales, music accounts for more than 15 percent of retail (sales are about 70 times as great as rental sales).

In the latter half of the 1970s, business software, such as company guides, accounted for more than 60 percent of video software sales. But as the VTR became more widespread, the percentage accounted for by personal-use video software increased, and reached more than 90 percent in 1989. This shows that the VTR is used mainly for spare time entertainment, and the considerable growth achieved by personal-use video software is a good example of how technological development is enriching our lives.

The domestic-use video camera made its appearance in the early 1980s, and with this, videos are now widely used outdoors as well. Looking at production number, production value and diffusion rates for VTR in the early 1980s, it can be expected that the video camera market will continue to expand.

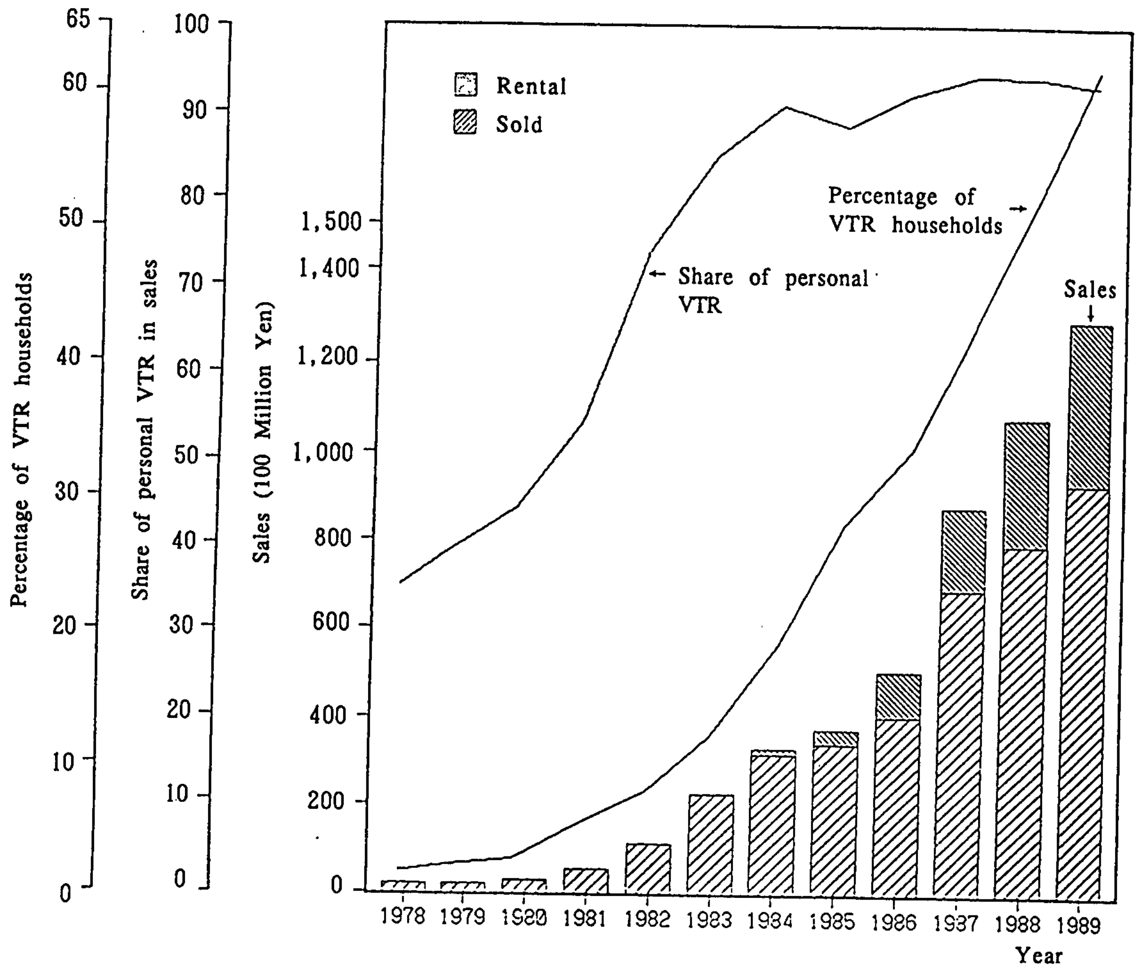
Notes:
1. Referred to overseas as VCR and VTR in Japan.
2. Video software sales indicated here are sale by software manufacturers. Therefore the "rental" sales amount is the value of the software lease contracts between video software manufacturers and video rental shops, and not the amount of sales by video rental shops.

Figure 8-2-8 Changes in VTR and Video Camera Production



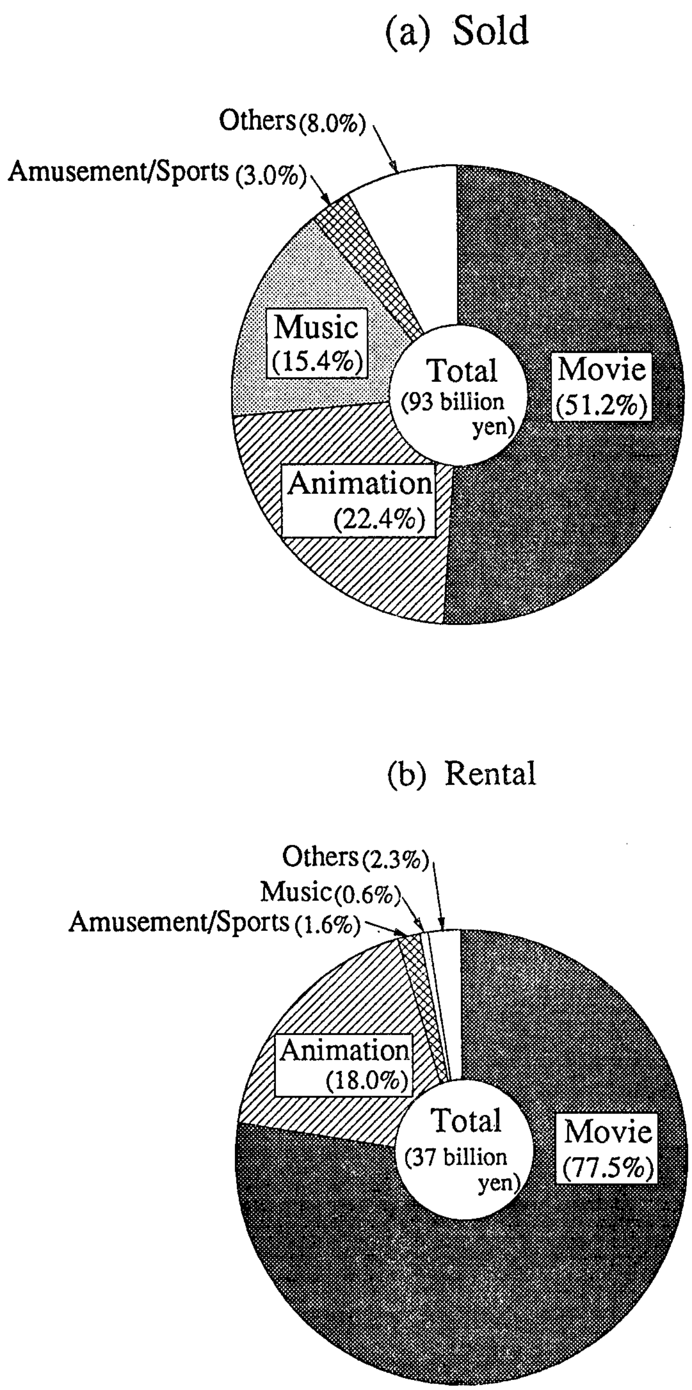
Source: MITI, and Economic Planning Agency
See Table 8-2-9.

Figure 8-2-9 Changes in Video Software Sales



Source: Japan Video Association
See Table 8-2-10, Table 8-2-11.

Figure 8-2-10 Video Software Sales by Genre (1989)



Source: Japan Video Association
See Table 8-2-12

(2) Spread of Personal Computers

Japan began producing 8-bit personal computers in the latter half of the 1970s, and from then until the first half of the 1980s domestic demand for mainly 8-bit computers realized steady growth. The 16-bit computer first appeared on the market in the early 1980s, and following a period of steady growth until the mid 1980s, demand soared. In 1988 the 16-bit computer accounted for more than 70 percent of the domestic shipment amount. But in 1989 the domestic shipment share of the 16-bit computer had already started to decrease slightly, while that of the 32-bit computer doubled from 1988 to 20 percent. Personal computer demand quickly shifted to large-capacity high-speed machines, and this change can also be seen in the increased software shipment amount. As the performance of personal computers improved, they became lighter and more compact, ranging from the desk-top models to lap-top and Notebook computers. In fiscal 1989 about 910,000 lap-top computers (including Notebook computers) were shipped by manufacturers (domestic - 430,000; export - 480,000), accounting for almost 40 percent of the total shipment of personal computers.

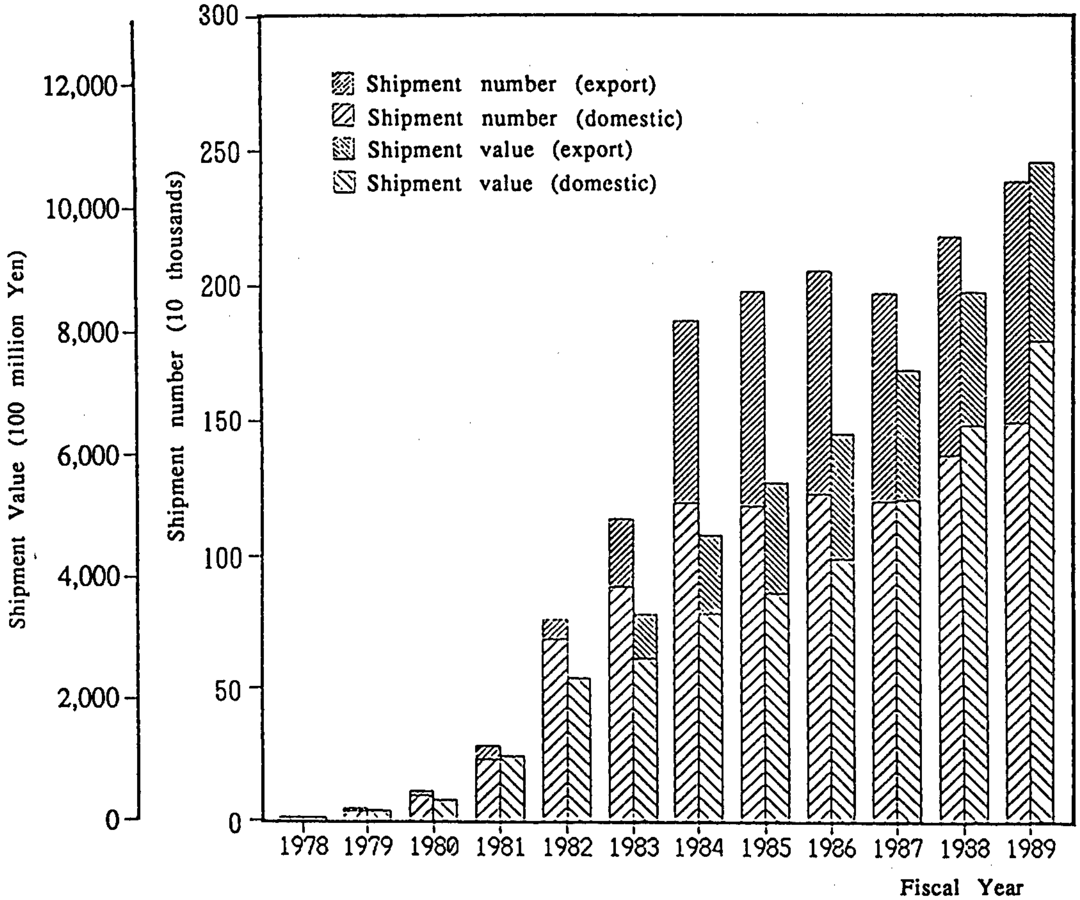
The growth in personal computer software shipment varies greatly depending on the type of software (Fig. 8-2-12). In 1985 computer games software accounted for 22 percent of software shipment, followed by word processing software with 14 percent; but in 1989 these had dropped to 9.3 percent and 8.7 percent respectively. Instead, industrial software, including CAD software and specific-industry-oriented software (eg. software for vehicle servicing centers, medical centers and so on) increased markedly, accounting for 25 percent of total software shipment in 1989. This indicates that use of personal computers has increased as their performance improves.

More people are using their personal computers in communication as reflected in the annual growth of communications software shipment of around 25 percent in 1986 and 1987, more than 40 percent in 1988, and 55 percent in 1989 (Note 2).

Notes:

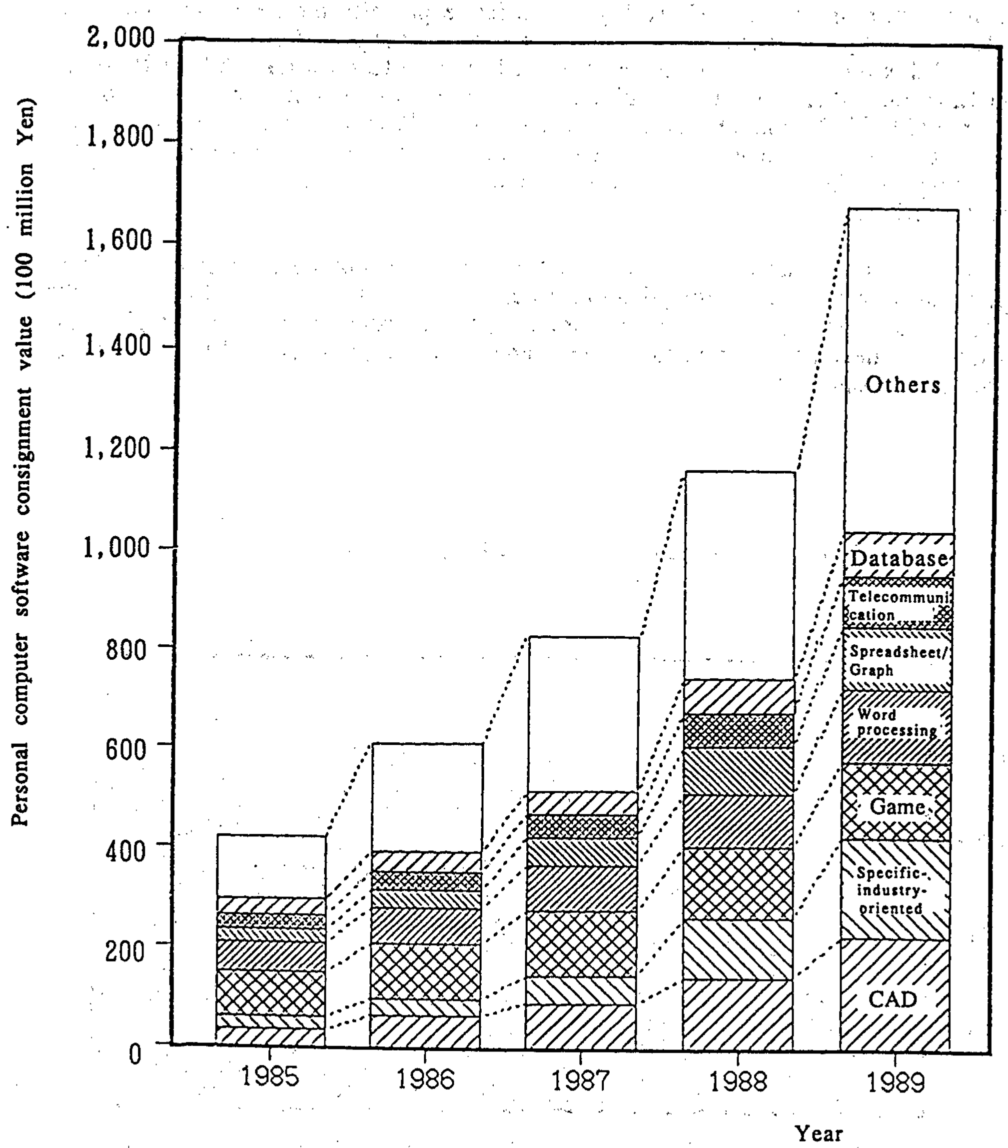
1. Personal computer shipments amount are the amount which includes the computer itself and peripheral equipment.
2. According to a survey conducted in March 1989 by the Ministry of Posts and Telecommunications, there were 185,300 business computer communications subscribers. The number of PC-VAN and NIFTY-Serve subscribers doubled each year from 1988, when the service was introduced, and as of the end of November 1990, there were 353,000 subscribers.
3. The graph at Figure 8-2-10 is based on Source 14 with changes to some of the classifications.
4. The graph at Figure 8-2-12 is based on Sources 15 and 16 with changes to some of the classifications.

Figure 8-2-11 Trends in Personal Computer Shipments



Source: Japan Electronic Industry Development Association (JEIDA)
See Table 8-2-13.

Figure 8-2-12 Trends in Personal Computer Software Shipments



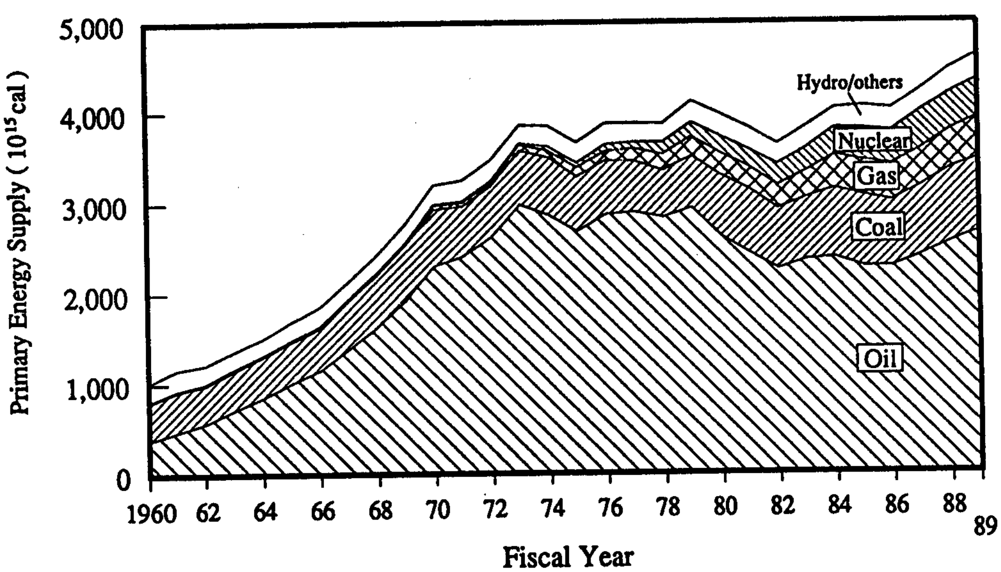
Source: Japan Personal Computer Software Association.
Japan Personal Computer Software Technology Research Institute.
See Table 8-2-14.

8.3 Contribution to Preserving the Global Environment

In the 1960s, Japan's energy consumption, centering on petroleum, jumped owing to the rapid expansion of the mining and manufacturing industries; especially the heavy and chemical industries. Consequently, Japan suffered serious environmental pollution from the mid 1960s. In order to control this problem, Japan enacted the Air Pollution Control Law, Water Pollution Prevention Law and other laws and regulations, and is also developing pollution control technology under MITI's National Research and Development Program for Large-scale Projects. The result has been a considerable reduction in air pollution caused by sulphur oxide. But on the other hand, nitrogen oxide caused by an increase in motor vehicle traffic and water pollution from sewage are still serious problems.

This section examines how Japan approaches pollution control by looking at the state of exhaust gas desulphurization systems and denitrification systems as concrete examples of investment in pollution control equipment. Because concern for the global environment is growing rapidly, the present condition of and cuts to carbon dioxide emissions, which is regarded as the main cause of global warming, are examined.

Figure 8-3-1 Japan's Primary Energy Supply



Source: MITI
See Table 8-3-1

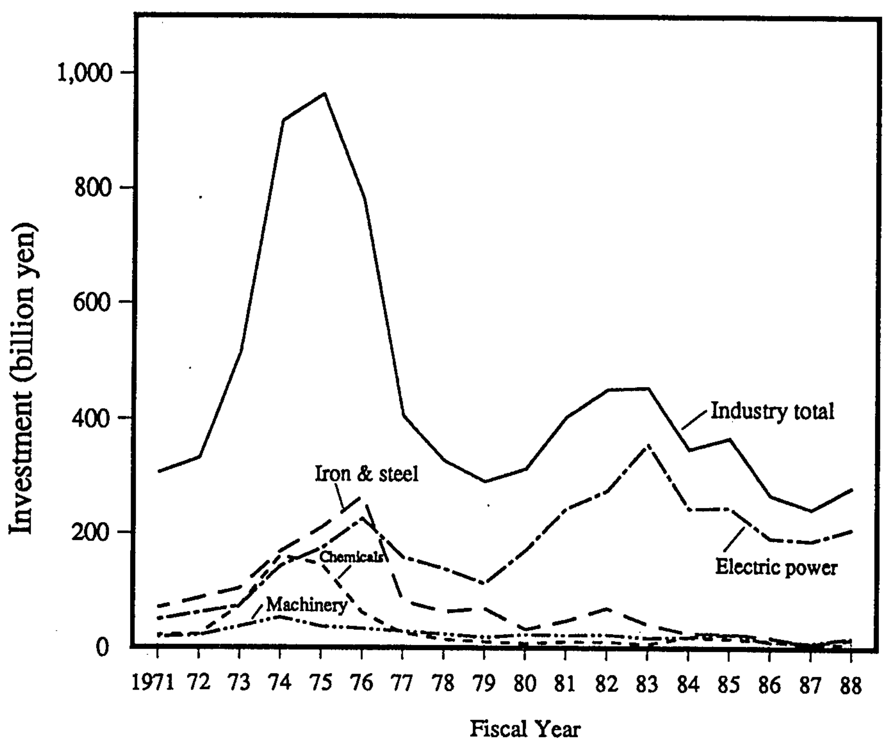
8.3.1 Investment in Pollution Control Equipment

(1) Amount of Investment

During the 1960s Japan's energy consumption increased significantly at an annual rate of about 10 percent, and as a result, energy consumption in fiscal 1970 was three times as great as in fiscal 1960. As can be seen in Fig. 8-3-1, the increase in energy consumption was met by an increase in oil supplies. During this period the major source of Japan's energy supply shifted from coal to oil.

Greater energy consumption gave rise to the serious environmental pollution mentioned earlier, so the private sector pushed ahead with pollution control measures, investing ¥964,500 million, or about one-fifth of total capital investment, in pollution control equipment in fiscal 1975. This was the equivalent of 0.51 percent of GNP. By the latter half of the 1970s installation of pollution control equipment in existing facilities had just about run its course, and this, coupled with a slow-down in production activities, resulted in a fall in expenditures on pollution control equipment. Then, in the early 1980s, electric power companies began constructing large capacity thermal power stations driven by LNG, which is less of a burden on the environment, and with this, the amount of investment in pollution control equipment again rose.

Figure 8-3-2 Changes in the Amount of Investment in Pollution Control Equipment by the Private Sector

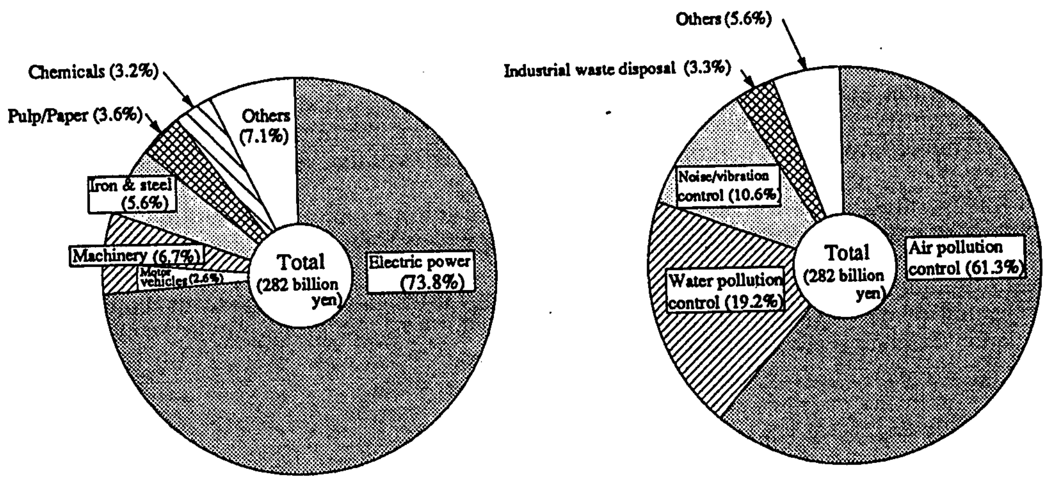


Source: MITI
See Table 8-3-2

In fiscal 1988 1,160 companies invested a total of ¥281,500 million in pollution control equipment, or 4.1 percent of their total capital investment of ¥6,850,300 million. By industry, the electric power industry invested the most with ¥207,700 million, followed by the machinery industry with ¥18,900 million (of which the motor vehicle industry invested ¥7,400 million), iron and steel industry with ¥15,900 million, paper and pulp industry with ¥10,100 million, and chemical industry with ¥8,900 million. These five industries alone account for more 90 percent of investment by all industries. As for type of equipment, ¥172,600 million was spent on air pollution control facilities and ¥54,000 million on water pollution control facilities, and together these two kinds of facilities account for 80 percent of investment.

Figure 8-3-3 Investment in Pollution Control Equipment (Fiscal 1988)

(a) by industry (b) by type



Source: MITI

See Table 8-3-3

(2) Production of Pollution Control Equipment

Whereas the private sector has concentrated on air pollution control in their equipment investment, the public sector has concentrated on water pollution control and waste disposal.

Figure 8-3-4 shows the amount of pollution control equipment production (actual results) generated by public sector demand. The rise in production was virtually rectilinear in the 1970s, and this is vastly different from the fluctuations shown by private sector investment during the same period. The rise in production of water pollution control equipment was particularly steep, and this can attributed to the promotion of water pollution control measures at factories and business establishments following the enactment of the Water Pollution Prevention Law in 1970, and also to the establishment of sewage treatment facilities necessitated by the growing number of cases of inland water and sea pollution caused by Japan's under-developed sewerage system. However, the percentage of homes in Japan connected to municipal sewerage systems is considerably lower than in U.S.A. and Europe (Note 6), and further development is required.

In fiscal 1988 the amount of pollution control equipment production generated by public sector demand was ¥464,800 million, of which water pollution control equipment was the highest with ¥283,400 million, followed by waste disposal equipment with ¥168,800 million. Together, they accounted for more than 90 percent of public-sector demand.

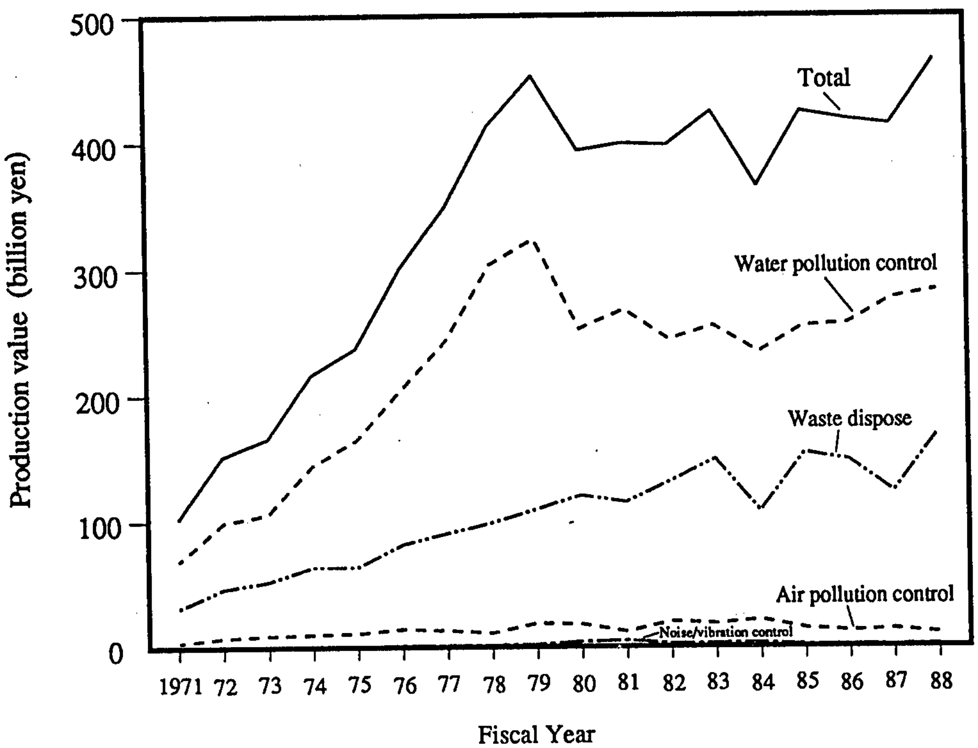
Japan's pollution control technology has contributed much to environmental preservation overseas as well. In fiscal 1988, pollution control equipment produced for export amounted to ¥20,900 million, and accounted for 3.2 percent of total pollution control equipment production. By equipment type, air pollution control equipment ranked the highest with ¥11,530 million, followed by water pollution control equipment with ¥6,220 million, and together, they accounted for more than 80 percent. By export region, Southeast Asia was highest with ¥7,140 million, next was North America with ¥5,260 million and then Europe with ¥5,250 million. These three regions accounted for more than 80 percent of pollution control equipment exports.

Japan's pollution control and energy-saving technology is considered to be outstanding, so much is expected of the Japanese contribution to preservation of the global environment through international technical cooperation.

Notes:

1. "Hydraulic power" in Fig. 8-3-1 includes geothermal heat and new energy.
2. The pollution control equipment investment survey carried out by MITI in February 1988 reviewed industrial classifications. "Machinery" in Fig. 8-3-3 is the total of "general machinery", "electronic machinery", "electric machinery" and "motor vehicles".
3. "Electric power" in Fig. 8-3-2 also includes power from non-thermal power generation from fiscal 1983.
4. The public sector includes associations financed by self-governing bodies.
5. Amount of capital investment is construction base; amount of equipment production is payment base.
6. The percentage of people (percent of total population) living in houses connected to sewerage systems in Japan, North America and the major countries of Europe is shown below: Japan (1989) - 40 percent; U.S.A. (1986) - 73 percent; West Germany (1983) - 91 percent; U.K. (1982) - 95 percent; France (1983) - 64 percent; Canada (1980) - 74 percent; Italy (1980) - 55 percent

Figure 8-3-4 Pollution Control Equipment Production (Municipal Demand)



Source: Japan Society of Industrial Machinery Manufacturers

See Table 8-3-4

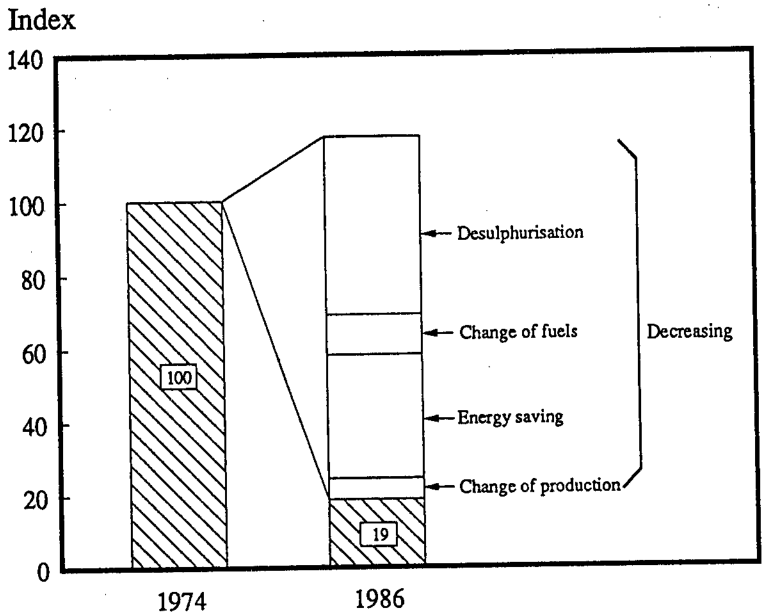
8.3.2 Establishment of Exhaust Gas Desulphurization Systems and Denitrification Systems

(1) Sulphur Oxides

The oil crises stifled an increase in energy consumption, and prompted a drop in oil dependence through a shift in the make-up of energy supply (shift to natural gas, and an increase in nuclear power supply). This also contributed to an improvement in the reduced levels of air pollution.

Moreover, comprehensive measures were adopted to reduce sulphur oxides (SOx), such as using low-sulphur crude oil and establishing exhaust gas desulphurization systems (Fig. 8-3-6), and these have led to a significant drop in the concentration of sulphur dioxide in the air (Fig. 8-3-7). Analyses reveal that desulphurization and energy conservation have greatly contributed to the drop in SOx emissions (Fig. 8-3-5).

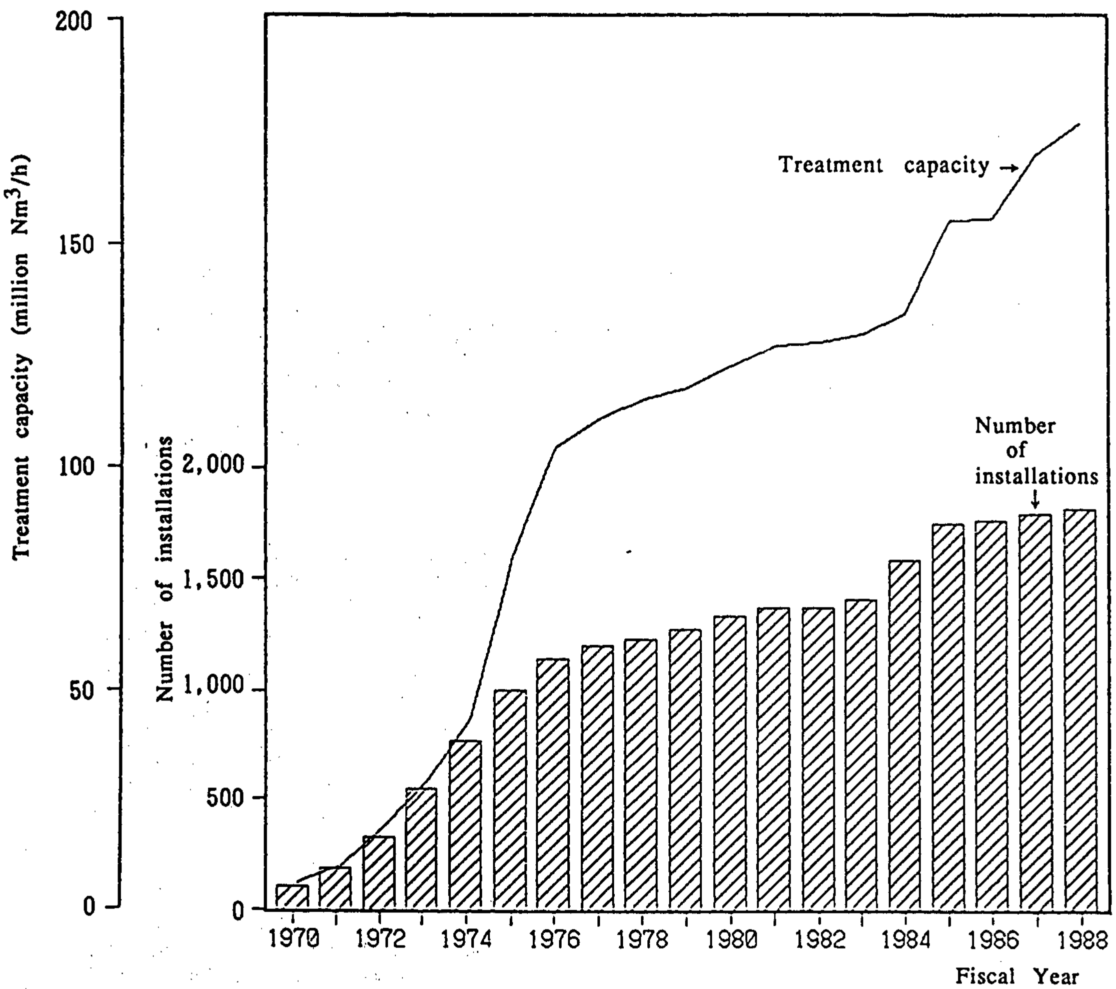
Figure 8-3-5 Factors Contributing to Lower SOx Emissions



Source: Environment Agency

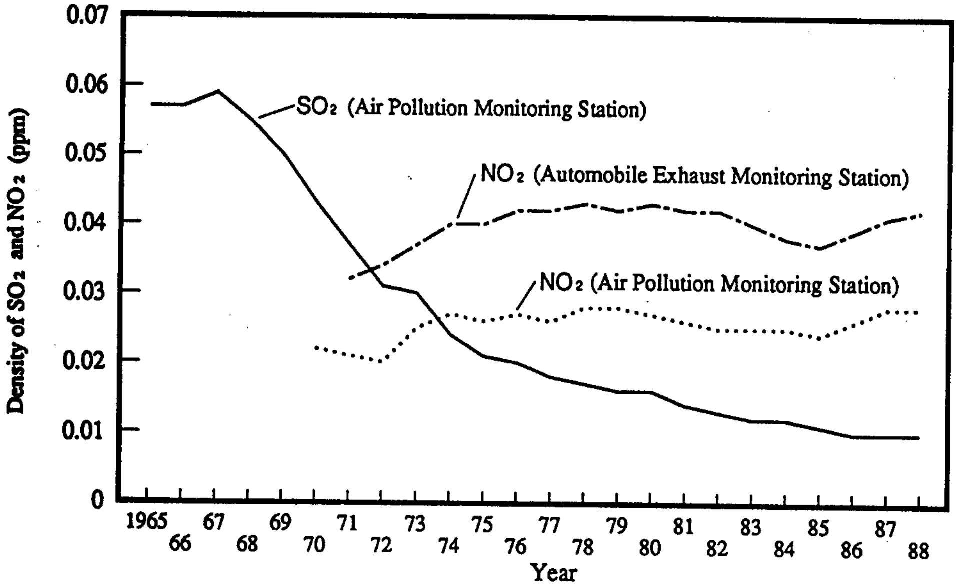
An international comparison reveals that energy demand in the United States is 5-10 times as great as in Japan and Europe, and as a result, the level of SOx emissions is ten times times as high. Moreover, all countries in North America and Europe have a higher basic emission unit value (primary energy ratio): assuming Japan has a value of 1, U.K. is 6.0, U.S.A. - 3.8, West Germany - 2.7 and France - 2.4. The reason Japan's basic emission unit being so low is that industry accounts for a high percentage of total energy consumption, and Japanese industry is well ahead of their American and European counterparts in terms of energy conservation and environmental measures.The U.K. relies heavily on coal for its energy supply, and this is reflected in its high basic emission unit value.

Figure 8-3-6 Establishment of Exhaust Gas Desulphurization Systems



Source: Environment Agency, "White Paper on Environment" 1990
See Table 8-3-5

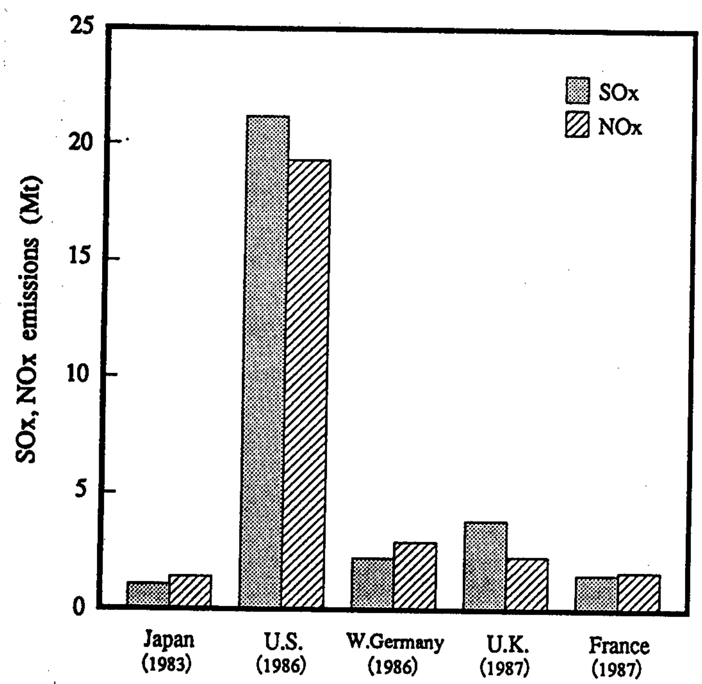
Figure 8-3-7 Changes in SO_2 and NO_2 Concentrations



Source: Environment Agency, "White Paper on Environment" 1990

See Table 8-3-7

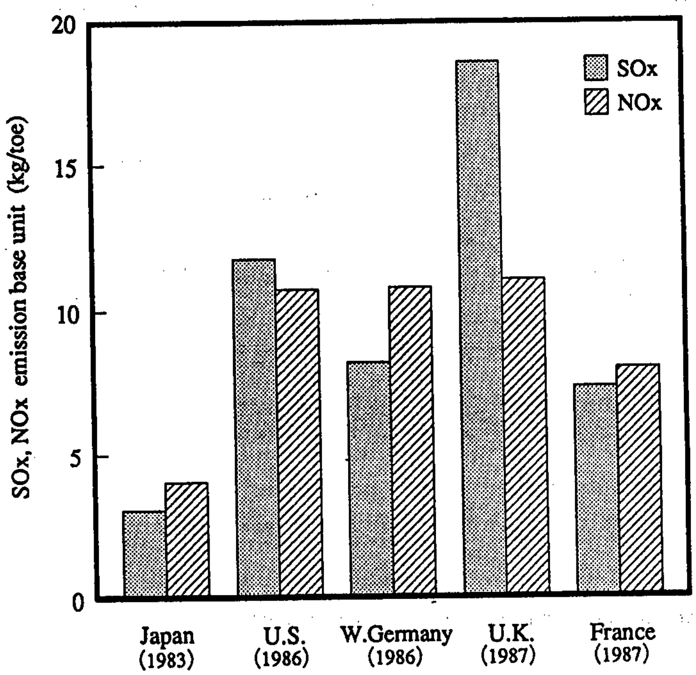
Figure 8-3-8 SOx and NOx Emissions



Source: OECD, "OECD Environmental Data, Compendium 1989"

See Table 8-3-6

Figure 8-3-9 SOx and NOx Basic Emission Unit (TPER Ratio)



Source: OECD, "OECD Environmental Data, Compendium 1989"

See Table 8-3-6

(2) Nitrogen Oxides

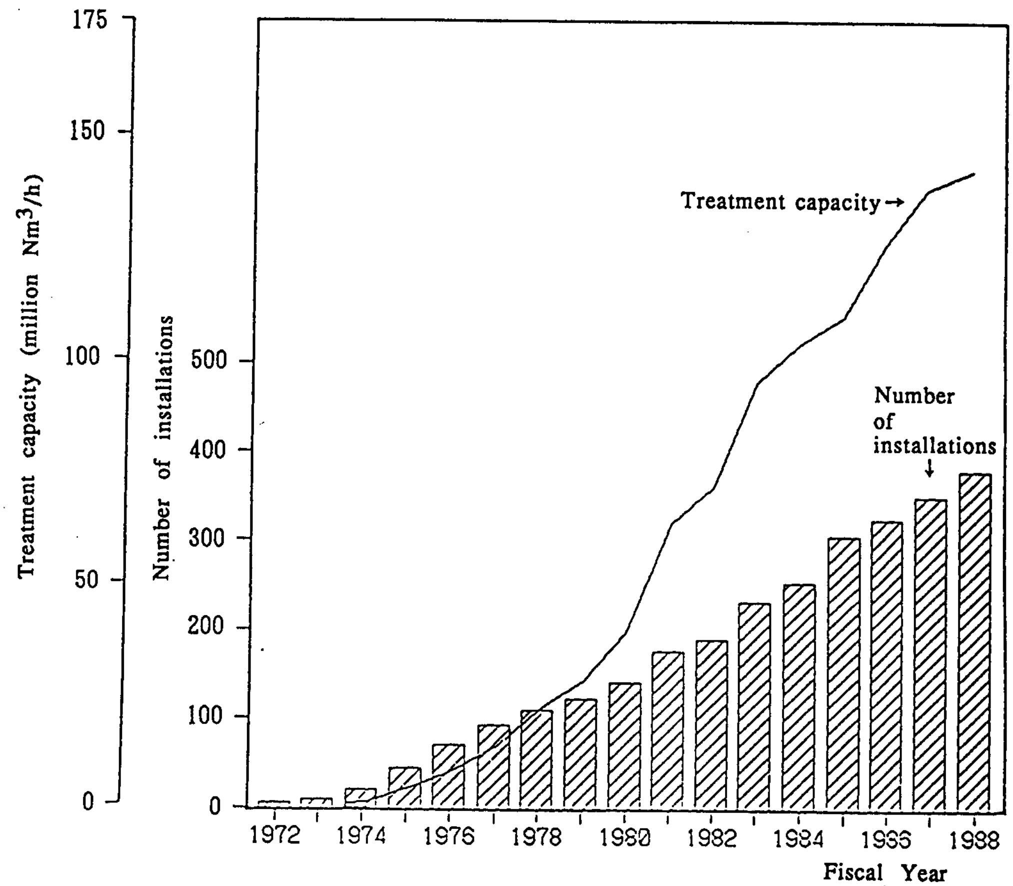
Since most nitrogen oxides (NOx) in the air result from the burning of fossil fuels, Japan has been promoting the development of more efficient combustion methods and establishment of denitrification systems as means of reducing NOx (Fig. 8-3-10). However in contrast to the significant improvement in SO_2 concentrations shown in Fig. 8-3-7, NO_2 concentrations dropped only slightly in the years after 1979, and in fact since 1986 concentrations have returned to the high levels of the late 1970s.

The reason for this is that although NOx emissions from factories and other stationary sources have been decreasing, this has been more than offset by the rise in emission levels from the increased volume of motor vehicle traffic. The effect of motor vehicles on NOx concentrations is most evident in the major cities: in the Tokyo region motor vehicle exhaust accounts for 67 percent of NOx, while in the Yokohama region it is 32 percent, and in the Osaka region it is 47 percent (fiscal 1985). And diesel-powered vehicles, which emit large amounts of NOx, now account for a higher percentage of motor vehicle exhaust.

Comparisons reveal that the NOx basic emission unit value (primary energy ratio) for U.S.A., West Germany and U.K. is almost three times as high and for France twice as high as that for Japan. France has a lower basic unit value than the other North American and European countries because a high percentage of its energy supply is from nuclear power generation.

Japan's dependence on petroleum for its primary energy dropped to 56.3 percent in fiscal 1985, but with the recent increase in energy consumption brought about by a business recovery, demand for petroleum-generated energy has grown, and in 1989 petroleum accounted for 57.9 percent of primary energy, marking a return to a high level of dependence.

Figure 8-3-10 Establishment of Denitrification Systems



Source: Environment Agency, "White Paper on Environment" 1990
See Table 8-3-5

Note:
1. Concentrations of SO_2 and NO_2 shown in Fig. 8-3-7 are the average values at 15 general environmental and atmospheric measuring stations and at 22 motor vehicle exhaust gas measuring stations.

8.3.3 Carbon Dioxide Emissions

(1) Amount of CO_2 Emissions

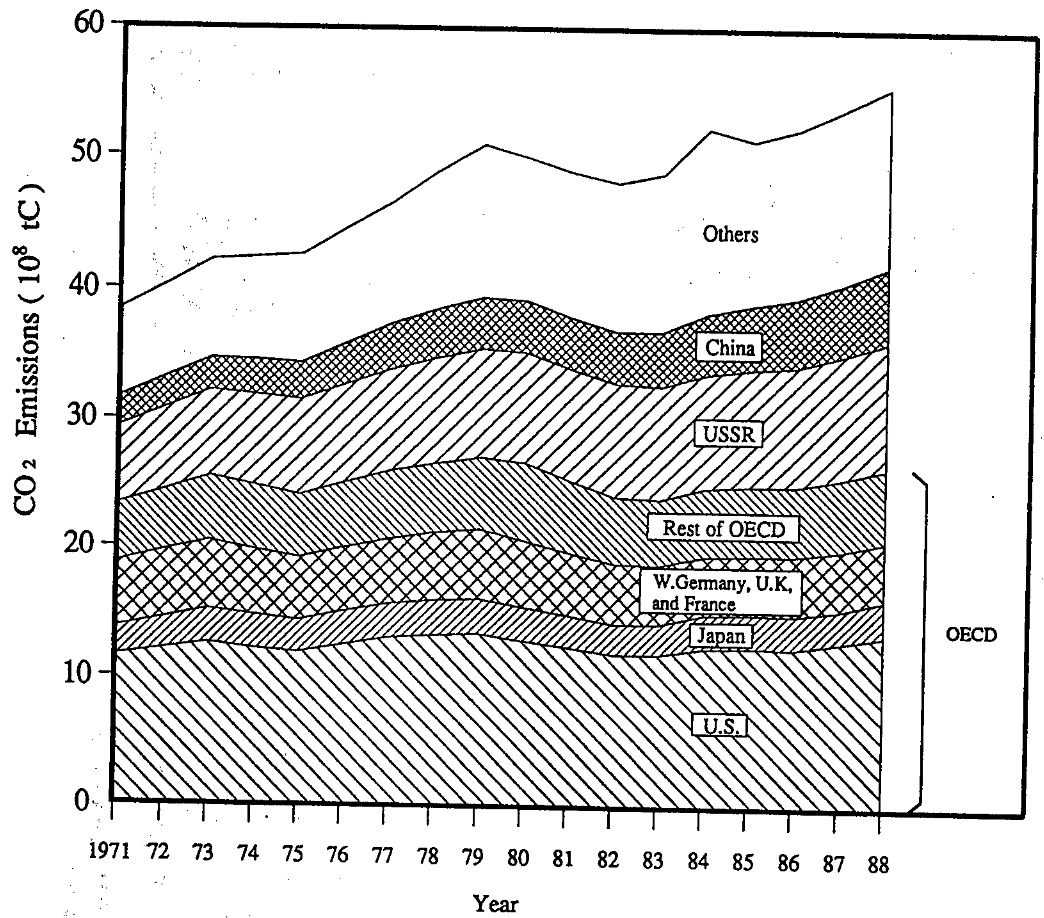
In 1971 about 93 percent of the world's primary energy came from fossil fuels (coal, petroleum and natural gas). And although some headway had been made in changing the energy supply make-up (mainly lowering dependence on petroleum), in 1988 fossil fuels still accounted for a high 87 percent of primary energy.

The amount of carbon dioxide CO_2 produced world-wide by burning fossil fuels was 3,830 million tC (converted value of carbon) in 1971. In 1988 CO_2 emission reached 5,560 million tC, an increase of 1,730 million tC over the 1971 figure. As shown in Fig. 8-3-11, between 1971 and 1988 emission levels in the OECD countries generally remained constant, while major increases were recorded in the U.S.S.R. and China. While the rise in emission levels in Asia (not including China and Japan) was twice that of the other regions.

In 1988 the U.S.A. generated the highest percentage of the world's CO_2 emissions with 24 percent, followed by U.S.S.R. with 18 percent, China with 10 percent, and Japan with 5 percent. These four countries accounted for 57 percent of the world's CO_2 emissions. Other countries included West Germany with 3.5 percent, U.K. with 2.8 percent and France with 1.8 percent. In 1988 the OECD countries accounted for 48 percent of the world's fossil fuel consumption, and 47 percent of the world's CO_2 emissions.

A look at CO_2 basic emission unit values for selected countries (primary energy ratio) reveals that although the basic emission unit is decreasing in every case, the decrease is small, and even after the oil crises there has been little change to the energy supply make-up. France, however, has seen its basic emission unit drop significantly since 1980; but as shown in Fig. 8-3-12, this is attributed to greater use of nuclear power for its energy needs. In 1988 nuclear power supplied about 30 percent of France's primary energy. In Canada, a high percentage of the country's energy supply comes from hydraulic power, so here the basic emission unit value is considerably lower than in other countries. In contrast, about three quarters of China's primary energy comes from coal, and this is reflected in its high basic emission unit. In 1988 per capita emission (tC per person) was 5.4 in the U.S.A., 3.2 in West Germany, 2.7 in U.K., 2.3 in Japan and 1.8 in France, while the OECD average stood at 3.2.

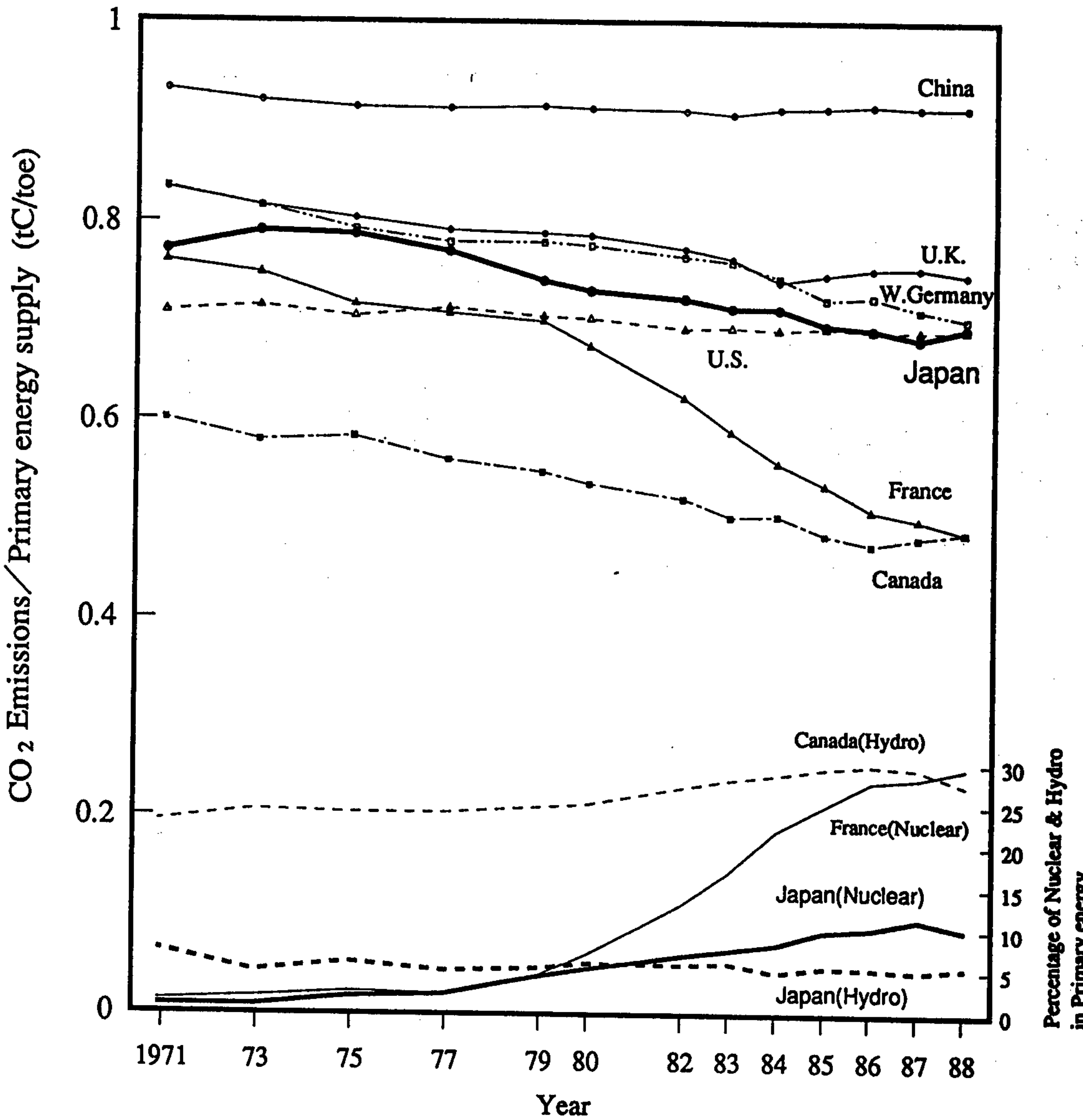
Figure 8-3-11 CO_2 Emissions from Fossil Fuel Consumption



Source: OECD, "Energy Balances of OECD Countries 1987-1988"
OECD, "World Energy Statistics and Balances 1971-1987, 1985-1988"

See Table 8-3-8

Figure 8-3-12 CO_2 Emissions (TPER Ratio)



Source: OECD, "Energy Balances of OECD Countries 1987-1988"

OECD, "World Energy Statistics and Balances 1971-1987,1985-1988"

See Table 8-3-8, Table 8-3-9

(2) Controlling the CO_2 Emissions

Controlling the CO_2 emissions through energy conservation and changes to the energy supply make-up is examined.

First, in measuring control of CO_2 emissions through energy conservation the basic unit of primary energy (GDP ratio) is used as an energy conservation indicator. This ratio dropped by an average of 2 percent per year over the ten years from 1973 in Japan, North America and the major European countries, but over the last five years this decrease has slowed down to an annual average of about 1 percent. In Japan's case, this slow-down is seen as being due to substantial advances made by Japan in improving energy use efficiency following the oil crises has diminished the scope for further energy conservation (refer to 8.1.2 Energy Efficiency). Nevertheless, it is believed that Japan can continue contributing to the control of CO_2 emission amount by pushing further ahead with comprehensive energy conservation measures (Note 3).

In terms of control through changes to the energy supply make-up, Japan has the highest dependence on petroleum among the OECD countries, and this has become a factor behind Japan's high level of CO_2 emission. Thus, without changing the total energy supply for 1988, if Japan were to reduce energy from petroleum by 10 percent and make up for this loss by increasing energy from LNG, the CO_2 emission amount would drop by 18 million tC (6.6 percent of Japan's total emission for 1988). Through this it can seen that changing to non-fossil fuels for energy is more effective in controlling the CO2 emission amount than changing among fossil fuels. This is further supported by the fact that in 1988 the amount of CO2 emission in the U.K., where a high proportion of the energy supply is from fossil fuels (particularly coal), was 1.5 times as great as in France, which used about the same amount of primary energy as the U.K. (Note 4).

Notes:

1. CO_2 emissions are the value calculated from the basic emission unit based on the IEA-ORAU model and the primary energy amount generated from coal, petroleum and natural gas in Sources 4 and 22.
2. Where there are no statistical values for a year, the values for the year preceding and the year following are joined by a straight line.
3. Japan has been systematically and comprehensively promoting global warming counter-measures as controlling CO_2 emissions under the "Global Warming Prevention Action Plan", formulated in October 1990.
4. The total supply of primary energy in 1988 was: U.K. - 208.52 Mtoe; France - 208.9 Mtoe. (1 toe = 10^7 kcal).

8.4 Science, Technology and Culture

Development of science and technology has greatly influenced such areas of culture as writing, imaging and art. For example, word processors are becoming indispensable not just in preparing business documents, but also in any form of writing activity. And the means of providing and acquiring information have undergone massive changes from "reading and writing" to "audio-visual".

Through the progress of electronics technology, computers are now used for such creative activities as art and music. With the launching and practical application of a communications satellite by the private sector in Japan, space communications is now in full swing, and information and cultural exchanges with other countries through these satellites are gathering pace.

8.4.1 Use of Science and Technology in Art and Entertainment

Here computer graphics (CG) and high-definition television (HDTV) are taken as examples in observing the effective use of science and technology in art and entertainment.

The amount of information obtained visually (images) is much greater than the amount obtained by the written or spoken word. And since CG can put this vast amount of information to effective use, it is now employed widely in television programmes and commercials. NHK (Japan Broadcasting Corporation) uses CG in many of its programmes (Note 1); for example, in science programmes to depict the complexity and precision of the human body, and in historical programmes to show the financial and political power held by historical figures. And with the increased power of personal computers, even individuals are able to use CG in design and illustration with relative ease. For example, over the last few year the Japan Illustration Exhibition (Note 2) has seen an increase in the number of CG works submitted for showing and also an improvement in their quality; and of the 38 works that received awards in 1990, five were created using CG.

As for HDTV, R&D has been continuing at the NHK Broadcast Technology Institute since 1970, and at present, trial broadcasts are carried out for one hour every day on NHK satellite Channel 1. HDTV screens contains five times as much information as conventional television screens, and with its sharp pictures, HDTV is now beginning to be used in artistic and cultural fields.

One example of this is HDTV's use in art galleries. Normally galleries only have limited display space, and this often makes it difficult for them to display all of their works. So in 1989 a gallery opened an "HDTV Gallery Corner", where visitors can view a specially made HDTV programme introducing all of the works held in stock by the gallery. This enabled the gallery to show its many works to its visitors. It has also made it possible for people in Japan to view works of art held by overseas art galleries. The range of the works is broad, and includes paintings, photographs, design and sculpture.

In addition to broadcast images and design fields, it is expected that the CG described here will be used to a greater extent in such fields as science, technology and education. HDTV also has the potential to create an image culture in various fields, including movies, education and printing, and in conjunction with CG, HDTV is expected to make a significant contribution to art and culture.

Notes:
1. CG were in 360 NHK programmes in fiscal 1988, increasing to 495 in fiscal 1989 (NHK Broadcasting Department survey).
2. This is an illustration exhibition sponsored by the International Association for the Promotion of Art and Culture, and has been held every year since 1983.

8.4.2 Information and Cultural Exchange

Much more information is now exchanged with other countries through the international telephone service and international satellite editions of national newspapers. And in broadcasting, the increasing volume of images transmitted among countries is also contributing to cultural exchanges.

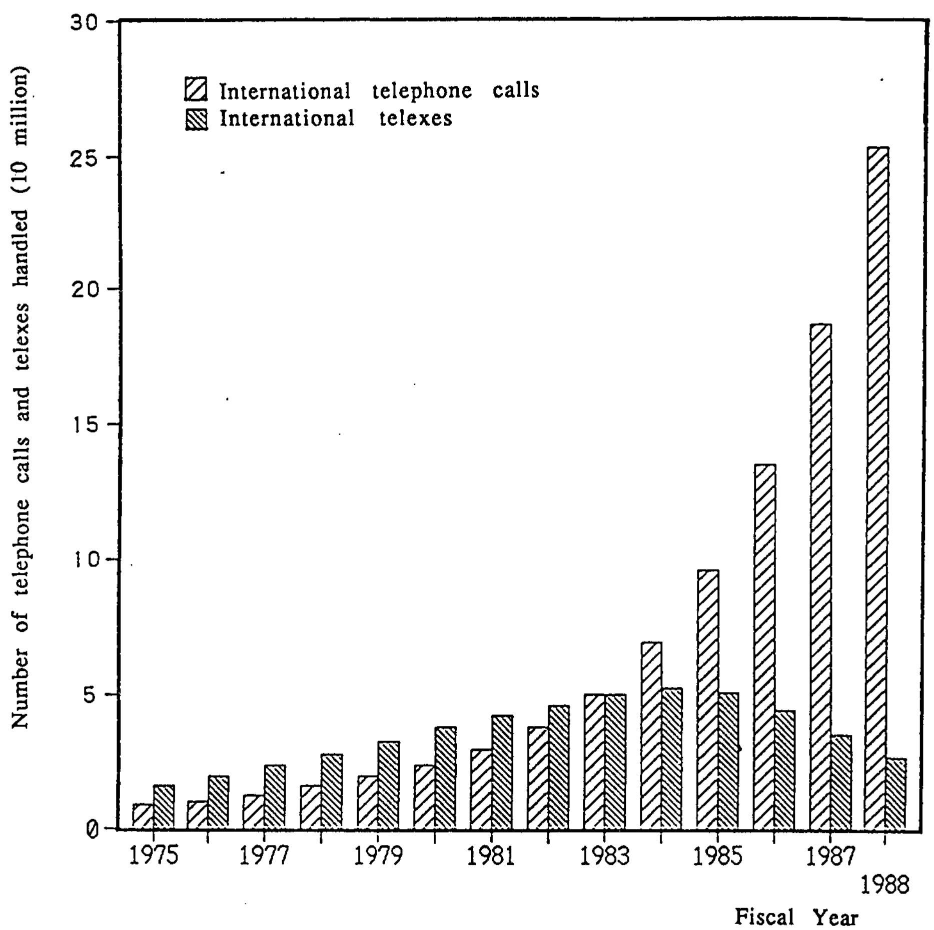
(1) International Telephone Services

As of March 1989 there were 8,305 international telephone circuits in Japan, of which 70 percent were communication satellite circuits and 30 percent were submarine cable circuits. As the telephone grew in importance in information flow among countries, the number of calls handled (Note 1) by Japan's international telephone service increased dramatically - the number in fiscal 1988 was ten times as great as in fiscal 1980 (Fig 8-4-1). On the other hand, the number of international telexes handled has been dropping every year since the mid 1980s. These changes are a good indication that information exchanges with other countries are rapidly shifting from the telex to the facsimile.

Special features of the facsimile are that it can send information using existing documents (diagrams, photographs as well as text), and that the other party does not have to be present to receive that information. The opening of circuits in Japan in fiscal 1972 was the trigger that set off the rapid growth of facsimile communications using the public telephone network. And the increase in the number of international telephone calls handled closely matches the increase in facsimile production shown at Fig. 8-4-2, and in this we can see that the increase in international telephone calls handled is largely due to the increase in facsimile communication.

Export of facsimile machines has been growing remarkably since about 1985, and in 1989 more than half of the facsimiles produced in Japan were destined for overseas markets. Such growth in facsimile communication and facsimile exports is one example of Japan's contribution to internationalizing information and communication.

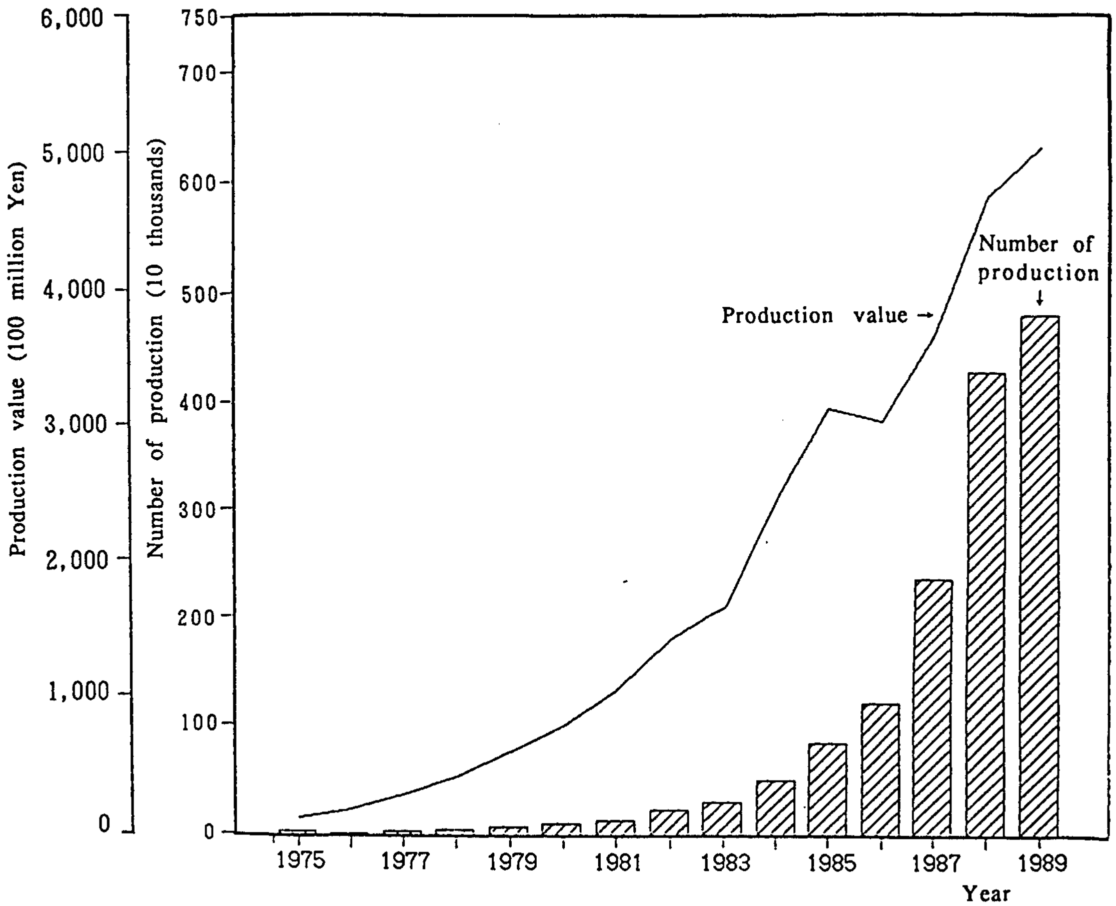
Figure 8-4-1 Number of International Telephone Calls and Telexes Handled



Source: Ministry of Posts and Telecommunications

See Table 8-4-1

Figure 8-4-2 Trends in Facsimile Production

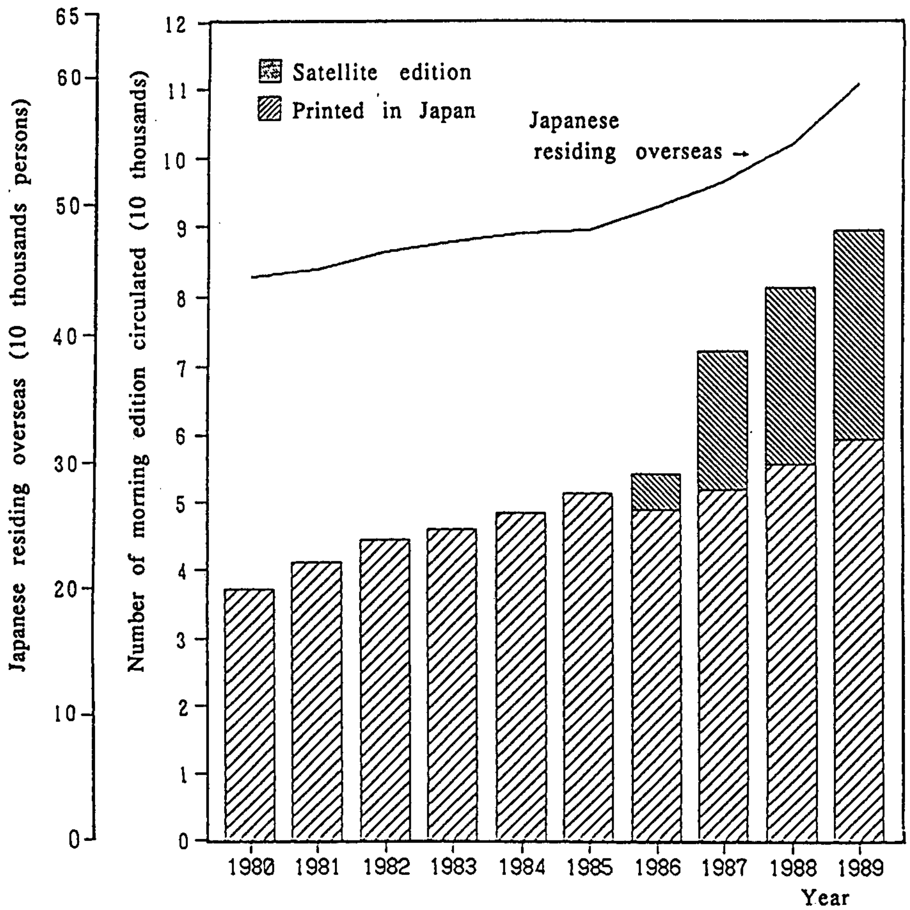


Source: MITI
See Table 8-4-2

(2) Newspaper Publication

As of October 1989, about 71.5 million domestic newspapers were printed (published) daily in Japan (morning edition - 49.1 million; evening edition - 22.4 million) (Note 2). Of these, about 86,000 (morning edition - 59,000; evening edition - 27,000) are sent overseas. Every year more and more Japanese are residing overseas (Note 3), especially those on extended posting, owing to the growing number of overseas subsidiaries and so on, and in line with this, more and more Japanese newspapers are sent overseas (Fig. 8-4-3). In 1986 data necessary for newspaper publication was transmitted overseas via the communications satellite, and with this, Japanese newspapers began to be printed overseas (international satellite edition). Although there are still only a few newspaper companies with this publication structure, newspaper circulation overseas for these companies has been growing steadily along with the circulation of their international satellite editions. This shows that science and technology has an important part in the international exchange of information through the timely publication of newspapers.

Figure 8-4-3 Overseas Circulation of Japanese Newspapers (Morning Edition)



Source: Asahi Shinbun, Nihon Keizai Shinbun, Japanese Newspaper Association, Ministry of Foreign Affairs

See Table 8-4-3, Table 8-4-4

(3) International Transmission of Images

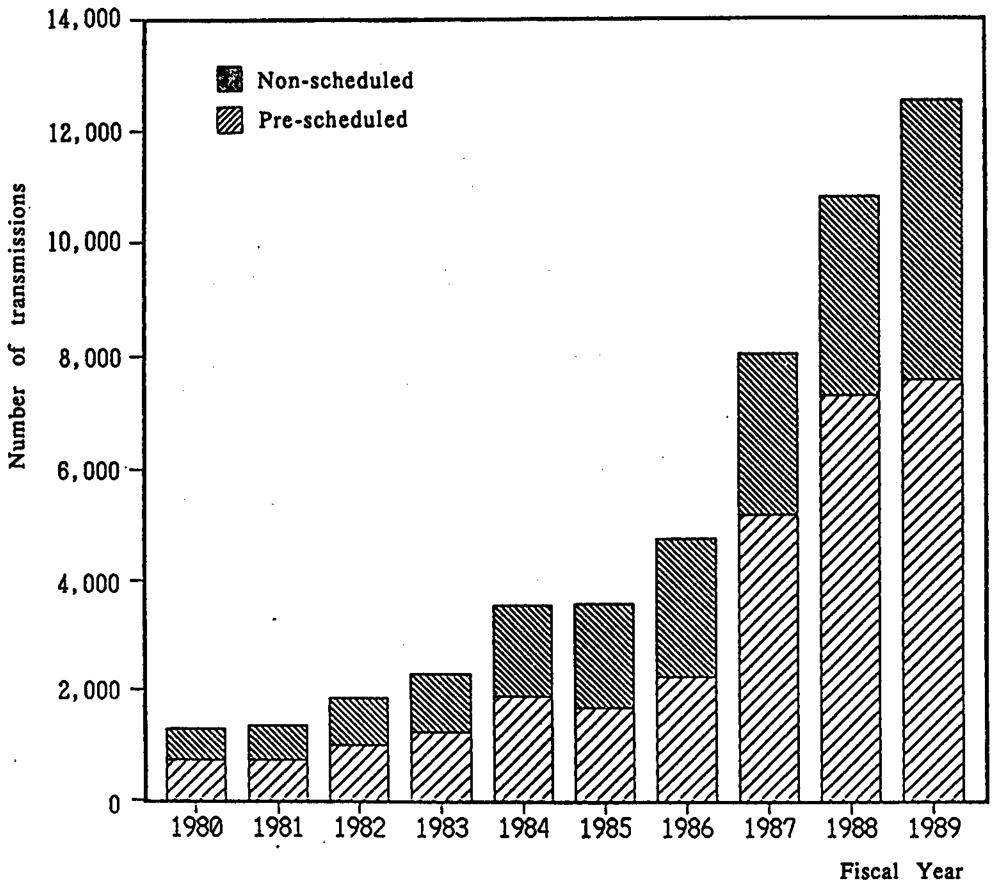
As for the transmission and receipt of images via NHK's satellite relay, along with the increase in pre-scheduled transmissions as a result of the move to 24-hour satellite broadcasting operations, described later, non-scheduled transmissions have been increasing significantly every year. This increase is partly due to a series of major overseas news stories, including the Chernobyl nuclear power station disaster in the Soviet Union in 1986, and in 1989, the Tiananmen Square incident in China and political and economic reform in Eastern Europe (Fig. 8-4-4, Fig. 8-4-5)
In fiscal 1989, there was an average of 34 transmissions, or more than 20 hours, per day. Most of the non-scheduled transmissions were from overseas to Japan, but there were also many reports on events and incidents occurring in Japan sent overseas, while news reports were exchanged with the countries of Asia (Note 4). Overseas culture has been introduced into Japan and vice versa through the overseas transmission of images via communication satellites. This shows that science and technology are contributing to international exchanges of culture.

In May 1984 NHK began satellite broadcast trials through broadcast satellite BS-2A, and in June 1990, full-scale satellite broadcasting began. The number of households receiving satellite broadcasts multiplied quickly following the introduction of 24-hour broadcasting in July 1987, and by December 1989, 6 percent of households (Note 5) had equipment to receive satellite broadcasts (Fig. 8-4-6). At the end of September 1990, the number of households receiving satellite broadcasts exceeded the three million mark. In the United States cable television, which uses communication satellite is widespread, so there is no satellite broadcasting (as of March 1991). As for Europe. in 1989, satellite broadcasting began successively in U.K., France and West Germany.

Notes:

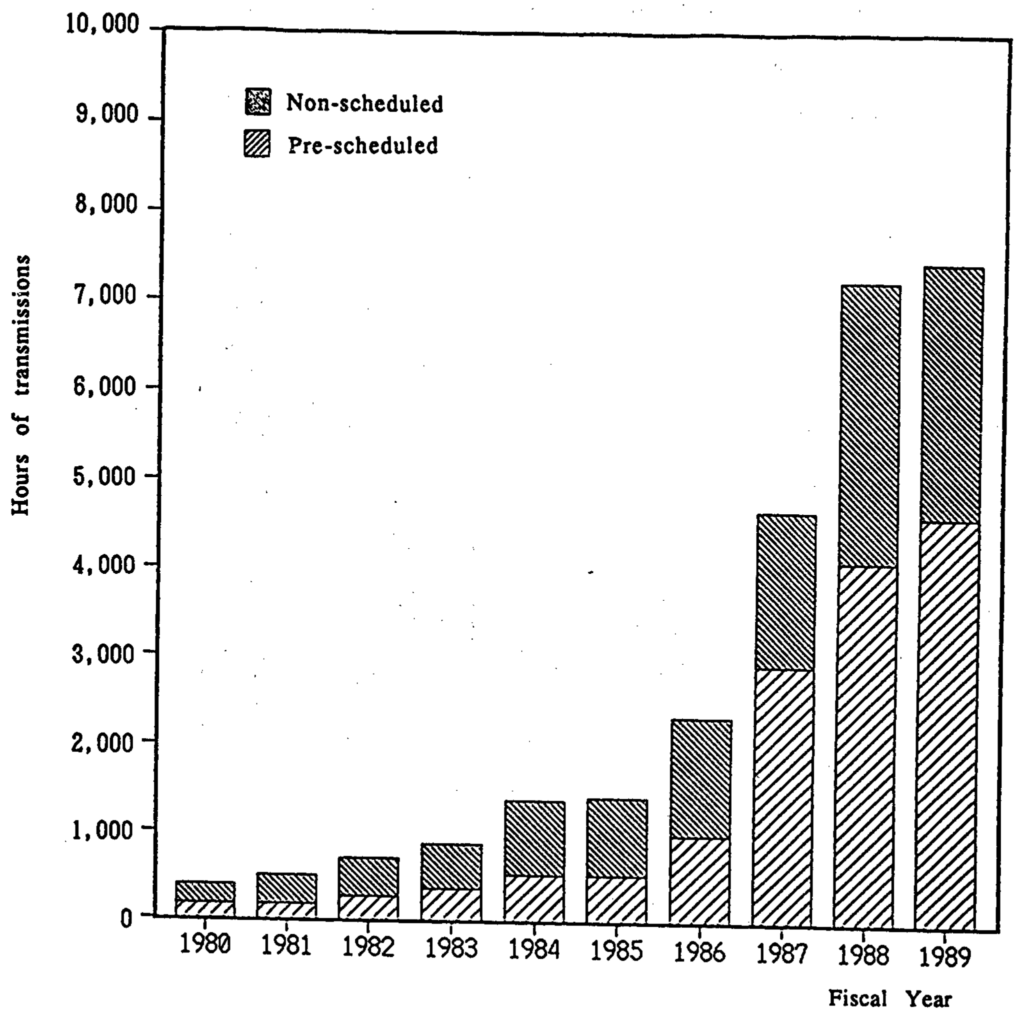
1. The number of international telephone calls and telexes handled is the total number of incoming and outgoing calls and telexes (including relays).
2. Figures from the survey carried out in October each year on the number of newspapers printed by companies belonging to the Japanese Newspaper Association.
3. Japanese residing overseas shown in Fig. 8-4-3 are Japanese citizens who are residing overseas for an extended period (more than three months) or who are residing overseas permanently. This does not, however, include Japanese residents in Taiwan. In 1980 there were 252,000 Japanese permanently residing overseas, but since 1981 the number has generally stayed around 240,000. On the other hand, the number residing overseas for an extended period has been increasing every year, reaching about 341,000 in 1989 (almost twice the number in 1980).
4. In Japan, NHK transmits pictures to the countries of Asia under the news exchange programme (Asia Vision), operated by the Asia Pacific Broadcast Federation. In fiscal 1989, NHK sent or received 694 image transmissions under the Asia Vision programme (slightly more than 5 percent of NHK's total international image transmissions), for a total time of 162 hours (slightly more than 2 percent of NHK's total international image transmission time). These totals do not include those in Figures 8-4-4 and 8-4-5.
5. Calculated from the number of households receiving satellite broadcasts as per the Ministry of Posts and Telecommunications survey (end of year) and the total number of television broadcast subscribers as per source 27 (end of fiscal year). As of the end of March 1990, there were about 1,210,000 NHK satellite broadcast subscribers, or about 3.6 percent of the total number of television broadcast subscribers.
6. The graphs at Figures 8-4-4 and 8-4-5 are based on Source 28 with changes to some of the classifications.

Figure 8-4-4 International Transmission of Images Via Satellite



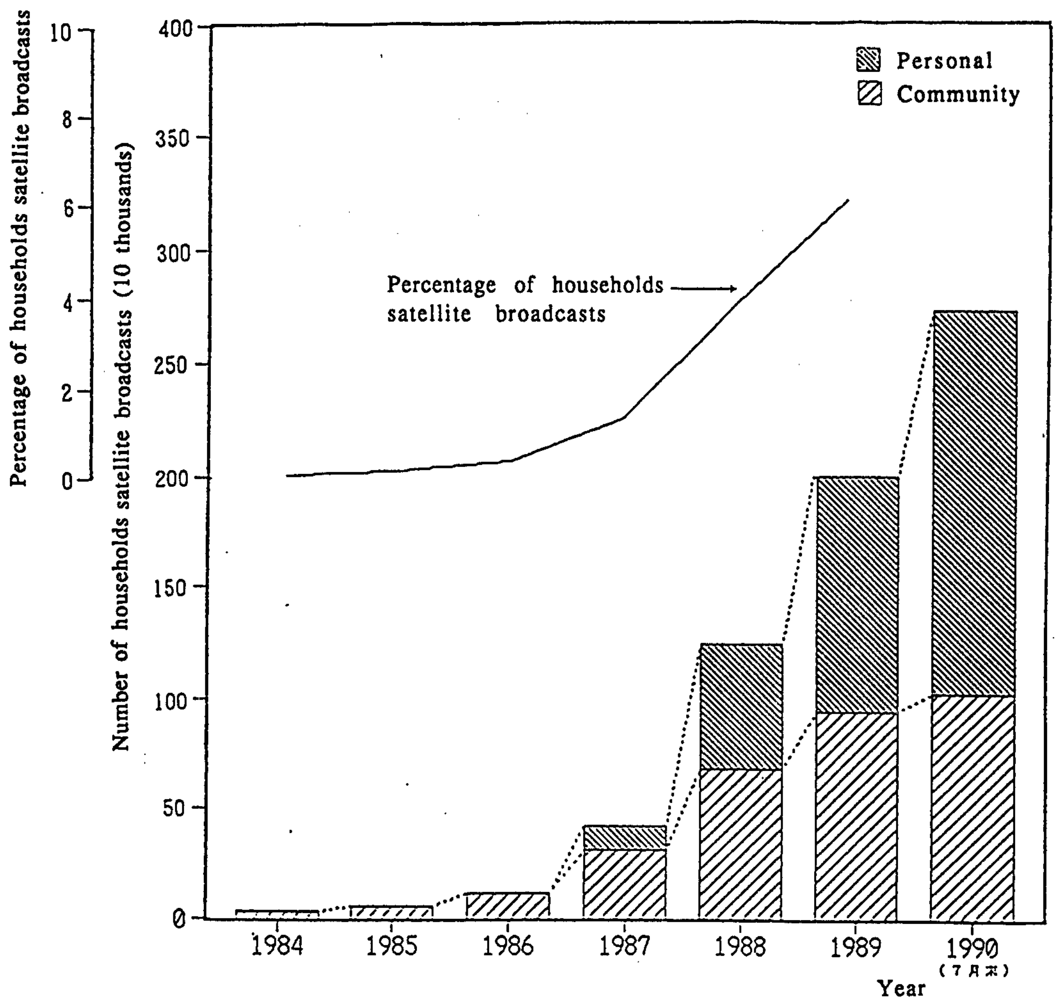
Source: NIPPON HOSO KYOKAI (*Japan Broadcasting Corporation*), "NHK Yearly Report"
See Table 8-4-5

Figure 8-4-5 International Transmission of Images Via Satellite



Source: NIPPON HOSO KYOKAI (*Japan Broadcasting Corporation*), "NHK Yearly Report"
See Table 8-4-5

Figure 8-4-6 Number of Households Receiving Satellite Broadcasts



Source: Ministry of Posts and Telecommunications,
NIPPON HOSO KYOKAI (*Japan Broadcasting Corporation*),
See Table 8-4-6, Table 8-4-7.

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CHAPTER 9

PUBLIC OPINION ON SCIENCE AND TECHNOLOGY

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PUBLIC OPINION ON SCIENCE AND TECHNOLOGY

An important indicator which reflects scientific and technological activities is the public opinion of science and technology. The reason for this is that although there are only few occasions in which people come into direct contact with such activities, the actual, and even potential effect, that the contact has on their lives is great. In this light, this chapter focuses on public opinion on science and technology. The chapter is divided into two sections: a general opinion; and opinion on individual scientific and technological issues and fields.

Most indicators introduced in this chapter are of general public opinion as gauged from public-opinion polls, and are therefore subjective indicators. Reliability is a major problem with such subjective indicators, so in choosing data, it is important to know who conducted the poll, the number of individuals polled, and the number of surveys on similar themes, selecting those results believed to be highly reliable. Moreover, there have been many polls on science and technology, covering a vast range of themes and asking many questions, so an important task is to choose the appropriate themes and questions from among this wide selection. In the surveys selected, the system standard for indicators explained in the Introduction is reviewed for compatibility. Then, Chapter 8, "Science & Technology and Society" was compared to distinguish fact and opinion indicators.

In the first section on the general opinions on science and technology, first a broad look at existing public-opinion polls is examined followed by a discussion of the results of polls on public interest on science and technology, sources of information, general knowledge and recognition of scientific and technical terms, perceptions and concerns of science and technology, and scientific and technological fields that should be promoted in the future. In section 2, awareness of individual scientific and technological issues and fields examines public opinions on information, energy, life sciences and the environment from various angles.

9.1 General Opinions on Science and Technology

This section clarifies how the general public perceives science and technology. This includes the two-way relationship between how the results of scientific and technological activities affect public awareness, and, conversely, how public awareness affects the promotion and direction of scientific and technological activities.

9.1.1 Public-opinion Polls on Science and Technology

Public awareness of science and technology can be measured by public opinion polls. Needless to say, themes of individual polls are determined by the polling organization, but it is also a fact that in determining themes, these organizations are bound by social conditions. Therefore, looking at the numerous opinion-poll themes side-by-side, individual polls reflect the range of public concern at the time surrounding the polling period. Thus public opinion polls have the function of reflecting an awareness of the times and polls on science and technology are no exception. Keeping this in mind, results are gathered from science and technology polls held in the past few years (Note, Reference 1) and presented them in Table 9-A.

From the table it can seen that the number of science and technology polls increased rapidly after the 1985 Science and Technology Exposition. Many polls in the 1960s were on environmental issues while polls after the oil shocks of the 1970s focused on energy issue. Also, nuclear power has been a constant poll theme, and many recent polls are looking at brain death and organ transplant issues. It is thus evident that opinion poll themes reflect the social conditions of the times.

Note:
Of the polls conducted during and after the 1960s, those related to science and technology which polled at least 3,000 adult males and females throughout Japan are chosen. Reference 1 and Sources 1-5 were used to gather these data.

Table 9-A Public Opinion Polls on Science and Technology

Theme of survey	Surveyer	Survey period	Number of samples	Number of respondents	Respond ratio [%]
Peaceful uses of nuclear enegy	Prime Minister's Office	1969/3	3,000	2,588	84.8
Nuclear power generation	Prime Minister's Office	1974/10	3,000	2,487	82.2
Science/Technology and nuclear energy	Prime Minister's Office	1976/10	5,000	3,972	79.4
Nuclear power generation	Mainichi Newspaper	1976/12	3,000	2,257	75.2
Energy	Yomiuri Newspaper	1979/6	3,000	2,288	75.5
Nuclear power generation	Asahi Newspaper	1979/6	3,000	2,592	86.4
UFO *	Yomiuri Newspaper	1979/8	3,000		
Forecast of rainfall probability	Yomiuri Newspaper	1981/3	3,000	2,168	72.3
Energy problem and nuclear power generation	Yomiuri Newspaper	1981/3	3,000	2,143	71.2
Computer society	Mainichi Newspaper	1981/12	3,000	2,356	78.5
Science and Technology	Prime Minister's Office	1981/12	3,000	2,368	78.9
Energy problem and nuclear power generation	Yomiuri Newspaper	1982/4	3,000	2,039	68.0
International science & technology exposition	Prime Minister's Office	1982/9	3,000	2,335	77.8
Artificial insemination, Brain death, Organ transplants	Yomiuri Newspaper	1982/10	3,000	2,139	71.3
Telecommunication service for household	Prime Minister's Office	1983/8	3,000	2,355	78.5
Brain death and organ transplants	Yomiuri Newspaper	1984/2	3,000	2,124	70.8
Nuclear energy	Prime Minister's Office	1984/3	3,000	2,255	75.1
International science & technology exposition	Prime Minister's Office	1984/3	3,000	2,507	76.0
International science & technology exposition	Prime Minister's Office	1984/9	3,000	2,595	81.7
International science & technology exposition	Yomiuri Newspaper	1985/2	3,000	2,216	73.9
New media	Yomiuri Newspaper	1985/3	3,000	2,178	72.6
Brain death	Mainichi Newspaper	1985/9	5,485	4,141	75.5
Brain death and organ transplants	Yomiuri Newspaper	1985/11	3,000	2,205	73.5
Information society	Prime Minister's Office	1985/11	3,000	2,349	78.3
Life sciences	Prime Minister's Office	1985/12	10,000	7,439	74.4
Interest in science and technology	Prime Minister's Office	1986/2	3,000	2,376	79.2
Nuclear power generation	Mainichi Newspaper	1986/5	3,000	2,252	75.1
Nuclear power generation, etc.	Asahi Newspaper	1986/6	3,000	2,315	77.2
Aids	Prime Minister's Office	1987/5	10,000	7,921	79.7
Service of medical care with health insurance	Prime Minister's Office	1987/6	5,000	4,000	80.0
Environmental problem	Prime Minister's Office	1988/1	3,000	2,362	78.7
Brain death, etc.	Asahi Newspaper	1988/3	3,000	2,345	78.2
Nuclear power generation, etc.	Asahi Newspaper	1988/9	3,000	2,342	78.1
Activities for environment protection	Prime Minister's Office	1988/10	3,000	2,443	81.4
Science/Technology and society	Prime Minister's Office	1990/1	3,000	2,237	74.6
Global environmental problem	Prime Minister's Office	1991/3	5,000	3,753	75.1

Note: We chose polls which had science and technology as their theme. In all cases, the population polled were males and female 20 years or older from all parts of Japan. Polliong was done through direct interviews by polling staff, and random sampling Multistage random sampling.

The asterisk * indicates that polling method and number polled are not known.

9.1.2 Interest in Science and Technology

Interest in science and technology forms the basis for public opinion to other questions and thus it is examined first (Note). According to the most recent poll conducted in 1990 (Source 6, Fig. 9-1-1), over half (55.9 percent) of the population expressed interested in science and technology: 10.2 percent are "very much interested" and 45.7 percent are "somewhat interested".

From 62 percent in 1976, the percentage of the population interested in science and technology (total "very much interested" and "somewhat interested") dropped to 52 percent in 1981, and down to 47.5 percent in 1986; however, in a 1987 poll it rose to 52.4 percent, and rose again in 1990 to 55.9 percent.

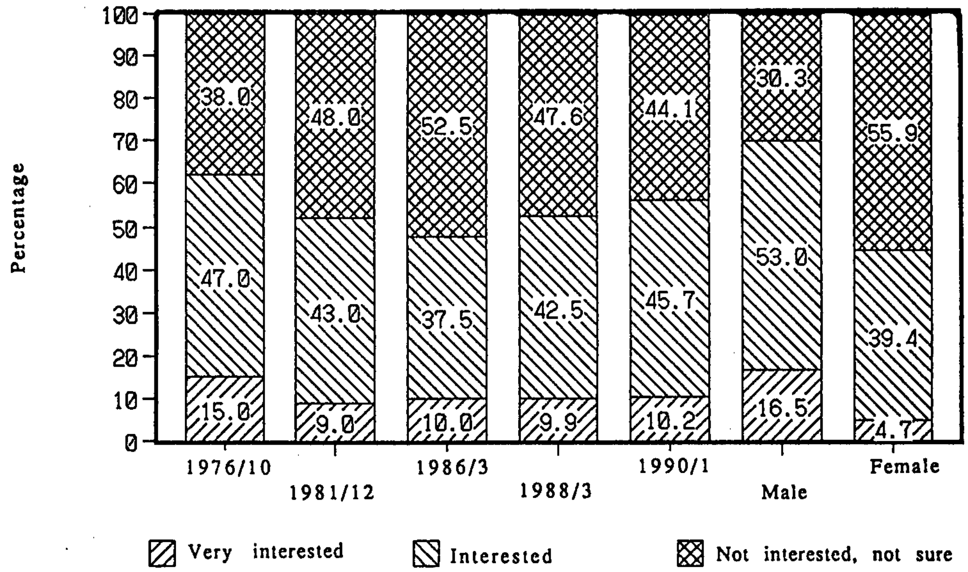
In all polls, men have expressed a greater interest in science and technology than women. For example, in a 1990 poll, 68.5 percent of men responded that they were interested in science and technology, while only 44.1 percent of women did so. In particular, 16.5 percent of males responded that they were "very much interested", but only 4.7 percent of women did so, or just over one-quarter. One trend that has appeared is that the higher the educational background, the greater the interest in science and technology.

Note:
Reference 2 is used in compiling this and subsequent indicators on public opinions on science and technology.

9.1.3 Sources of Information on Science and Technology

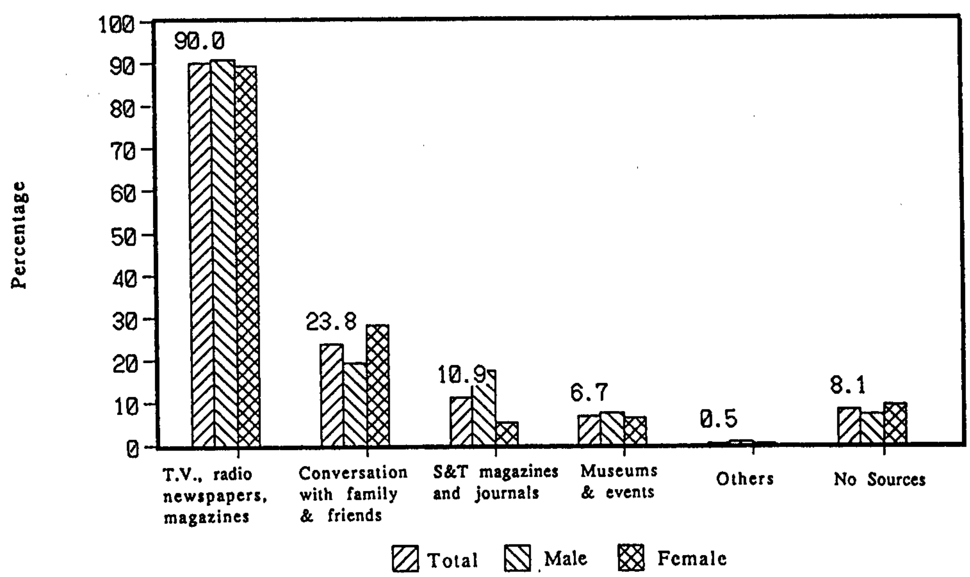
There is a close relationship between an interest in science and technology and the availability of information on science and technology. Polls (multiple choice) on sources of information (Source 6, Fig. 9-1-2) indicate that 90 percent of those polled rely on the mass media - television, radio, newspapers and general magazines - for information on science and technology. It is therefore no exaggeration to say that almost all scientific and technological information is obtained through the mass media. This was followed by conversations with family members and friends (23.8 percent), technical magazines and books on science and technology (10.9 percent). There are no major differences between the sexes regarding the mass media, but a higher percentage of men obtain their information from technical magazines and books (17.2 percent for men, 5.3 percent for women), whereas a higher percentage of women rely on conversations with family members and friends for their information (27.9 percent for women, 19.2 percent for men), thereby indicating that men tend to use technical sources of information more than women. What is important, however, is whether people are provided with sufficient opportunities or information to find out everything they want to know about science and technology. To this question, 26.6 percent responded that they are provided with sufficient opportunities or information, while 53.9 percent, or more than half, responded that they are not. This indicates that the majority of people polled perceive there is a lack of information on science and technology.

Figure 9-1-1 Interest in Science and Technology



Prime Minister's Office, "Opinion Survey on Science/Technology and Society" 1990
See Table 9-1-1

Figure 9-1-2 Sources of Information on Science and Technology



Prime Minister's Office, "Opinion Survey on Science/Technology and Society" 1990
See Table 9-1-2

9.1.4 Recognition of Scientific and Technological Terms

One survey questioned recognition of concrete scientific and technological terms as a means of determining knowledge about science and technology. Figure 9-1-3 (Source 6) shows the results of a survey on DNA, GNP and computer software. Of these three technical terms, most people recognized GNP. This was followed by computer software, and then DNA with the lowest level of recognition. A 1990 survey, however, saw DNA's level of public recognition increase somewhat.

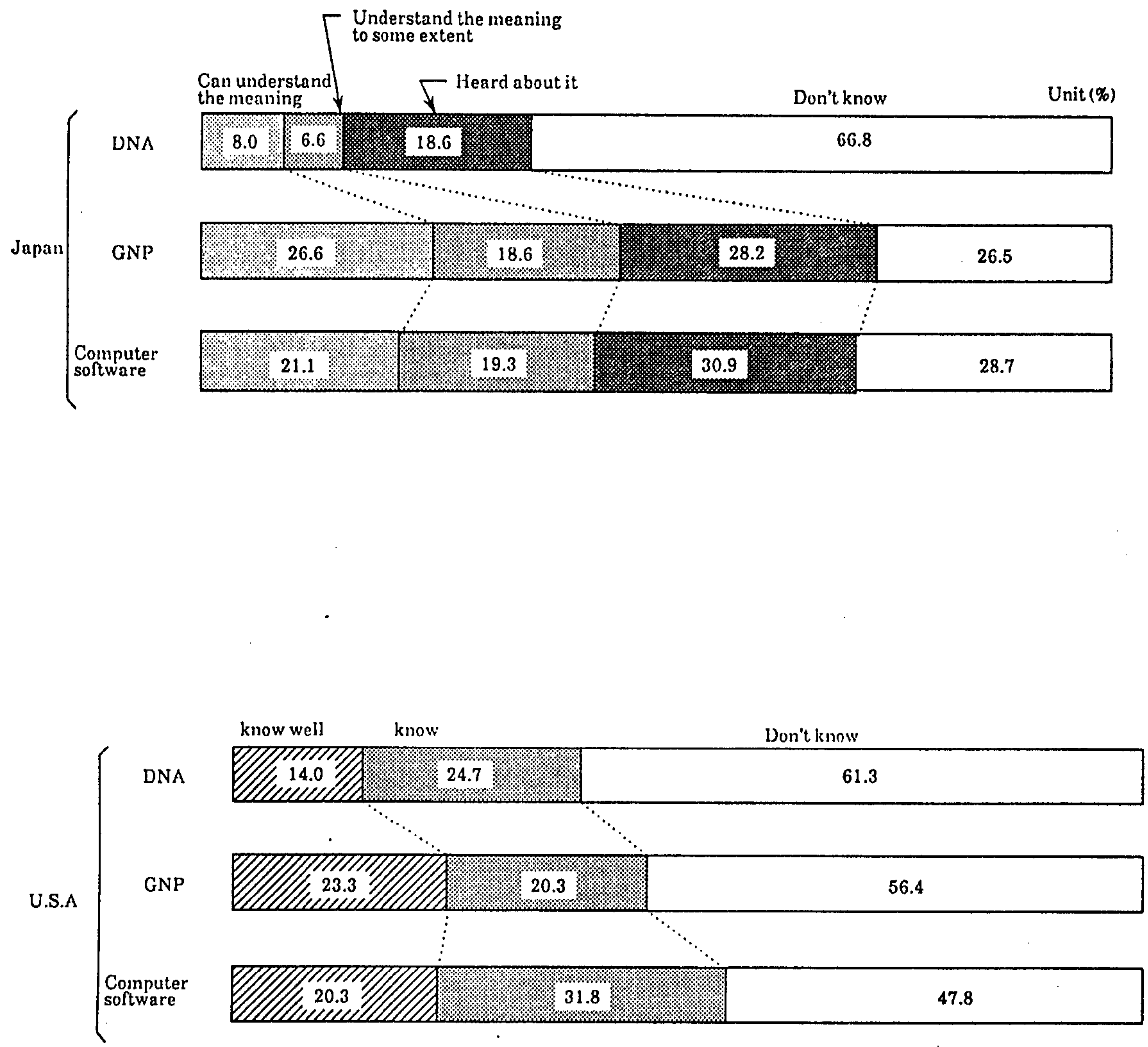
A similar survey was conducted in the United States (Source 7). Response choices are different so it is difficult to make precise comparisons (Note); however it can be observed that in the United States recognition of GNP is about the same as in Japan, but recognition of DNA and computer software is higher in the US than in Japan.

Note:
It is accepted that the response items "understand the meaning" and "understand the meaning somewhat" in the Japanese survey generally equate to the "good understanding" and "general understanding" in the U.S. survey. Furthermore, "have heard the term" and "do not understand" in the Japanese survey equate to the "poor or no understanding" in the U.S. survey.

9.1.5 Knowledge Regarding Science and Technology

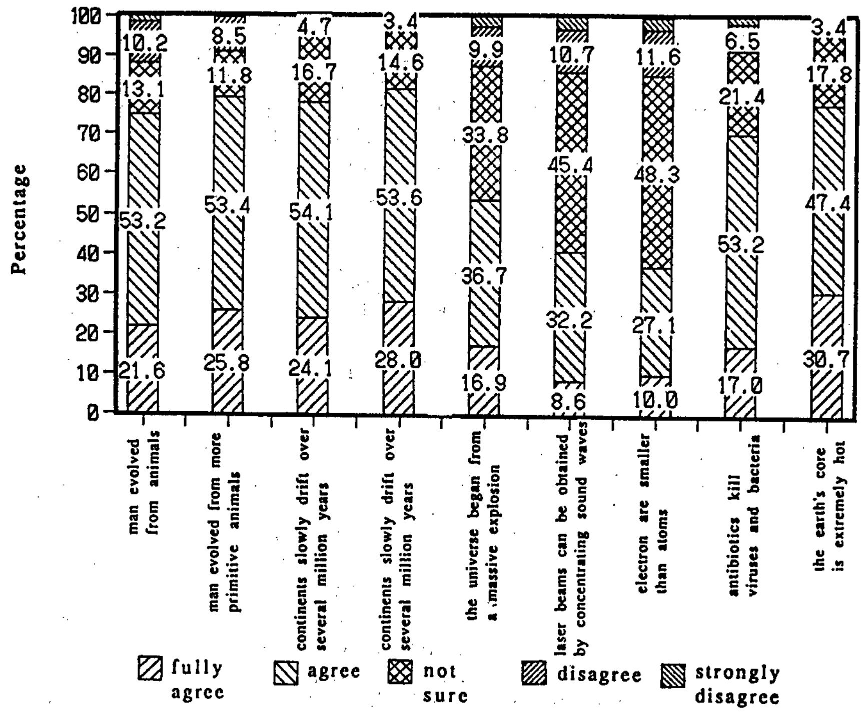
One survey asked not only about recognition of scientific terms, but also whether those polled agreed with certain hypotheses (Source 6, Fig. 9-1-4). According to this survey, 81.6 percent of those polled believe that "continents are moving little by little in a time span of thousands of years", 78.1 percent believe that "the earth's core is extremely hot", and 70.2 percent believe that "antibiotics kill viruses and bacteria" (percentages are of people who responded "definitely believe so" and "believe so"; same for all subsequent percentages). In contrast, a low level of knowledge was evident regarding "electrons are smaller than atoms" (37.1 percent), "laser beams can be obtained by focusing sound waves" (40.8 percent), and "the universe began from a massive explosion" (52.6 percent). Comparing responses in the latest survey with one carried out in 1987 to questions regarding the level of knowledge on evolution and continental drift , it can be seen that in both cases, the level of knowledge is increasing, though only slightly.

Figure 9-1-3 Recognition of Scientific and Technological Terms



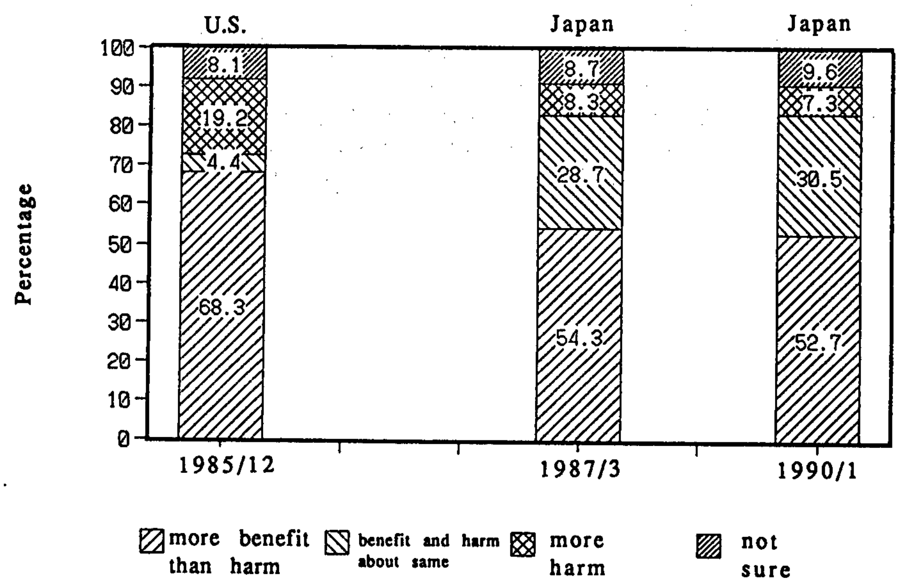
Prime Minister's Office, "Opinion Survey on Science/Technology and Society," 1990,
National Science Foundation, "Opinion Survey on Science and Technology," 1985.
See Table 9-1-3.

Figure 9-1-4 Awareness Regarding Scientific Hypotheses



Prime Minister's Office, "Opinion Survey on Science/Technology and Society" 1990
See Table 9-1-4.

Figure 9-1-5 Opinions on Achievements in Science and Technology



Prime Minister's Office, "Opinion Survey on Science/Technology and Society" 1990
See Table 9-1-5.

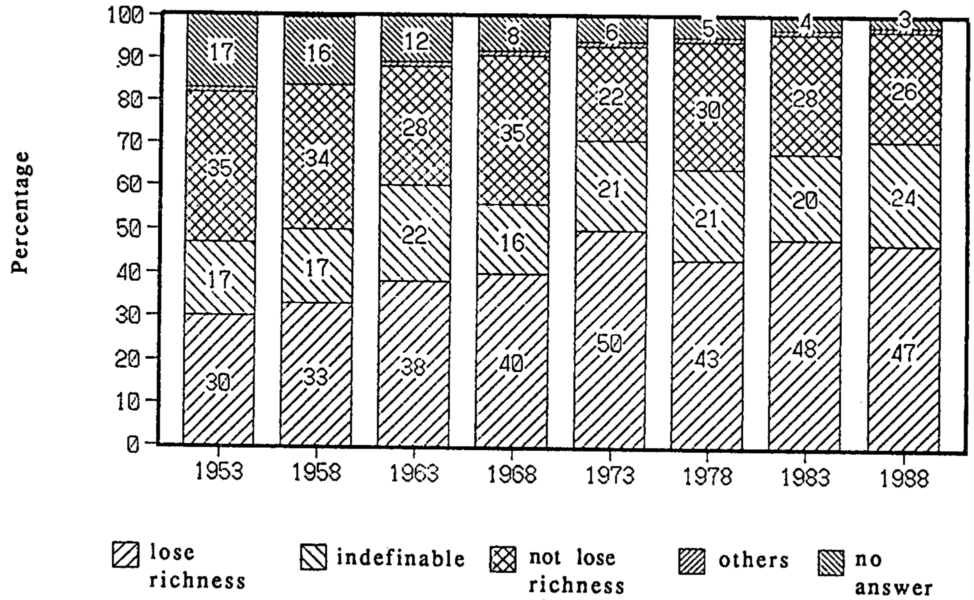
9.1.6 Opinions on Achievements in Science and Technology

Which public opinions regarding science and technology is formed on the basis of interest versus knowledge? Here results of a poll on the positive/negative effects of achievements in science and technology are discussed (Source 6, Fig.9-1-5). Of those polled, 52.7 percent responded that there are "more positive aspects", 30.5 percent responded with "both are about the same", and 7.3 percent responded that there are "more negative aspects". In a 1987 poll the percentages were 54.3 percent, 28.7 percent and 8.3 percent respectively,. Although there was a slightly higher percentage of people who believe that there are "more positive aspects" in the earlier poll, overall, there is very little difference between the two polls. These results can compared with the results from the same question in the poll undertaken in the United States mentioned earlier (Source 7). As can be seen in the figure, more people responded with "more positive aspects" (68.3 percent) and "more negative aspects" (19.2 percent) in the U.S. poll than in the Japanese poll, while fewer people responded with "both are about the same" (4.4 percent). It seems fair to interpret the differences in this comparison not as a difference in the perceptions of science and technology, but as a reflection of differences in national character.

In this way, when faced with a question of either positive or negative, most answers were positive. However, the opposite seems to be the case for questions that ask feelings about the relationship between scientific and technological progress and the morality and spiritual development. Figure 9-1-6 (Source 8) shows the percentage of people who agree/disagree with the statements "Life is becoming more convenient with the steady advance of science and technology, but along with this, we are gradually losing the richness in our lives," and "We shall not lose the richness in our lives, regardless of how mechanized society becomes." The percentage of people who agree with the former statement, that is "lose richness", has increased, reaching more than 50 percent in recent years. On the other hand, the percentage of people who disagreed with the latter statement, that is they believe they will "lose richness", is less than those who agreed, that is they believe they will "not lose richness". However, the percentage of people who responded "lose richness" has increased each year to reach over 30 percent. Responses to a question are greatly affected by the way a question is framed and by the choice of responses, but results show a growing tendency for people to believe that scientific and technological progress is not always linked to greater richness in their lives or to spiritual development.

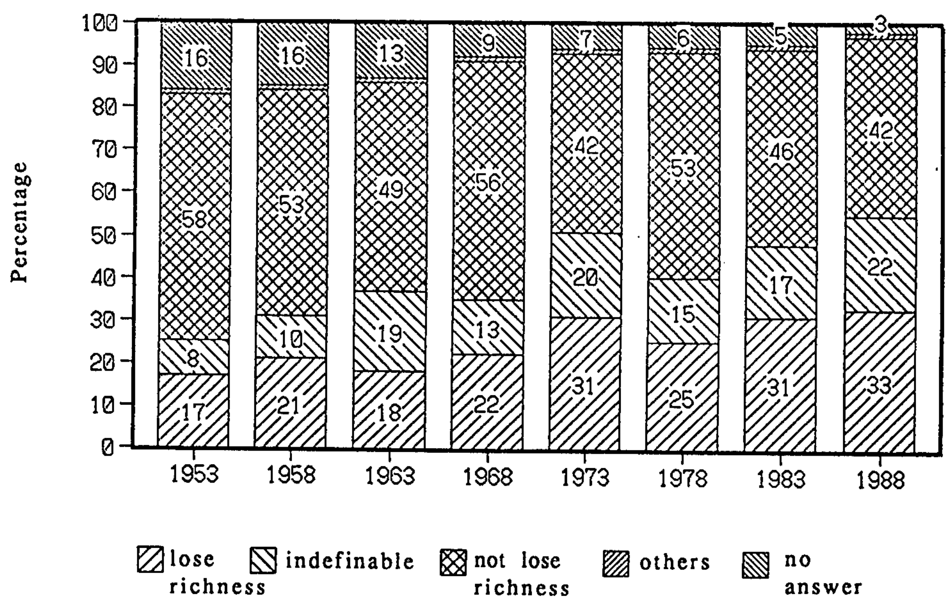
Other opinions regarding science and technology are shown in Fig. 9-1-7 (Source 6). Of those polled, 46.6 percent agreed with the statement "Work will become more interesting as science and technology advances", and 44.4 percent agreed with the statement "Our lives will become more comfortable as science and technology advances". Thus many people seem to have a positive view of the contribution that science and technology has made and can make to their working and living environment. However, more than half believe that social problems will become more serious; eg. 55.4 percent believe that "employment will fall due to the spread of robots and computers". The figure shows that few people perceive science and technology as being almighty, with just 19.6 percent believing that "Virtually all socioeconomic problems we are facing today can be resolved by scientific and technological progress."

Figure 9-1-6 Views Regarding Scientific and Technological Progress and Fulfillment in Life (1)



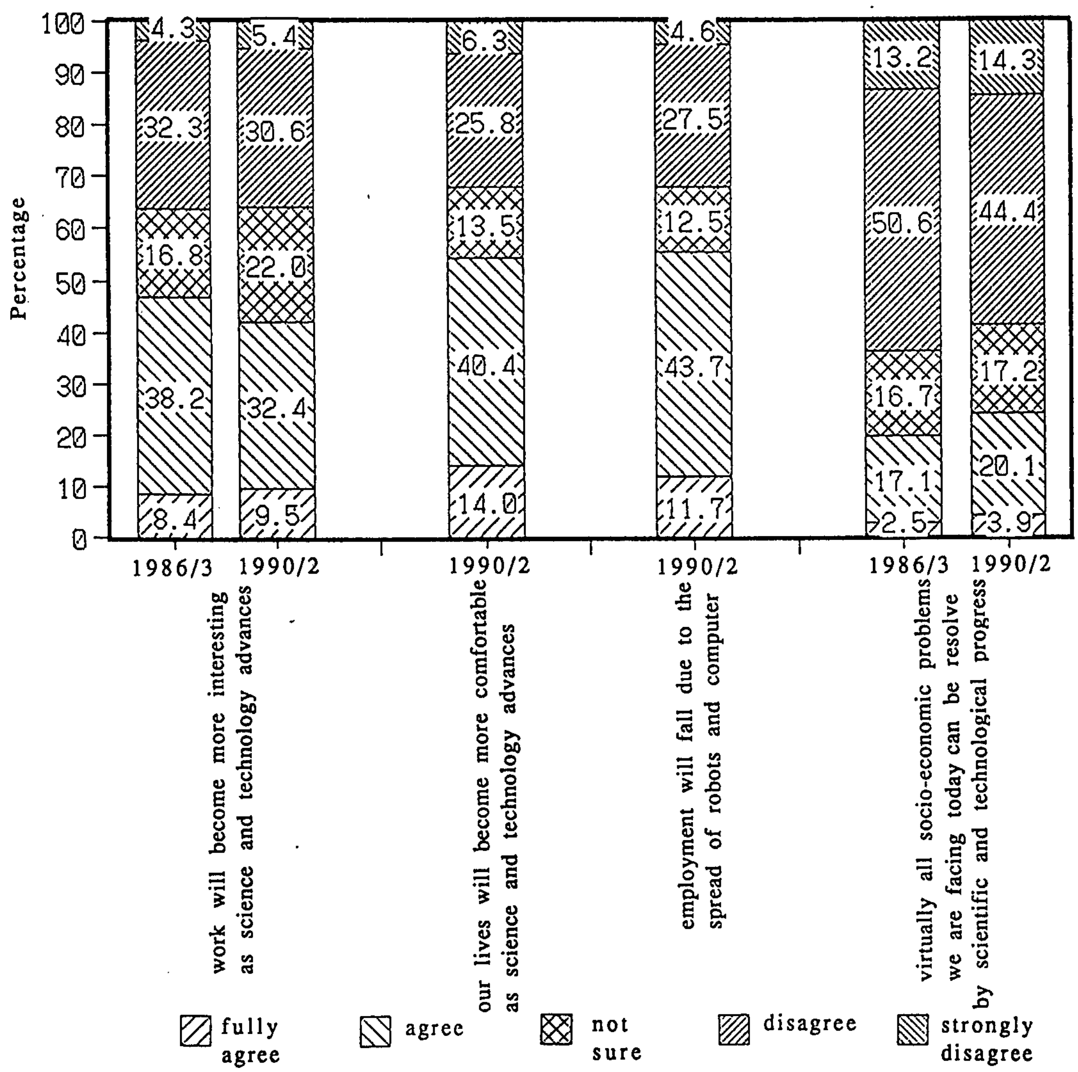
Institute of Statistical Mathematics, "A study of the Japanese National Character - The Eighth Nation Wide Survey - " (Research Report General Series No.69), 1989.

Figure 9-1-6 Views Regarding Scientific and Technological Progress and Fulfillment in Life (2)



Institute of Statistical Mathematics, "A study of the Japanese National Character - The Eighth Nation Wide Survey - " (Research Report General Series No.69), 1989.

Figure 9-1-7 Views on the Effects of Science and Technology



Prime Minister's Office, "Opinion Survey on Science/Technology and Society" 1990
See Table 9-1-7.

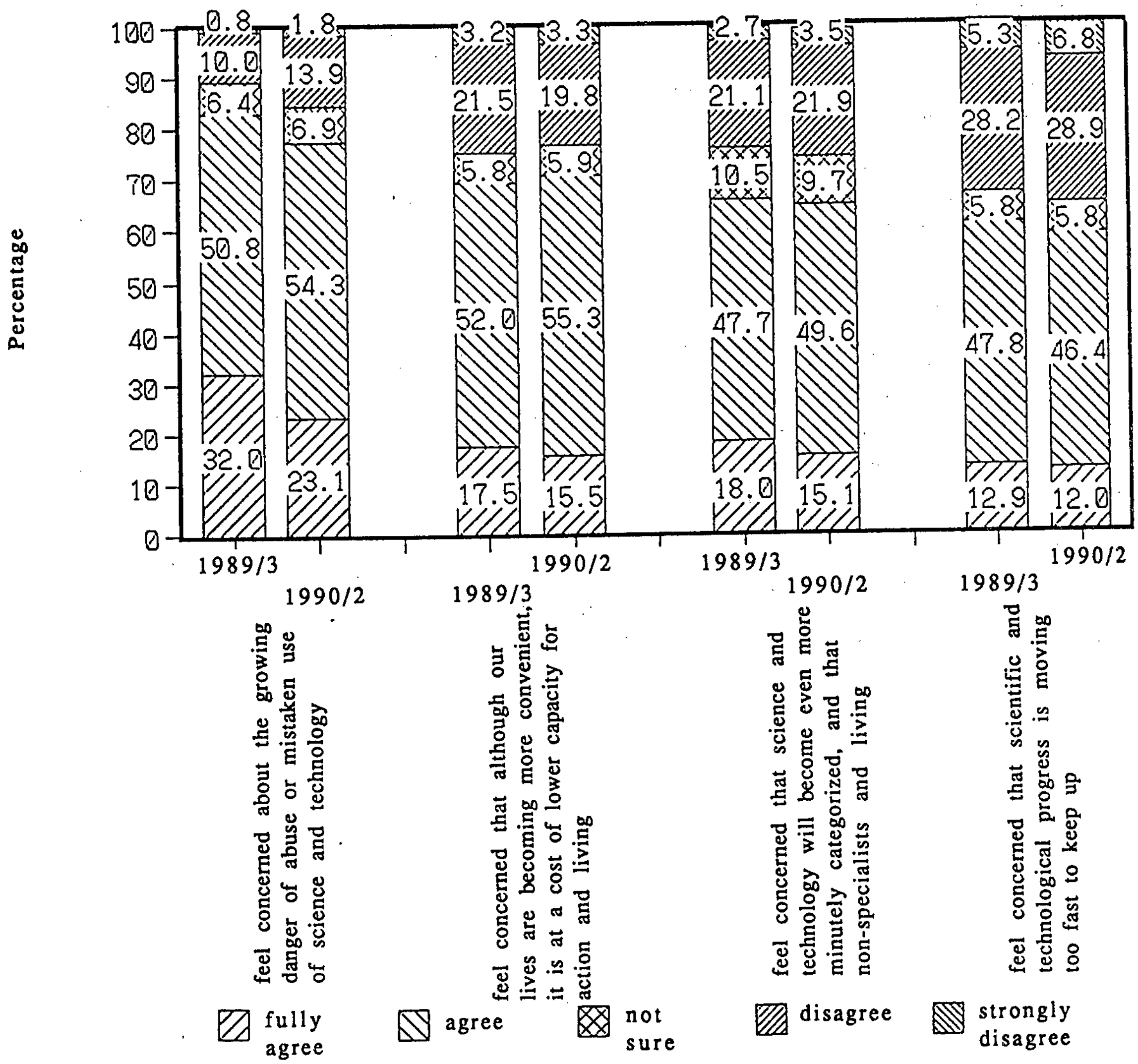
9.1.7 Concerns Regarding Science and Technology

Responses to a question on unease regarding scientific and technological advancement (Source 6, Fig. 9-1-8), 77.4 percent replied they "feel concerned about the growing danger of abuse or mistaken use of science and technology". Next was "feel concerned that although our lives are becoming more convenient, it is at a cost of a lower capacity for action and living" with 70.8 percent. Many people feel concerned weather the benefits from science and technology will, conversely, have a detrimental effect on life. These were followed by "feel concerned that science and technology will become even more minutely categorized, and that non-specialists will no longer be able to understand" with 64.7 percent; and "feel concerned that scientific and technological progress is moving too fast for me to keep up with" with 58.4 percent. What should be Noted here is that for each concern mentioned in the poll, more than half of the people responded that they felt such a concern. It should also be Noted, though, that the percentage of people who felt concerned was lower in almost all items than for the 1987 poll.

9.1.8 Future Promotion of Scientific and Technological Fields

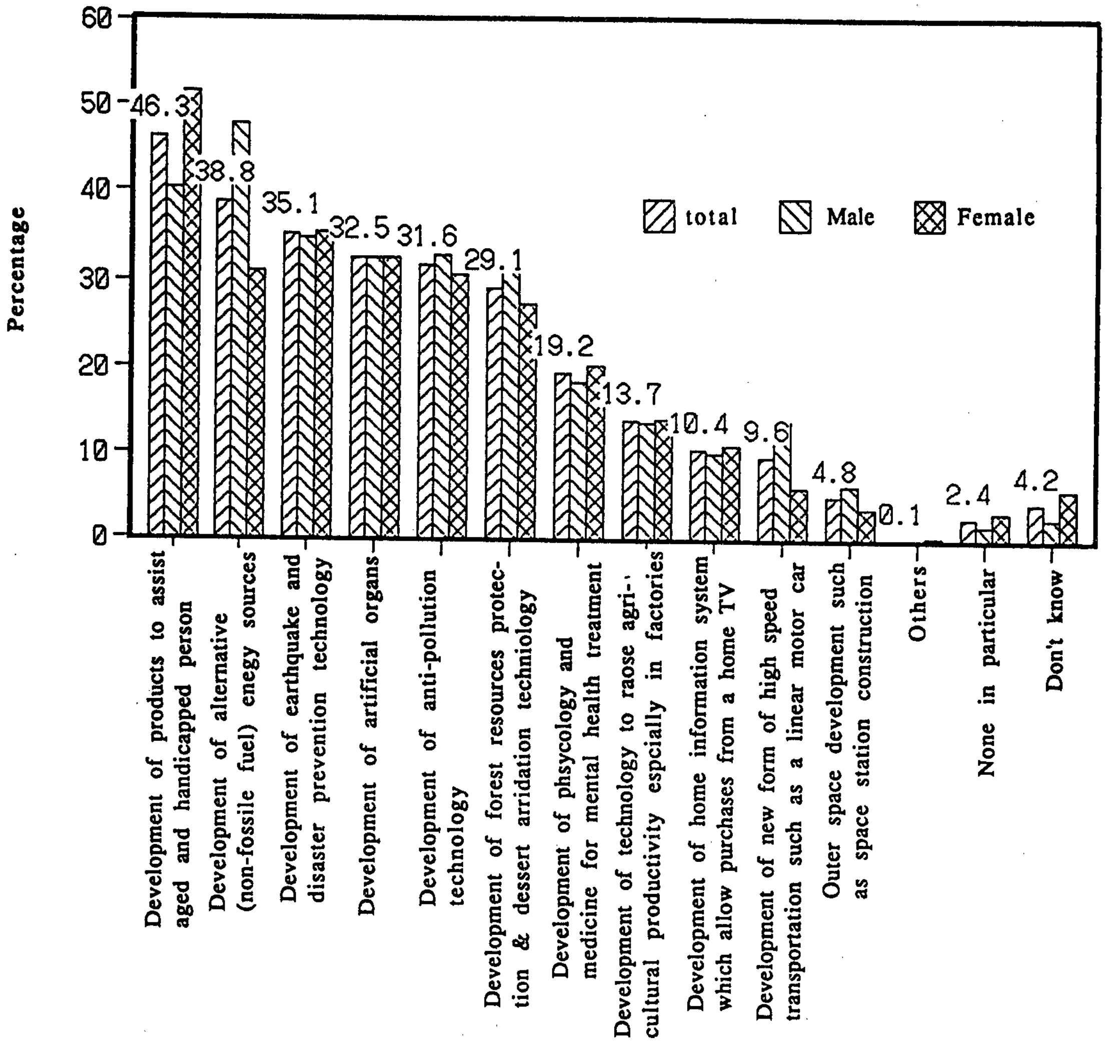
Responses on what scientific and technological fields people believe should be developed are a reflection of desires on the promotion of science and technology. To this multiple choice question (Source 6, Fig. 9-1-9), the highest percentage (46.3 percent) chose "science and technology which can help the handicapped and the the elderly in their everyday lives". This was followed by "development of oil-substitute energy resources" with 38.8 percent. A considerable difference between men and women could be seen in these two technological fields: 51.6 percent of women but only 40.2 percent of men chose the welfare-related field, whereas 47.8 percent of men but only 30.9 percent of women chose energy-related field. Next came "development of earthquake warning and other disaster prevention technologies" with 35.1 percent, "development of artificial internal organs" with 32.5 percent, and "development of anti-pollution technologies, including carbon dioxide and chloroflurocarbon countermeasures" with 31.6 percent.

Figure 9-1-8 Concerns Regarding Science and Technology



Prime Minister's Office, "Opinion Survey on Science/Technology and Society" 1990
See Table 9-1-8.

Figure 9-1-9 Future Promotion of Scientific and Technological Fields



Prime Minister's Office, "Opinion Survey on Science/Technology and Society" 1990
See Table 9-1-9.

9.2 Public Awareness of Individual Scientific and Technological Issues and Fields

(I) "Information Society"

There has been much debate over the term " information society" (*joho shakai*) in recent years.

There is, however, no strict definition for the term, so it means different things to different people. It seems that perceptions of an "information society" change from year to year, owing to advances made in information technology. Here, information society refers to as a society which has a highly developed means of distributing information. Public opinion of such an information society is discussed below.

9.2.1. Perceptions of the "Information Society"

According to a survey carried out by the Prime Minister's Office in July 1985 (Source 9), 84.2 percent of the people surveyed said they know of the term "information society". From this it can be seen that the term is widely used in society as a majority of people have heard of the term. In a survey carried out almost five years earlier in February 1981, this percentage stood at 71.1 percent, so over this five-year period, recognition rose by slightly more than 13 points, indicating the speed with which this term is becoming a part of our daily lives.

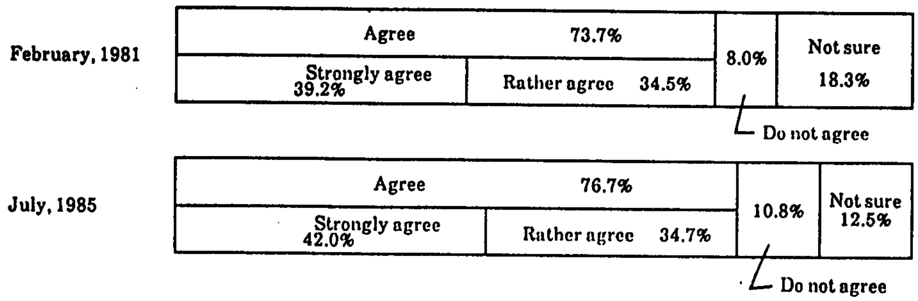
Perceptions of whether our society is developing into an information society is important in gauging public awareness regarding science and technology. Specifically, one question put to people was "Do you think today's society is an information society?". More than three-quarters (76.7 percent) believe that ours is an information society (those who responded with "yes" and "yes, to a degree"). In the survey five years ago the percentage was 73.7 percent, so it has generally stayed at the same level. By sex and age grouping, men and younger people have a stronger feeling that today's society is an information society (Source 9, Fig. 9-2-1). This tendency is similar to that for people who know of the term "information society".

9.2.2 Concerns Regarding "Information Society"

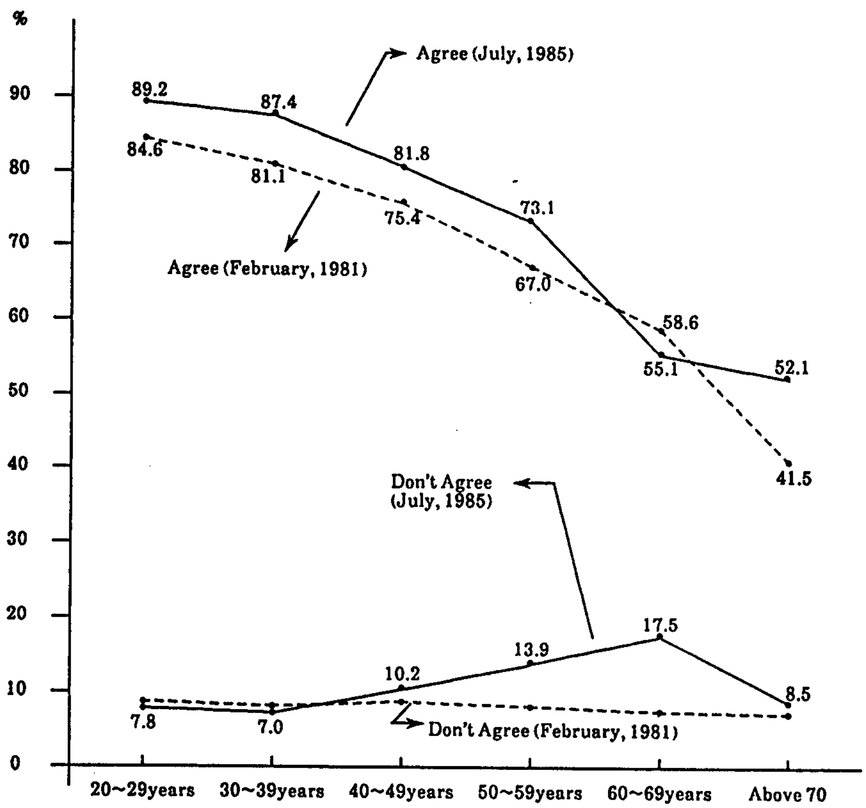
What concerns do people have of an information society? To a question on this with multiple-choice responses (Source 9, Fig. 9-2-2), the highest percentage of people (47.0 percent) responded with "there is too much information", followed by "it is convenient" with 35.4 percent. These two were by far the most popular responses. From this it can be seen that there is a strong negative image of there being too much information, but directly after this is a positive image of convenience. Although the percentages for both of these responses dropped slightly from the previous survey, the trend has generally stayed the same. Two responses where percentages did change significantly from the survey five years ago were "has little bearing on me" with 8.3 percent, and "feel cramped by controls placed on society" with 12.8 percent. This was a sharp rise for both compared to the previous survey, and from this a negative image of the information society has increased over this five-year period.

Figure 9-2-1 Public Perceptions of an "Information Society"

(1) Average



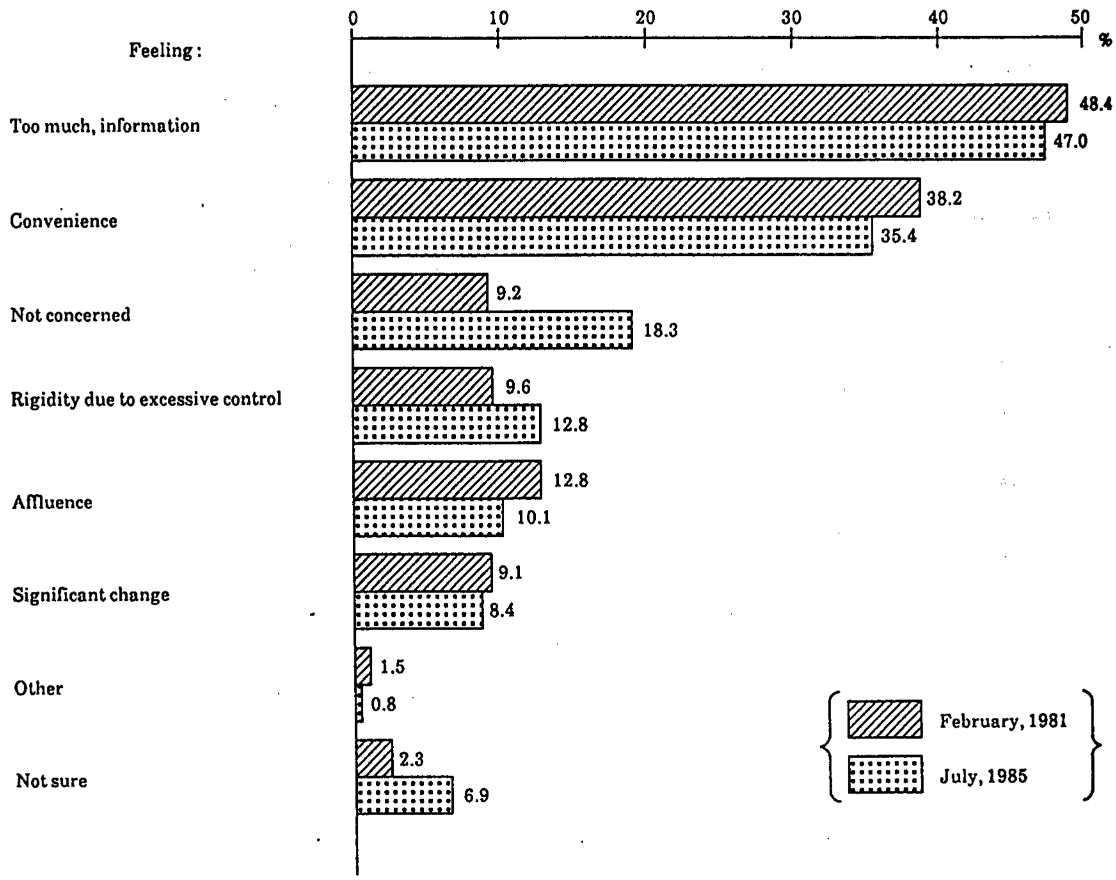
(2) Age distribution



(Note) This shows distribution of answers by age groups of persons who said they knew the term "information (Joho-ka) society".

Prime Minister's Office, "Opinion Survey on Privacy protection," 1981,
Prime Minister's Office, "Opinion Survey on protection of personal information," 1985.
See Table 9-2-1.

Figure 9-2-2 Concerns Regarding "Information Society"



(Note) Responses to a question "do you agree that we live in information (Joho-ka) society", excluding those who said they didn't know.

Prime Minister's Office, "Opinion Survey on Privacy protection," 1981,
Prime Minister's Office, "Opinion Survey on protection of personal information," 1985.
See Table 9-2-2.

9.2.3 Computer Awareness

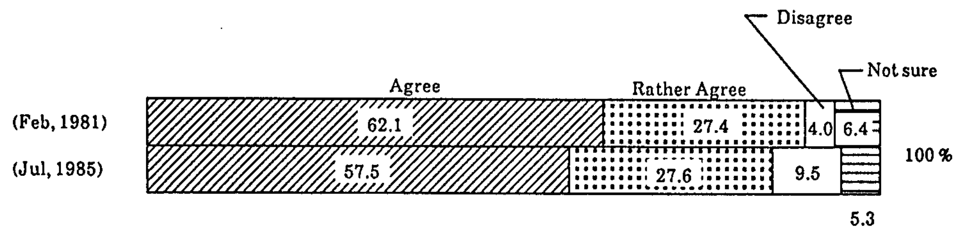
The development and spread of computers has been a major factor contributing to progress towards an information society. Surveys on views regarding computers and their widespread use indicate that the percentage of people who believe that "computers are indispensable in present-day society" (those who responded to the question with "yes" and "yes, to a degree" - 46 percent in the 1976 survey, 86.4 percent in the 1981 survey, and 78.1 percent in the 1985 survey). This means that although 80 percent of those polled in the 1980s believed that computers are indispensable, 20 percent did not. This percentage can be taken as reflecting doubts about the spread of computers or about the shift towards an information society.

Note:
Questions regarding use of computers come from source 9, and refer to Fig. 9-2-3

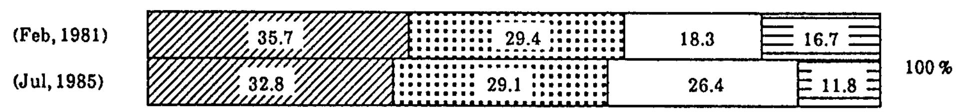
Use of computers is addressed in surveys which put forward a number of statements and then asked people whether they agreed with the statements (Source 9, Fig. 9-2-3). The highest percentage of people in the 1985 survey agreed (responded "agree" or "agree somewhat") with the statement "any conflict of interest that arises through the computer is caused by the person using it". This recognizes the neutrality of computer technology, and shows an awareness that people who use computers and not computer technology are responsible for any conflict of interests that may arise. Almost three-quarters, or 73.3 percent, agreed with this opinion. Next highest was the statement "computers do not always work for the benefit of the individual" with 61.9 percent of people agreeing. This statement is meant to indicate that computers are not always introduced with the interest of the individual in mind; that is, there is a possibility that the interest of companies or government offices will be given priority. Agreeing with "somehow, I just cannot get used to computers" were 56.1 percent, while 51.3 percent agreed with "the spread of computers increases the risk of people's private lives being violated". It is therefore clear that at least half of the people have difficulty in becoming familiar with computers or feel that computers have the potential to pose a risk to their private lives. Comparing these results with the previous survey in 1981, the percentage of people who believe that "the spread of computers increases the risk of people's private lives being violated" increased by almost nine points from 42.5 percent to 51.3 percent. Apart from this, there was not a great deal of difference between the two surveys.

Figure 9-2-3 Views Regarding the Spread of Computers

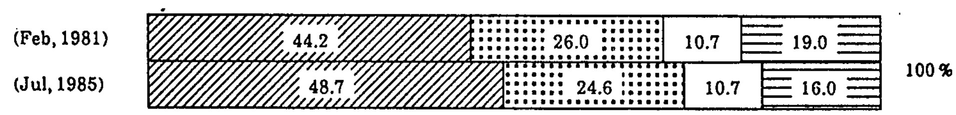
① Computers have greatly contributed to convenience in our life.



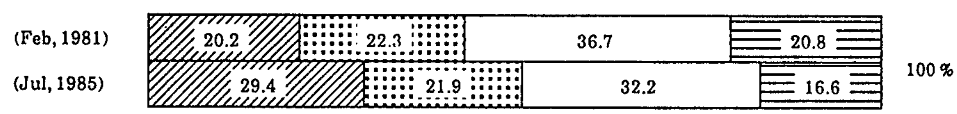
② Computers do not necessarily serve the interests of individuals.



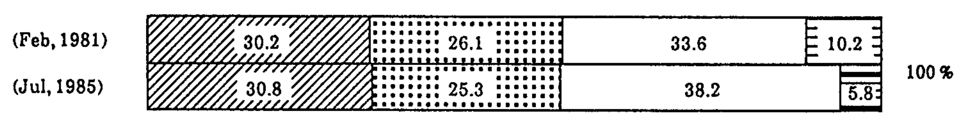
③ Whether computers create or not conflict of interests depends on who are using them.



④ Proliferation of computers has increased the risks of infringement of privacy.



⑤ We so often hear about computers, but they don't look friendly to us.



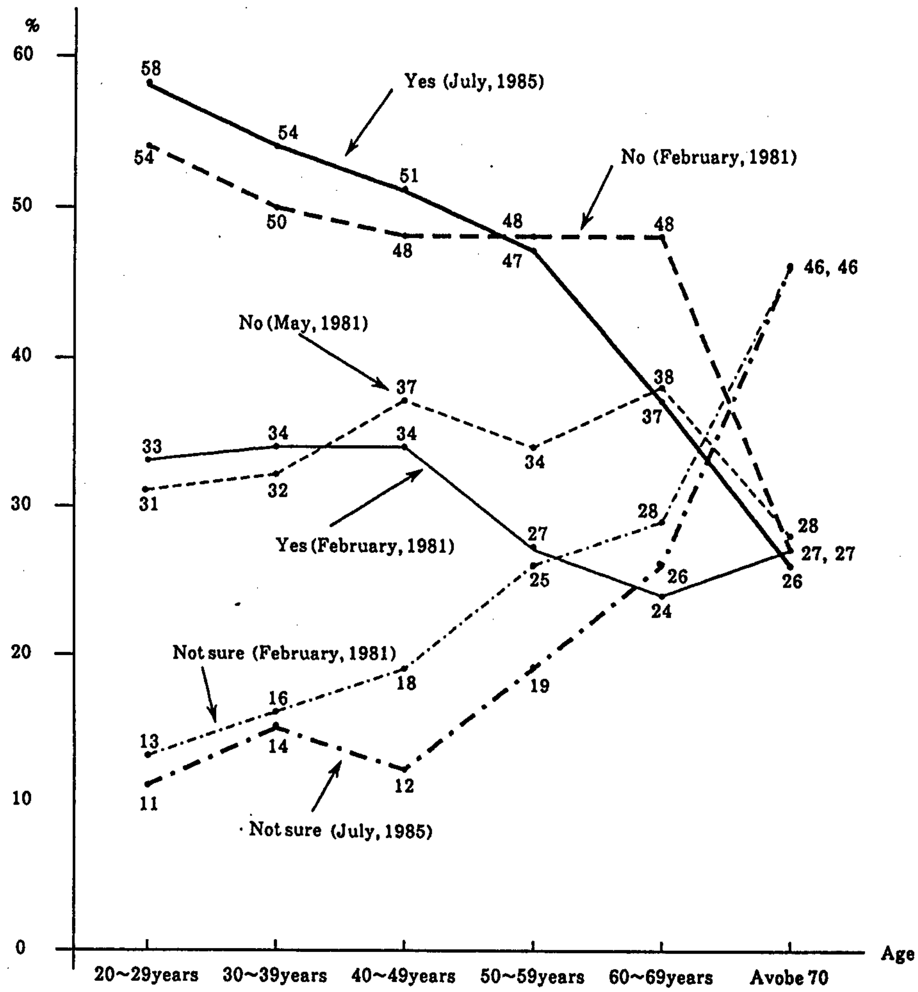
Prime Minister's Office, "Opinion Survey on Privacy protection," 1981,
Prime Minister's Office, "Opinion Survey on protection of personal information," 1985.
See Table 9-2-3.

9.2.4 Invasion of Privacy

Within this sense of danger that the spread of computers will violate our private lives, people are particularly concerned about invasion of their privacy. So we shall now examine surveys on invasion of privacy (Source 9). In a 1976 survey 23 percent of the people indicated that they felt concerned about the issue of protecting the individual's privacy. This jumped to 60.5 percent in the 1981 survey, and to 62 percent in the 1985 survey. Such an increase in concern over protecting privacy is thought to reflect society's growing concern about privacy with the rapidly expanding use of computer data bases and on-line systems from the late 1970s. The percentage who responded "yes" to the question "do you believe invasion of privacy has increased" rose from 31 percent in the 1981 survey to 48 percent in the 1985 survey, while those who responded "no" decreased from 49 percent to 34 percent. By age (Source 9, Fig. 9-2-4), for both surveys the higher the age group, the lower the percentage of "yes" responses, while the percentage of "do not know" responses rose as the age group rose. From this we can see a trend in which people in the younger age groups have more opportunities to come into contact with information so they have a greater interest in the information society, and this, in turn, leads them to feel greater concern about the danger of the individual's privacy being violated. From this it is evident that the lower the age group and the greater the opportunities to come into contact with computers, the stronger the concern about invasion of privacy; so if the present situation continues, we can expect this feeling of concern to increase more and more.

This is also supported by the responses to a question about prospects of people's privacy being violated through computers. In the 1981 survey 57.5 percent responded that they expect invasion of privacy to increase (total of "expect it to increase considerably" and "expect it to increase somewhat"), but this jumped about 13 points to 70.6 percent in the 1985 survey. In contrast, for both surveys not even 5 percent of the people surveyed expect invasion of privacy to decrease. "Do not know" responses dropped from 18.0 percent in 1981 to 15.1 percent in 1985. Although no definite conclusions can be drawn just from these two surveys, we can infer that people's concern about invasion of privacy will increase as computer systems improve and become even more widespread, and as more and more people, particularly the younger generation, have the experience of actually using them.

Figure 9-2-4 Views Regarding Invasion of Privacy



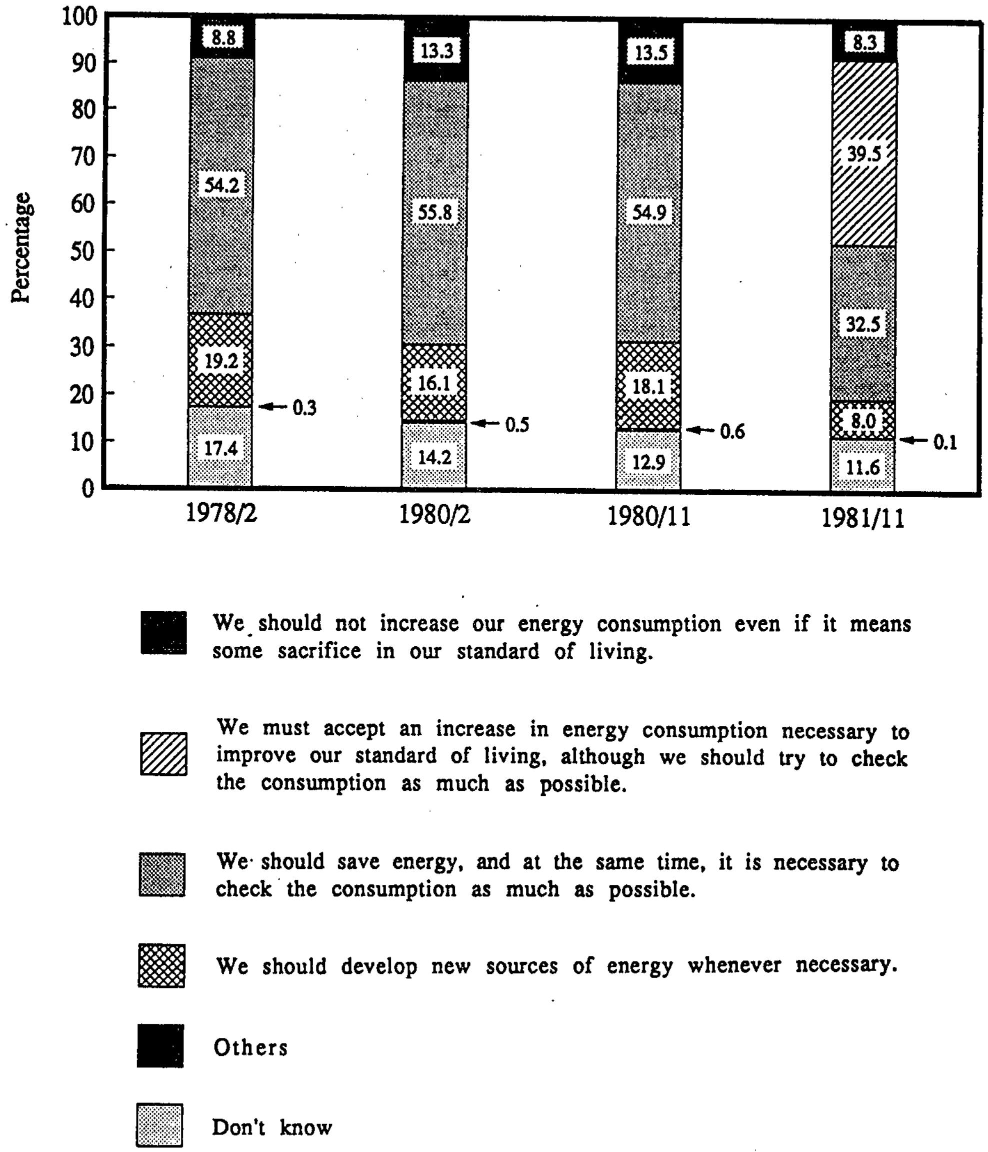
Prime Minister's Office, "Opinion Survey on Privacy protection," 1981,
Prime Minister's Office, "Opinion Survey on protection of personal information," 1985.
See Table 9-2-4.

(II) Energy (Particularly Nuclear Power Generation)

9.2.5 Energy Conservation

Since the first oil shock there have been numerous surveys on public opinion concerning energy conservation and countermeasures and other energy issues. Of these, surveys on countermeasures have been carried out not just to gauge awareness of energy issues, but to ascertain the general public's sense of values with respect to energy. Responses to the following question are examined: "It has been forecast that even if we take steps to save energy, our energy consumption will continue to increase; how do you feel about this?" (Source 10, Fig. 9-2-5). For each of the four surveys conducted between 1978 and 1981, about 10 percent of those surveyed agreed with the statement "we should not increase our energy consumption even if it means our living standards will drop". In contrast, a high percentage agreed with the statement "as well as making an effort to save energy, shortfalls in supply should be made up by developing new forms of energy", or "an increase in energy consumption as our standard of living rises cannot be helped, but we should limit the increase as much as possible". On these results, it seems that while most people view a rising standard of living positively, they also believe that they should make every effort to save energy, and that any energy shortages in this process should be met by new energy developments.

Figure 9-2-5 Views on Energy Conservation



Note: The second answer was not included in respondent's choice of the survey in 1987 and 1980.

Prime Minister's Office, "Opinion Survey on Energy and Resource Use" 1978, 1980,
Prime Minister's Office, "Opinion Survey on Energy Use" 1980, 1981.
See Table 9-2-5.

9.2.6 Nuclear Power Generation

A central pillar of Japan's energy policies is energy conservation and a steady move away from oil as an energy source. Previous public opinion polls show that people support energy conservation. One area that is viewed as greatly facilitating a move away from oil is nuclear power generation. There has been much debate on nuclear power generation both in Japan and overseas, particularly in the light of accidents at Three Mile Island and Chernobyl, and shut-downs at several nuclear power facilities in Japan. The following section examines public opinion on nuclear power generation (Reference 3).

People were asked whether they support or oppose the promotion of nuclear power generation (Note, Source 11, Fig. 9-2-6). The results of this poll, undertaken nine times by the Asahi Shimbun between 1978 and 1990 indicate that in 1978 "support" stood at 55 percent, and although this dropped to 50 percent the following year, it rose again to 62 percent at the end of the same year. These were the highest percentages for the "support" side. "Support" then started to decrease, and by the 1986 poll, "support" and "oppose" percentages were reversed.

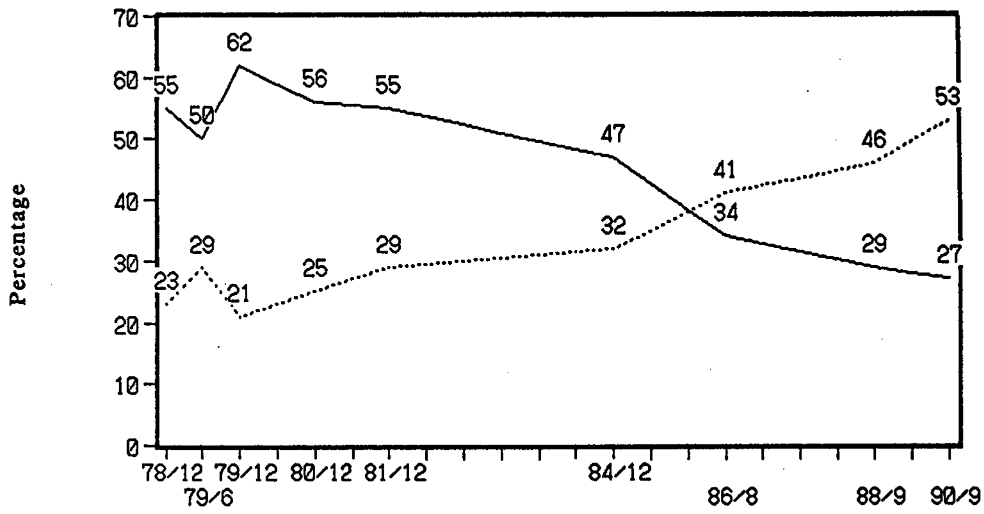
The Three Mile Island accident occurred in March 1979, and as expected, the accident had a direct effect on the poll conducted shortly after in June: support dropped by five points, and opposition rose by six points. The effect soon wore off, however, and by the end of the same year support had risen twelve points, and opposition had dropped eight points. After this, though, support started to decrease and opposition increased, perhaps because of anti-nuclear campaigns precipitated by the accidents at nuclear power generation facilities, or because of the news reports covering these accidents. This trend now appears to be well fixed.

The Chernobyl accident in April 1986 accelerated this trend, and at this point, support and opposition percentages reversed. Moreover, since then, the gap between the two has continued to grow wider. Although it is only one of the possible interpretations, it cannot be denied that these two major accidents had a significant effect on public opinion about nuclear power generation.

For example, the accidents greatly influenced public opinion about the safety of nuclear power generation. Comparison of the poll in June 1979, immediately after the Three Mile Island accident, and the poll in September 1988, after the extent of the Chernobyl accident had become reasonably clear, shows the percentage of people who agree with the statement "nuclear power generation can be made safe through technology and proper controls" dropped sharply from 52 percent to 32 percent. On the other hand, the percentage of people who agree with the statement "there are risks with nuclear power generation that are beyond the control of human beings" jumped 23 points from 33 percent to 56 percent. The Chernobyl accident brought about a great change in views. What must kept in mind here is literal interpretation of opposition to the promotion of nuclear power generation means opposition to the construction of additional nuclear power generation facilities, and in this context, it can include an approval of the present level of nuclear power generation. In fact, in the poll by Asahi Shimbun in September 1988 most people (55 percent) responded to the question "what should happen with nuclear power generation?" with the positive view of "remain at the current level", while 17 percent responded with "should be reduced", and 10 percent responded with "should be stopped". Thus the negative opinions were in a minority with 27 percent. Nine percent supported active promotion and responded with "should be increased".

Note: The reason the Asahi poll is chosen is that it has as its theme nuclear power or nuclear power generation, that is, it comprises many questions related to and concentrated on nuclear power generation, and that the questions and possible responses remain unchanged. Thus it is a highly reliable poll which allows accurate time series comparisons. However, the response choice of support or oppose has its limitations, for it does not seem to reflect any middle-of-the-road views.

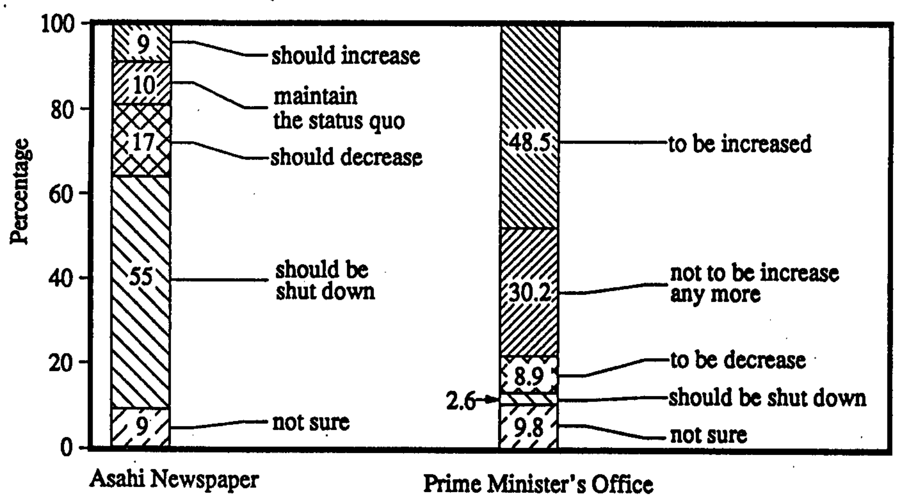
Figure 9-2-6 Views on the Promotion of Nuclear Power Generation



Asahi Newspaper

See Table 9-2-6.

Reference: Opinion for the Future of Nuclear Power Generation



Asahi Newspaper
Prime Minister's Office, "Opinion Survey on Nuclear Energy" 1990

9.2.7 Future Power Generation Systems

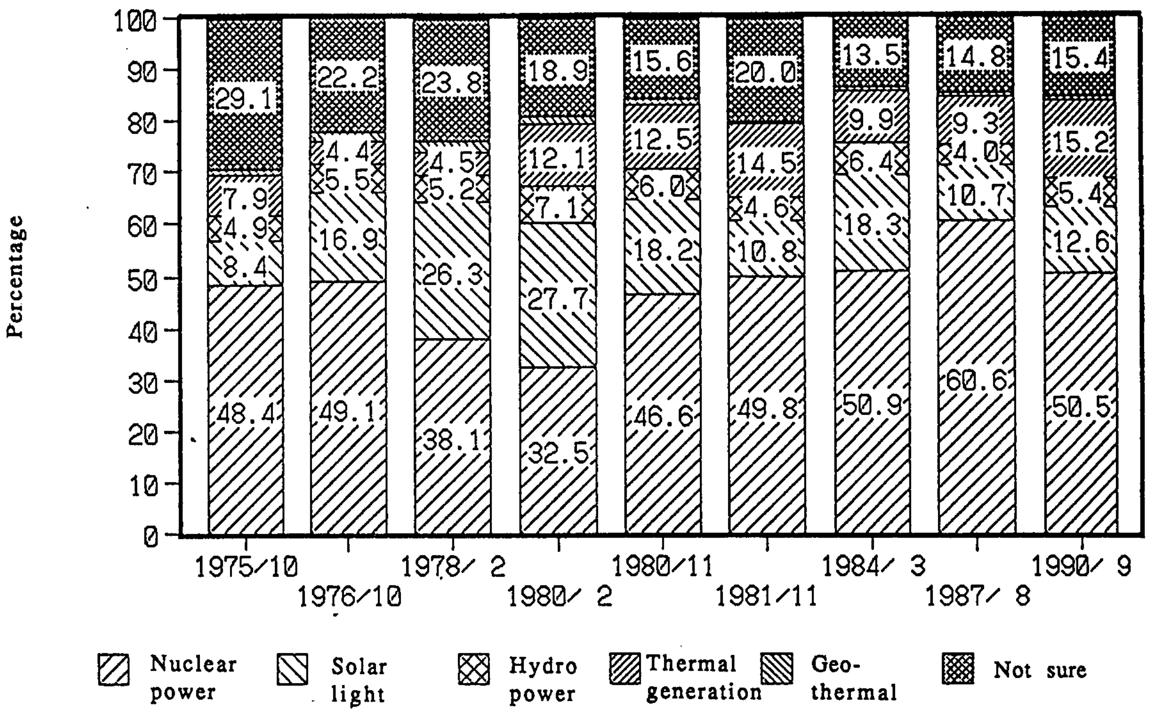
Surveys on future power generation systems are also important in determining opinions towards nuclear power generation (Source 12, Fig. 9-2-7). In the survey examined here, people were asked to chose from among prepared responses what they believe would become the major source of electric power in the future. The survey was conducted nine times between 1975 and 1990, allowing for a comparison of results over an extended period. In the 1975 and 1976 surveys almost half of those surveyed chose nuclear power generation, but this dropped to 38.1 percent in 1978, and then to its lowest point of 32.5 percent in 1980. The percentage then started to rise, reaching more than 60 percent in 1987. Although the percentage dropped again in 1990, more than half (50.5 percent) still chose nuclear power generation as the major source of electric power in the future.

The trend for solar power generation is almost the reverse of that for nuclear power generation. That is, the percentage of people choosing this response increased from 1975 to 1980, after which it tended to fluctuate. Tests showed that solar power had only limited promise as a generation system, and the initial expectations and hopes cooled as people's knowledge deepened. The percentage who chose thermal power generation increased steadily until 1981, after which it decreased. As for other power generation systems, the percentage has remained fairly constant throughout the nine surveys.

Looking at nuclear power generation in the light of this survey and the one conducted by the Asahi Shimbun, one can conclude either (1) despite their opposition to the promotion of nuclear power generation, people believe this cannot but become the major system in Japan in view of the tight energy situation owing to Japan's extremely limited energy resources, and the environmental situation; or (2) nuclear power generation will become the major power generation system regardless of opposition. In a survey conducted in 1990 by the Prime Minister's Office on the necessity for nuclear power generation, 64.5 percent agreed (responded "agree" or "agree somewhat") with the statement "nuclear power generation is necessary when we consider future energy supply and demand". From this it can be said that interpretation (1) above is probably the more appropriate.

When asked how much is known about nuclear power generation systems, which forms the background to the above responses, the majority (60.3 percent) responded "do not know". In contrast, just 2.4 percent responded "know well", while, together, "know well" and "know a little" amounted to 39.7 percent. This should be kept in mind when interpreting responses.

Figure 9-2-7 Future Power Generation Systems



Prime Minister's Office, "Opinion Survey on Nuclear Power Generation" 1975, "Opinion Survey on Science/Technology and Nuclear Power" 1976, "Opinion Survey on Enegy and Resource Use" 1978, 1980, "Opinion Survey on Enegy Use" 1980, 1981, "Opinion Survey on Nuclear Power" 1984, 1987, 1990.
See Table 9-2-7.

(III) Life Sciences

In science and technology, life sciences are indispensable for raising the well-being of humankind, and its advancement in medicine, food, energy and various other fields is highly desirable. In fact, all countries including Japan are looking towards the new century and giving the life sciences very high research and development priority. Public opinion of the life sciences is looked at in this section with particular attention to future development and effects on daily life.

9.2.8 Knowledge About Life Sciences

According to a survey which asked people whether they were aware of achievements made in the life sciences (Source 13), 86.8 percent responded that they "are aware", while just 7.3 percent responded that they "are not aware". Those who responded that they "are aware" were then asked to indicate what these achievements were (multiple response, Source 13, Fig. 9-2-8). "In-vitro fertilization" and "artificial hearts transplants" topped the list with 75.2 percent and 73.0 percent respectively. These were followed by "energy generated from household rubbish" with 43.1 percent, "treatments for cancer and hereditary diseases" with 40.1 percent, and "high-yielding plants and trees" with 36.0 percent. From this it can said that there is a strong tendency for people to be aware of advances made in medical care, which is generally a familiar part of our lives. This result may be because the list of achievements was too specialized, only 24.7 percent indicated "medicines made from coliform bacteria (insulin, growth hormones)", while a mere 7.3 percent indicated "medicines that slow down the ageing process". These results can be seen as indicating the state of public interest in the life sciences, and also the extent to which the mass media are providing the general public with information on this field of science.

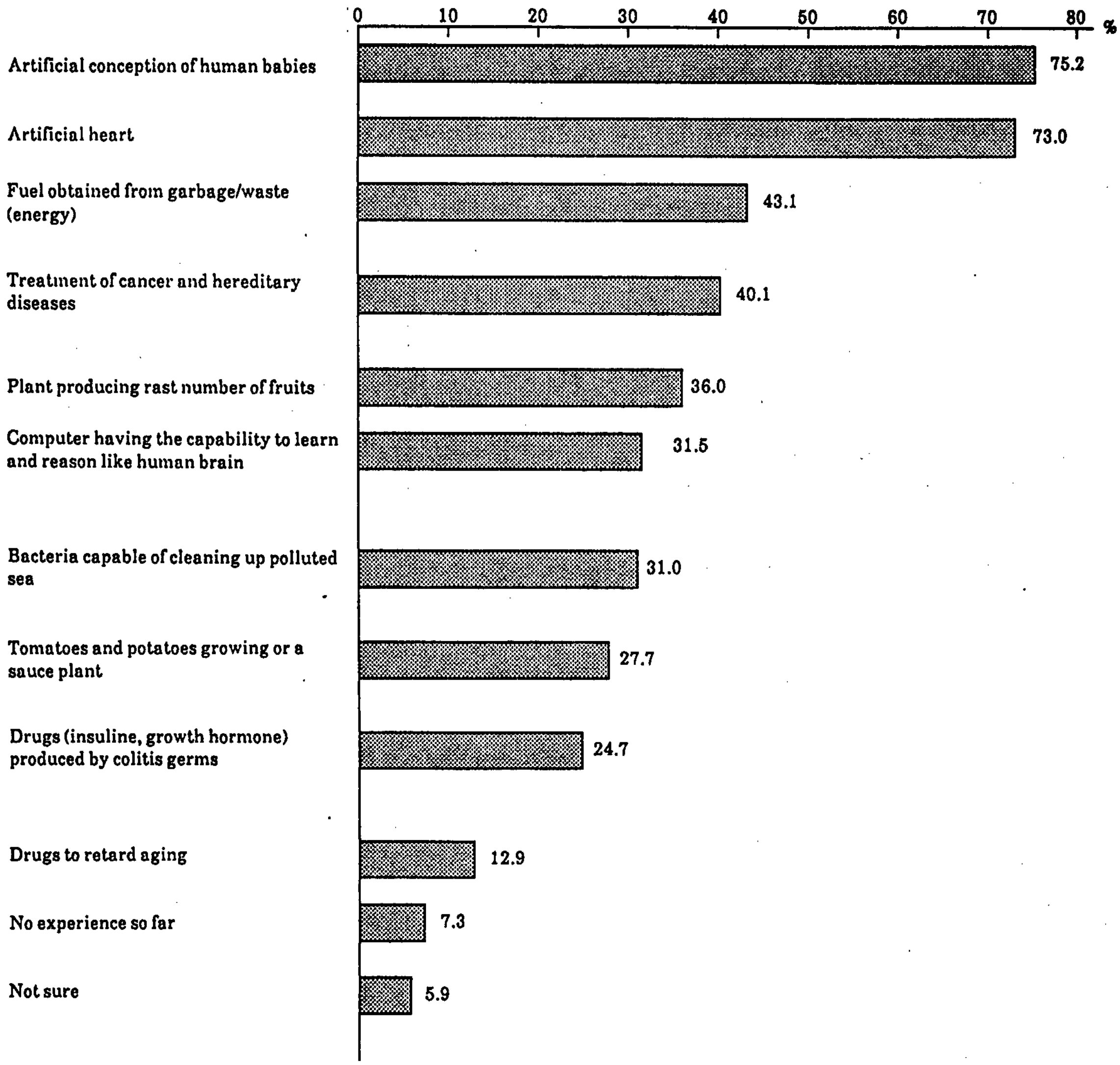
9.2.9 Expectations Regarding Life Sciences

It has been shown that many people are interested in the life sciences, and as a result, much is expected from advances in the life sciences. The vast majority (82.6 percent) of those surveyed responded that they "have some expectations" regarding the life sciences, while just 4.2 percent said that they "have no expectations". Those who responded that they "have expectations" were then asked to indicate what these expectations were (multiple response, Source 13, Fig. 9-2-9). With 45.3 percent, "treatments for cancer and hereditary diseases" headed the list by a large majority, and from this it is evident that people are optimistic as to what the life sciences can contribute to the treatment of cancer and so on. Well behind this was "pollution control" with 13.0 percent, improvement of living standards" with 11.2 percent, and "promotion of new industries" with 4.9 percent. Expectations of the medical aspects of the life sciences described here are a reflection of the fact that the life sciences have achieved their fastest growth in the medical field.

9.2.10 Prolonging Life

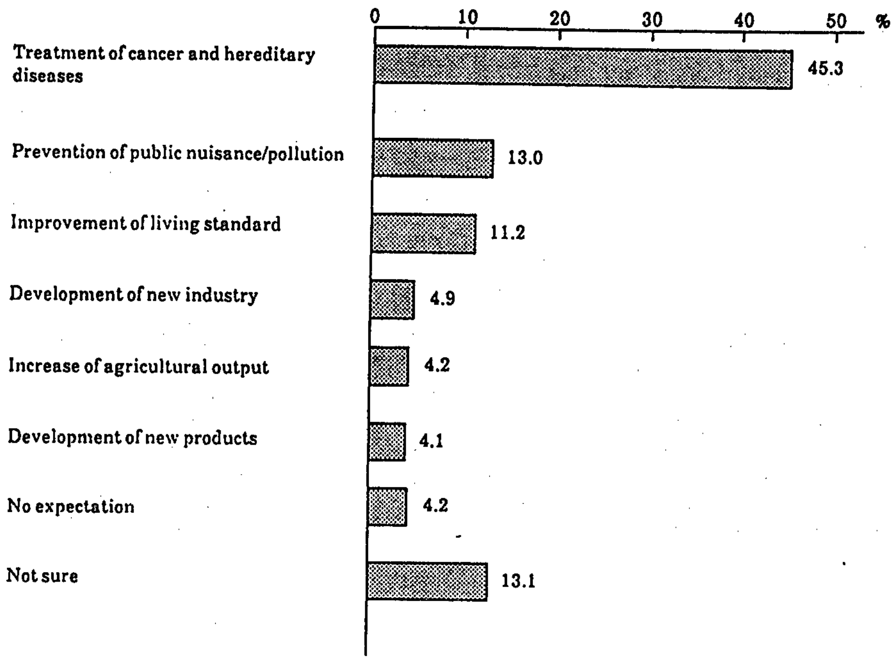
Achievements in the medical aspects of the life sciences ultimately mean a contribution to prolonging human life. Examination here is on a survey which probed views on receiving medical care needed to prolong life if put in that situation (Source 13). Overall, 65.2 percent of those surveyed chose the *natural path,* responding that they would "prefer to let nature run its course without too much human intervention". This contrasts with the 27.2 percent that chose the *scientific path* in responding that they would "prefer to prolong life as much as possible through the maximum use of the latest medical advances" (Note). Thus the majority of people would seem to prefer the natural path. Comparing this with the 1985 survey, the percentage of people who chose the natural path rose from 59.6 percent to 62.5 percent, while the percentage for the scientific path dropped from 32.1 percent to 27.2 percent. The 1985 survey analyzed results by sex, age group and academic background (Source 13, Fig.9-2-10). "Prefer to let nature run its course" was chosen by more women (61.8 percent) than men (56.8 percent); moreover, the higher the age group, and also the lower the educational background, the higher the percentage that chose this option. On the other hand, "prefer to prolong life as much as possible" was chosen by more men (36.0 percent) than women (28.9 percent), and also the younger the age group, and the higher the educational background, the higher the percentage.

Figure 9-2-8 Opinion on Achievements in the Life Sciences



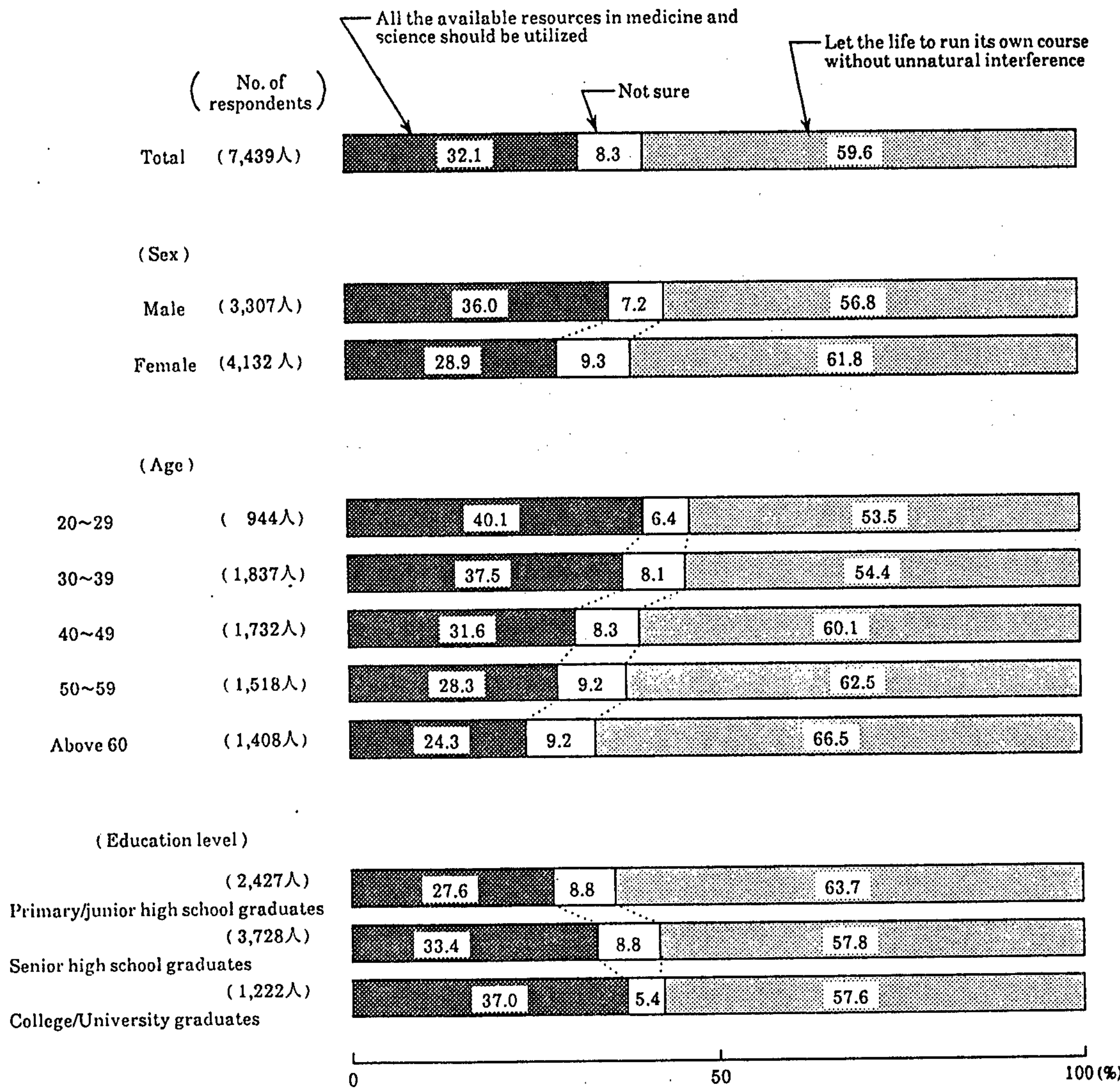
Prime Minister's Office, "Opinion Survey on Life Science," 1985.
See Table 9-2-8.

Figure 9-2-9 Expectations Regarding Life Sciences



Prime Minister's Office, "Opinion Survey on Life Science," 1985.
See Table 9-2-9.

Figure 9-2-10 Views on Medical Care to Prolong Life



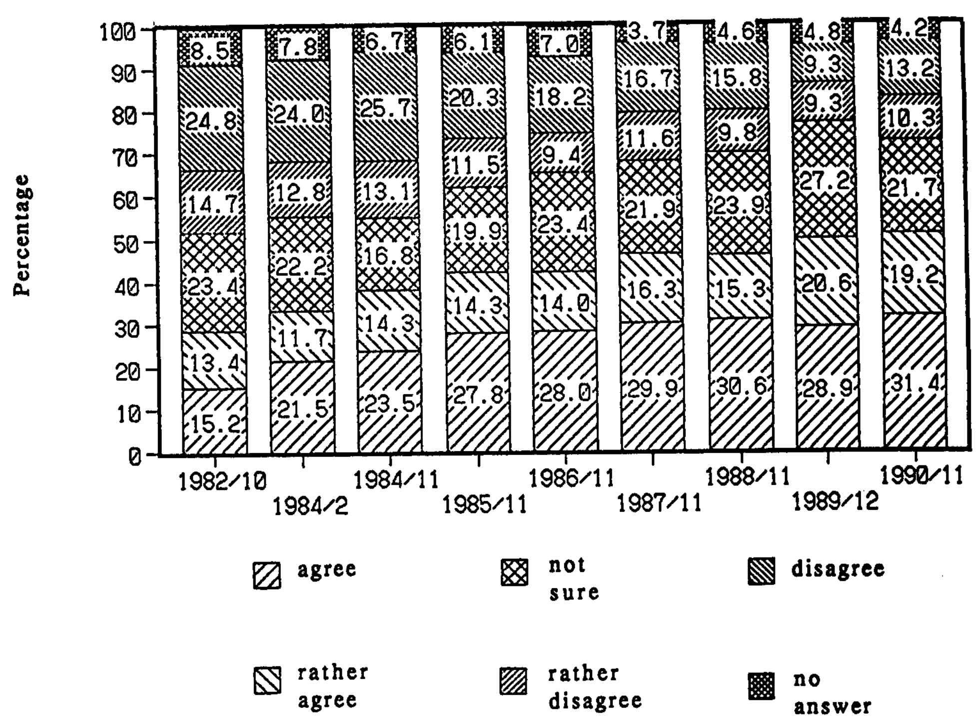
Prime Minister's Office, "Opinion Survey on Life Science," 1985.
See Table 9-2-10.

9.2.11 Brain Death Issues

Brain death and organ transplant issues are the two most debated in life sciences. As for definitions of death and opinions on brain death (Source 14), 23.7 percent responded that "death should be recognized at when the brain stops functioning", while 24.1 percent responded that "death should not be recognized until the heart has stopped beating". Thus the two conflicting views are fairly evenly balanced. There is also a view that society as a group should not determine the definition of death; rather, it should be left to the individual. In fact, the highest percentage (36.7 percent) responded that "it should be left to the will of the individual concerned where possible, or to the family members".

The Yomiuri Shimbun has conducted a number of polls on whether death should be recognized at when the brain stops functioning. Unlike the surveys by the Prime Minister's Office, the Yomiuri surveys did not have "it should be left to the will of the individual concerned" as a response option. Instead, the surveys only asked the propriety of brain death. According to the surveys (Source 15, Figure 9-2-11), the percentage of people who believe that brain death should be judged as death ("brain death should be judged as death" and "if pressed to decide, I should say that brain death should be judged as death") increased with each successive survey, reaching 42.1 percent in the 1985 poll. The percentage of people who believe that brain death should not be judged as death ("brain death should not be judged as death" and "if pressed to decide, I should say that brain death should not be judged as death") exceeded the brain death recognition view in the 1982 poll with 39.5 percent, but this dropped to 31.8 percent in the 1985 poll, and the relative positions of the two opposing views were reversed. Fewer and fewer people were responding with "cannot decide", and from this it can be said that more people are making up their minds about this issue. Also, over the next few years the number of people who believe that "death should be recognized at brain death" will probably increase.

Figure 9-2-11 Views Regarding Judgement of Brain Death



The Yomiuri Newspaper National Opinion Surveys
See Table 9-2-11.

9.2.12 Life Sciences Research

Life sciences research is closely connected to society, particularly in the aspect of medical care. As discussed earlier, this is evident in a deep interest in the life sciences. Responses to a poll on views regarding life sciences research, and whether the results of this research should be used within society are discussed below(Source 13, Fig. 9-2-12).

Only 9.5 percent of those polled believe in non-interference, agreeing with the statement "there is no need for interference in life sciences research and its application within society". On the other hand, 3.5 percent believe that "life sciences research is acceptable but should not be put to practical use in society", and 1.2 percent believe that "both research and application in society should be prohibited", for a total of 4.7 percent against life science research or its application. The highest percentage of people (42.6 percent) agreed with the statement "both research and use in society are acceptable, but national consensus is necessary before use". This was followed by "national consensus is necessary even at the research stage" with 21.7 percent. Generally, if consensus is necessary at the research stage, it would be even more necessary at the application stage, so it is reasonable to say that 64.3 percent believe that national consensus is necessary when the results of life sciences research are being used in society. By gender, age and educational background, slightly more men than women, and more people in their 20s (49.4 percent) and 30s (51.3 percent) agreed with "national consensus is necessary before its use", while the higher the educational background the higher the percentage of people who agreed with this statement.

(IV) Environmental Conservation

Until the 1970s environmental issues mainly revolved around industrial pollution, and in many cases, concern was limited to environmental problems that occurred in the mining and manufacturing industries, and within specific regions. These days, however, environmental issues are of a global nature, and people throughout the world now share a concern for the environment.

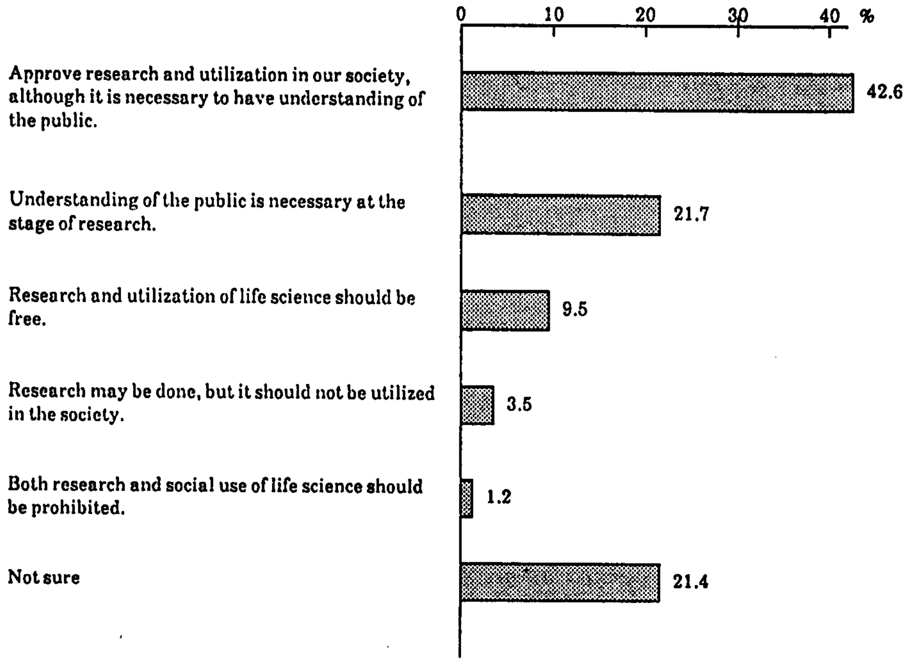
9.2.13 Nature and Human Beings

Public opinion on the relationship between nature and human beings is examined in the following section(Source 16, Fig. 9-2-13). In both polls only about 10 percent approve of "human beings' regulating nature". On the other hand, around 30 percent believe that human beings should not regulate nature, and that we should "leave nature to run its course with no human intervention", and although the percentage choosing this response is increasing, it is not the most popular response. The most popular response is midway between these two views, namely, "human beings should adhere to the principles regulating nature, but at the same time use nature for the benefit of mankind". And although around half those polled agree with this idea of symbiosis, the percentage is decreasing.

9.2.14 Technological Progress and the Environment

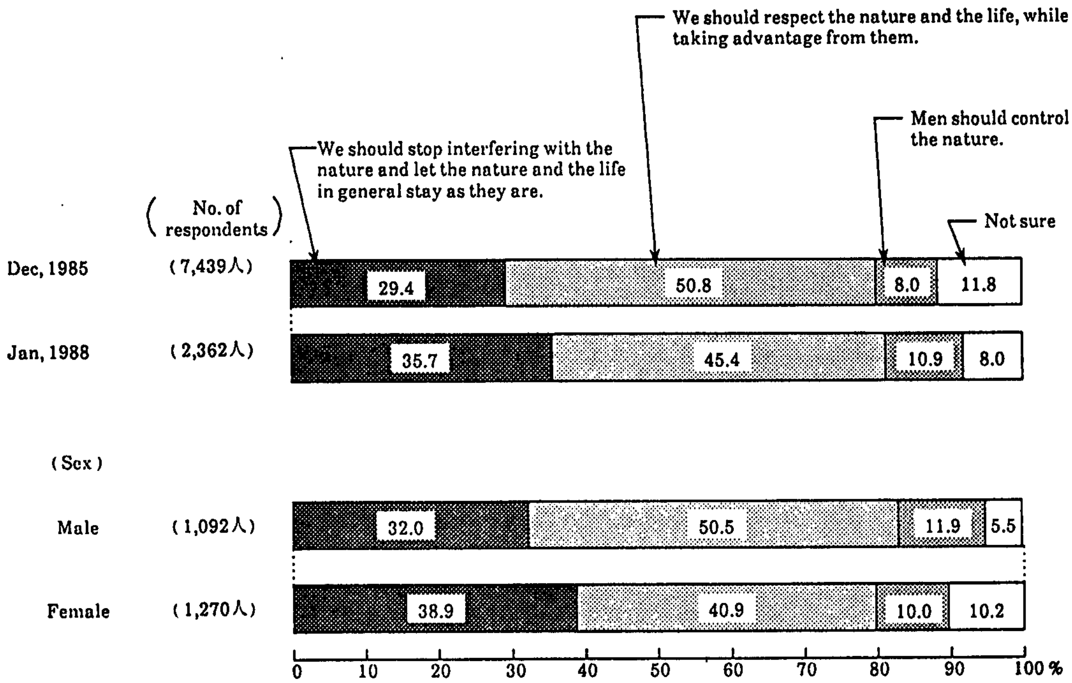
A survey on the relationship between technological progress and the environment (Source 16) reveals that people are fairly evenly divided among three main views. The highest percentage (28.0 percent) feel "greatly concerned about possible environmental problems resulting from technological progress"; followed by those who take the opposing view and feel that "technology is *clean* so there is no need to worry" with 23.0 percent; and those who feel that "a certain degree of pollution cannot be helped" with 21.3 percent. A fourth and equally substantial group were those who responded "do not know", with 26.5 percent. By gender, there was a high response of women with "do not know", 32.4 percent, while the higher percentages among the men were in "technology is clean so there is no need to worry" and "a certain degree of pollution cannot be helped".

Figure 9-2-12 Views Regarding Life Sciences Research



Prime Minister's Office, "Opinion Survey on Life Science," 1985.
See Table 9-2-12.

Figure 9-2-13 Views Regarding Relationship Between Human Beings and Nature



Prime Minister's Office, "Public opinion survey on environmental issues," 1988,
Prime Minister's Office, "Opinion Survey concerning life science," 1985.
See Table 9-2-13.

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CHAPTER 10

OUTLOOK FOR SCIENCE AND TECHNOLOGY INDICATOR DEVELOPMENT

This is Japan's first report on science and technology indicators, but it will have little meaning if it is not published at regular intervals. Fortunately, the National Institute of Science and Technology Policy is planning the next edition of this report. This report can be seen as the first step in the development of Japan's science and technology indicators. If published regularly, further enhancement of and research on indicators is foreseeable. Based on experience gained during the development of these indicators, future improvements and outlook can be divided into the following five items.

(1) Enhancement of related statistical data
(2) Establishing an indicator data base
(3) Evaluating the need for indicators
(4) International cooperation in development of indicators
(5) Improvement of science and technology indicators

(1) Enhancement of Related Statistical Data

Indicators are developed from statistical data. Future enhancement of indicators, must strive for collection of appropriate and related statistical data. The means to this ends can be considered as follows.

(a) Enhancement of Existing Statistical Data

When drawing up science and technology indicators statistics that conform to the indicator system were found, in addition to statistics collected in line with administrative aims. Among existing statistics, there are still many data suitable as science and technology indicators that remain buried, so there is a need to make every effort to collect this data.

(b) Proposing Improvements to Existing Administrative Statistics Surveys

Existing statistics, particularly administrative statistical data, are collected for administrative purposes. Consequently, they are not always suitable to help us gain an understanding of scientific and technological activities. To prepare better science and technology indicators, there is a need to ask surveying organizations to improve their existing statistics; for example, ask them to add survey items or to unify industrial classifications.

(c) Requesting Detailed Analysis of Surveying Agencies

Statistical data are collected and analyzed in line with administrative aims, and are used to achieve administrative aims. However, separate analysis, tables or figures will often allow a better understanding of scientific and technological activities. A great deal of cost and effort is associated with gathering these data, so to use them in areas additional to their initial purpose is not only beneficial, but also useful for other social needs as well. In fact, Article 15-2 of the Statistics Law provides for external use of designated statistics, and it is thought that this article has such a situation of social use in mind. Designated statistics were used with approval in accordance with this provision when developing indicators. Regular cooperation from surveying agencies in analysis for these indicators, and also in developing new indicators should be sought at every opportunity.

(d) Examining the Need for New Official Statistical Surveys

It is widely recognized among OECD countries that existing science and technology indicators and the statistics collected are insufficient. Specifically, it has been pointed out that there are not enough statistical data on such fields as software, technological innovation, international exchanges, and technology projection, and also not enough technical manuals for international comparison. Japan, which has been said to be a prize student of the Frascatti Manual (The Measurement of Scientific and Technical Activities - Proposed Standard Practice for Surveys of Research and Experimental Development, "Frascatti Manual"), is no exception. There is a need to collect statistical data that keeps pace with changes in an era which places increasing importance on scientific and technological activities. To this end, there is a need to carry out surveys which can supplement existing statistical data. But these surveys must be carried out regularly, achieve a high response rate, and be highly reliable. So in addition to measures (a)-(c) mentioned above, new official surveys will become necessary.

(2) Establishing an Indicator Database

As the group that prepared this report on science and technology indicators, it is our hope for wide use and dissemination by as many people and organizations as possible. The most fundamental medium for ensuring wide distribution to users is a report. However, as seen in the spread of personal computer communications over the past few years, distributing data through the electronic media will facilitate use by a greater number of users. In fact, the National Science Foundation (NSF) in the United States arranged the tables in their Science and Engineering indicators report into a database, allowing users to gain free access to these data through the personal computer network. Using this as a reference, the following concrete measures with regard to the future establishment of an indicator data base can be considered.

(a) Enabling Personal Computer Communication Access

This would enable users to gain access through domestic and overseas personal computer communications networks. First, NISTEP would establish a host computer that could respond to the needs of users in Japan. Floppy disks would also be prepared for the convenience of users without access to a personal computer communication system. And if text, tables, figures are translated into English, it is possible to respond with the same level of support to requests from overseas.

At the international level, it would be possible to link to overseas users through communications networks such as BITNET. Ideally a link up with the NSF, which has developed numerous indicators and has an abundance of data, and the responsible organizations within the OECD, is possible in the establishment of a tripolar network with regard to science and technology indicators. With such a core network, the potential to cover the world with a science and technology indicator information user network, such as by linking in to UNESCO's STEPAN (Science and Technology Policy - Asia Network), which is actively working towards similar goals is further possible. Once this take place, not only exchanges of data, but diverse and new plans also become possible, including exchange of analysis results and research, teleconferences, and Delphi technology forecasts for the world's experts.

(b) Releasing Statistical Data to the Public

In developing indicators, one of the jobs that required a great amount of effort was gaining access to statistical data that could form the basis of these indicators. By shortening the time required for this, much more effort could be spent on analysis. The same is true for the readers of this report. If they could gain access to the raw statistical data used in drawing up these indicators, they would be able to analyze and interpret the data in for their specific purposes. Accommodation of user needs for access to raw data should be promoted where possible. At present these data are not in a form that can easily be used, so there is a need to sort out the statistical data recorded on magnetic tape or floppy disks, to establish some conformity in classifications, and to set up a uniform structure. It is also expected that the volume of data will be immense. Although there are such challenges, every effort is needed to release statistical data to the public, using the latest innovations in rapidly advancing information technology.

(3) Evaluating the Need for Indicators

It is thought that there is considerable and widespread need for science and technology indicators. Clarification of how this report has or has not met the needs is needed. That is, as well as ascertaining the need for science and technology indicators, developing indicators which conform to the need is just as important. At present it is envisaged that the people or organizations that have a need for science and technology indicators are central and local government policy-makers, R&D scientists and engineers, the mass media, and overseas individuals or organizations that are connected with science and technology. The following are measures to ascertain the need for indicators, and ensure their on-going improvement.

(a) Holding seminars for people and organizations connected with science and technology in Japan.

(b) Holding seminars for people and organizations connected with science and technology overseas.

(4) International Cooperation in Development of Indicators

With the experience of compiling this report, Japan can make a significant international contribution to the development of science and technology indicators. As the first step, the English translation and publication by NISTEP of this report is one example. The following can be considered as additional concrete measures for international cooperation.

(a) Proposing Measures Which Promote International Comparisons

International comparisons in science and technology have never been more sought after than at present. However, such comparisons are not easy. One reason is that scientific and technological activities are closely linked to the culture, history, and legal system of the country in which they are carried out. For example, in the case of R&D scientists and engineers, the definition of a researcher varies from country to country, as does the method of measuring their activities. The same can be said about research and development expenditures. Since there are differences in each country regarding these areas, international comparisons of related statistical data and indicators are extremely difficult. So there is a need to cooperate in the preparation of a manual which covers the various definitions and gauging methods and which can be used by each country. For example, in this report we developed indicators in accordance with the Frascatti Manual of the OECD for FTE (Full-Time-Equivalence) of researcher personnel and the socioeconomic purpose classification of the government's science and technology budget. This is one example of Japan's contribution in the area of international comparison of S&T indicators.

Assuming that it is difficult to set common definitions and measuring methods that can be used internationally, there is little meaning in international comparisons of absolute values or that are over a only a single year. In such a case, there is meaning, however, in international comparisons of relative values or time trends. An example of relative values is R&D expenditures as a percentage of GDP. This is thought to reflect each country's R&D effort, and it does make sense to compare this effort. And as an example of time trends, the percentage of basic research expenditure as a percentage of overall R&D expenditures is examined. Even though there is little point in comparing each country's basic research expenditure percentage for a single year, comparing trends of each country's effort in basic research over an extended period does have significance. Through design of analysis along these lines, international comparison becomes possible, even for indicators which to date have been considered to be very difficult to compare. A variety of analysis in compiling these indicators had ben attempted in the hope of contributing internationally to indicator development.

(b) Participating in the Drafting of an International Indicator Manual

A Japanese representative (Note 1) has participated in revising the OECD Frascatti Manual, shouldering part of the responsibility for scientific and technological projections. There was also

Japanese participation in the construction of a scientific and technological information management system in Asia for STEPAN (Note 2). On the basis of the experience gained in developing these science and technology indicators and also analysis of Japan's R&D and scientific and technological activities, Japan shall actively participate in the preparation or revision of international manuals.

(c) Cooperating with the Development of Science and Technology Indicators in Developing Countries

There are increasing opportunities for preparing indicators in developing countries. One example is STEPAN, supported by UNESCO and other international organizations. NISTEP has made every effort to cooperate in such activities. And based on our experience, Japan shall provide even more cooperation to the developing countries in the development and drawing up of science and technology indicators.

(5) Improvement of Science and Technology Indicators

It is hoped that science and technology indicators will be published regularly. And this means that a review of indicators can be carried out each time they are published. And with on-going improvements can be expected. Concrete ways in which the indicators can be improved will become clear as the need for indicators are ascertained, as described in (3) above. Moreover, potential needs will be revealed through the establishment and use of an indicator database, as described in (2) above. There are also improvement measures from the viewpoint of international cooperation (4). Such measures for improving indicators can be brought together in the following stages.

(a) Improve the Indicators and the Indicator System

When developing these indicators, new indicators were developed totally independently from existing indicator reports such as those for science, technology and society, and citation analysis of scientific and technical papers and patents, developing new indicators. On the other hand, there were also groups of indicators for which there was not sufficient time to undertake adequate examination. The first step to improving indicators is to retain the indicators that have been improved, and strive to improve those indicators for subsequent editions.

As mentioned in the first section on related statistical data, there is a strong possibility that related data, which form the basis for indicators in subsequent editions, will be further enhanced. This enhancement is directly linked to an improvement in the indicators.

Given that these improvement are from the viewpoint of the suppliers, they should also be improvement from the viewpoint of the users. This is because there is a great possibility that the community and policy-makers will require new indicators. In fact, one such requirement is for international comparisons described earlier. If science and technology indicators are prepared to discover the range of scientific and technological activities in a country, then there must be an adequate response to these needs. Through this it can be expected that indicators and the indicator system will evolve favorably.

It goes without saying that the reorganization of the indicator system itself is included in this evolutionary process. Even though it is not necessary to repeat the advantages in development, the necessity of this system cannot be overstated.

(b) Development Integrated Indicators (Develop Judgement Indicators)

As stated earlier, these science and technology indicators report on present conditions. Although attempts at various kinds of analysis are undertaken, development of these indicators has the primary aim of reflecting the actual state of scientific and technological activities as accurately as possible. It is natural, however, to consider moving up to a higher level when developing indicators. Higher level indicators are judgement type indicators. It is said that there are two kinds of judgement type indicators: (i) a priori, and (ii) statistical analysis type. The first is a priori to select indicators which seem to form a relationship when combining internationally related indicators, and then calculate the integrated amount after weighting the indicators appropriately. There are similar kinds of integrated indicators. On the other hand, the statistical analysis type of indicators use principal component analysis and factor analysis, so a large amount of data is required. Since both have merits and shortfalls, it cannot be said that one method is always more suitable than the other. Whichever method is adopted, for a number of fields it is worthwhile developing integrated indicators that suit the aim, analyzing time trends, and attempting international comparisons.

(c) Attempt Evaluation of Science and Technology Policies (Attempt to Develop Evaluation Type Indicators)

The most sophisticated kinds of indicators are evaluation type indicators. This requires an understanding of the cause and effect relationship among a number of indicators. However, the detection of cause and effect relationships in the case of scientific and technological activities is expected to be quite difficult. Nevertheless, ascertaining the cause and effect relationship is possible by systematically identifying relationships among a pair of indicators from among many indicators, and if the pair of indicators can cover the major part of scientific and technological activities. This being so, evaluation policy effects is possible but not necessarily precise. Science and technology indicators can thus be expected to make a significant contribution in the formulation of science and technology policy. It is thus important to make the effort to develop policy evaluation indicators by a steady accumulation of research which investigates cause and effect relationships.

Notes:

1. As an expert on science and technology indicators, Professor Fujio Niwa, Director in Research of the 2nd Policy-Oriented Research Group, NISTEP, submitted a draft for science and technology projection at the science and technology experts conference within the OECD's Directorate of Science and Technology and Industry (DSTI) (April 1990).
2. Professor Niwa also participated in the STEPAN conference, submitting several papers and cooperating in the preparation of indicators (Colombo conference in 1989 and the Wollongong conference in 1991).

STATISTICAL TABLES

Chapter 4 R&D Activities in Industry, Academia and Government

Chapter 5 Regional R&D Activities

Chapter 6 Achievements of R&D Activities

Chapter 7 Internationalization of R&D

Chapter 8 Science, Technology and Society

Table 2-1-1 Performance of Elementary and Junior High School Students in Mathematics : international comparison

	Elemetary	Junior high scool			
Positon	Arthmetic	Algebla	Geometry	Probability /Statistics	Measurement
1st	Japan (60.3)	Japan (60.3)	Japan (57.6)	Japan (70.9)	Japan (68.6)
2nd	Netherland (59.3)	France (55.0)	Hungary (53.4)	Netherland (65.9)	Hungary (62.1)
3rd	Belgium (58.0) Canada (58.0)	Belgium (52.9)	Netherland (52.0)	Canada (61.3)	Netherland (61.9)
World	(50.5)	(43.1)	(41.4)	(54.7)	(50.8)

Note: Number in parenthes indicate correct response scores(%)
Source: National Institute of Educational Research, "IEA International Mathematics and Science Education Survey, Midterm Report", 1988.

Table 2-1-2 Performance of Senior High School Students in Mathematics : international comparison

Position	Set·relations· functions	Numeric system	Algebla	Geometry	Analysis	Probability· Statistics
1st	Hong Kong (79.5)	Hong Kong (77.7)	Hong Kong (78.3)	Hong Kong (65.1)	Hong Kong (71.2)	Hong Kong (72.6)
2nd	Japan (78.6)	Japan (78.6)	Japan (77.8)	Japan (60.0)	Japan (66.1)	Japan (70.0)
3rd	Finland (77.1)	Sweden (62.1)	Finland (68.8)	U.K. (51.4)	U.K. (57.5)	Sweden (63.9)
World	(61.6)	(49.5)	(57.4)	(42.4)	(44.1)	(49.5)

Note: Number in parenthes indicate correct response scores (%).
Source: National Institute of Educational Research, "IEA International Mathematics and Science Education Survey, Midterm Report", 1988.

Table 2-1-3 Performance of Primary and Secondary School Students in Science : international comparison

Position	Elemetary	Junior high
1st	Japan (64.2) Korea (64.2)	Hungary (72.3)
2nd	Finland (63.8)	Japan (67.3)
3rd	Sweden (61.3)	Netherland (66.0)
Japan	1st (64.2)	2nd (67.3)

Position	Senior high school students				
	HSS* focus group	Science focus group			
	Required science	General science	Biology	Chemistry	Physics
1st	Hungary (63.0)	Hong Kong (83.7)	Singapore (66.8)	Hong Kong (77.0)	Hong Kong B (69.9)
2nd	U.K. (60.3)	U.K. (82.0)	U.K. (63.4)	U.K. (69.5)	Hong Kong A (59.3)
3rd	Japan (57.7)	Hungary (81.3)	Hungary (59.7)	Singapore (66.1)	U.K. (58.3)
Japan	3rd (57.7)	7th (75.7)	7th (46.2)	11th (51.9)	5th (56.1)

(*) Humanities and Social Sciences

Note: Number in parenthes indicate correct response scores (%)
Source: National Institute of Educational Research, "IEA International Mathematics and Science Education Survey, Midterm Report", 1988.

Table 2-1-4 Installation of computers for Pedagonic Purposes in primary and Secondary Schools

Category of schools	Number of schools	Number of schools installing computers	Percentage of schools installing computers	Number of computers installed	Avrage number of computers installed
Primary schools	24,658	5,172	21.0	15,505	3.0
Juniour high schools	10,585	4,740	44.8	20,519	4.3
Seniour high schools	4,189	4,035	96.3	103,014	25.5
Schools of special education	869	547	62.9	2,061	3.8
Schools for the blind	67	61	91.0	280	4.6
Schools for the deaf	105	100	95.2	649	6.5
Schools for the otherwise handicapped	697	386	55.4	1,132	2.9
Total	40,301	14,494	36.0	141,099	9.7

Source:Ministry of Education

Table 2-1-5 Number of Information Science Courses and Students in High Schools

Category of schools		1980	1985	1986	1987	1988	1989
Information technology related courses	Number of courses	32	44	60	65	83	95
	Number of students	4,021	5,806	7,438	9,724	11,940	13,910
Information processing related courses	Number of courses	93	109	134	169	208	242
	Number of students	16,652	20,254	23,354	29,355	36,448	45,267
Total	Number of courses	125	153	194	234	291	337
	Number of students	20,673	26,060	30,792	39,079	48,388	59,177

Source:Ministry of Education, "Report of Basic Survey on Schools", various editions.

Table 2-1-6 Number of Technical Courses and their Students in High Schools

Year	Number of courses	Percentage (%)	Number of students (10,000 persons)	Percentage (%)
1955	394	5.3	23.7	9.2
1960	644	7.3	32.4	10.0
1965	925	10.7	62.4	12.3
1970	923	10.5	56.6	13.4
1975	918	11.0	50.9	11.8
1980	852	10.1	47.5	10.3
1985	839	9.9	47.8	9.3
1989	839	9.9	48.9	8.7

Source:Ministry of Education, "Report of Basic Survey on Schools", various editions.

Table 2-2-1 Applications for Higher Education by Department

Category of department	1965	1966	1967	1968	1969	1970	1971
Department of Law	31,326	40,915	44,002	59,255	58,369	53,196	52,430
Department of Economics	43,721	56,932	57,560	79,969	75,066	69,550	68,942
Department of Management	7,485	14,201	15,153	22,265	24,367	22,248	23,399
Department of Commerce	25,580	35,760	34,234	43,057	39,854	34,410	32,136
Department of Natural Science	5,592	7,297	7,385	10,264	11,421	12,889	13,008
Department of Engineering	39,294	53,610	54,559	78,027	86,620	89,455	90,315
Department of Science & Engineering	11,920	15,985	18,310	25,941	26,149	28,903	30,500
Total	164,918	224,700	231,203	318,778	321,846	310,651	310,730

Category of department	1972	1973	1974	1975	1976	1977	1978
Department of Law	54,799	54,546	60,329	66,547	62,913	66,901	62,437
Department of Economics	69,970	71,806	78,654	90,794	91,390	97,586	98,621
Department of Management	21,897	27,190	28,985	31,124	34,194	35,575	33,626
Department of Commerce	32,351	35,068	39,563	44,062	44,697	46,568	45,291
Department of Natural Science	13,167	12,252	13,247	-13,554	14,298	14,290	13,815
Department of Engineering	87,413	86,516	87,880	81,777	79,633	81,558	80,554
Department of Science & Engineering	29,580	28,767	26,671	27,723	26,544	26,687	27,032
Total	309,177	316,145	335,329	355,581	353,669	369,165	361,376

Category of department	1979	1980	1981	1982	1983	1984	1985
Department of Law	67,343	65,606	66,218	63,750	63,517	64,392	57,366
Department of Economics	96,824	100,099	98,838	96,437	100,542	97,370	92,611
Department of Management	34,641	34,158	33,687	34,930	34,670	31,673	28,881
Department of Commerce	46,142	45,979	46,973	49,133	48,592	48,827	46,651
Department of Natural Science	12,205	12,617	12,222	13,021	14,029	14,716	14,958
Department of Engineering	72,952	70,683	70,905	78,029	92,265	101,303	107,596
Department of Science & Engineering	25,509	26,381	29,846	30,730	33,720	35,159	36,026
Total	355,616	355,523	358,689	366,030	387,335	393,440	384,089

Category of department	1986	1987	1988	1989	1990
Department of Law	61,174	65,863	67,008	73,908	82,863
Department of Economics	98,614	111,383	127,062	137,076	148,261
Department of Management	33,566	33,072	38,059	44,010	47,215
Department of Commerce	53,946	54,270	60,399	66,539	68,708
Department of Natural Science	15,108	17,357	15,400	14,668	15,340
Department of Engineering	124,805	133,065	122,520	117,896	114,747
Department of Science & Engineering	37,417	33,462	34,993	37,838	40,798
Total	424,630	448,472	465,441	491,935	517,932

Source:National Institute of Science and Technology Policy, "Choice of Fields of Study among University Applicants".
(NISTEP REPORT No.12), 1990.

Table 2-2-2 Number of Students in Colleges and Universities by category of department (1)

(Unit:Person)

	1968	1969	1970	1971	1972	1973	1974	1975
Total	1,211,068	1,295,771	1,344,358	1,404,186	1,459,548	1,523,074	1,585,674	1,652,003
Male	991,126	1,059,705	1,100,352	1,144,893	1,182,048	1,218,496	1,253,274	1,295,836
Female	219,942	236,066	244,006	259,293	277,500	304,578	332,400	356,167
Humanities	160,957	171,867	170,907	177,661	188,621	199,225	206,394	215,933
Male	75,921	82,595	81,484	83,475	86,551	87,685	85,613	86,988
Female	85,036	89,272	89,423	94,186	102,070	111,540	120,781	128,945
Social sciences	511,614	543,037	562,162	582,380	612,197	634,835	660,276	688,667
Male	487,444	515,841	533,021	550,371	575,979	592,548	611,551	635,224
Female	24,170	27,196	29,141	32,009	36,218	42,287	48,725	53,443
Natural sciences	38,414	39,957	42,071	43,061	43,549	46,527	49,532	50,225
Male	33,115	34,496	36,442	37,383	37,676	40,225	42,588	42,981
Female	5,299	5,461	5,629	5,678	5,873	6,302	6,944	7,244
Engineering	242,816	268,026	283,674	301,089	308,326	317,606	326,121	333,959
Male	241,546	266,437	281,862	298,962	306,146	315,210	323,432	331,060
Female	1,270	1,589	1,812	2,127	2,180	2,396	2,689	2,899
Agriculture	45,398	48,361	49,853	52,609	52,816	55,099	57,048	58,996
Male	43,185	45,747	46,907	49,244	49,036	50,736	52,128	53,745
Female	2,213	2,614	2,946	3,365	3,780	4,363	4,920	5,251
Health	46,418	49,658	52,279	55,303	57,435	60,488	64,946	92,523
Male	28,977	30,522	32,352	34,365	35,313	36,926	39,401	62,568
Female	17,441	19,136	19,927	20,938	22,122	23,562	25,545	29,955
Home economics	21,324	23,069	23,292	23,932	24,402	25,692	27,081	29,081
Male	68	81	100	108	124	141	132	121
Female	21,256	22,988	23,192	23,824	24,278	25,551	26,949	28,960
Education & teacher training	85,717	90,080	92,619	96,906	99,974	106,495	112,878	119,486
Male	43,331	45,057	45,629	46,260	45,849	46,613	47,152	49,626
Female	42,386	45,023	46,990	50,646	54,125	59,882	65,726	69,860
Arts	25,170	28,380	29,722	32,026	29,252	36,112	37,969	38,964
Male	9,414	11,202	12,304	13,596	14,626	15,496	16,204	16,319
Female	15,756	17,178	17,418	18,430	14,626	20,616	21,765	22,645
Others	33,240	33,336	37,779	39,219	42,976	40,995	43,429	24,169
Male	28,125	27,727	30,251	31,129	30,748	32,916	35,073	17,204
Female	5,115	5,609	7,528	8,090	12,228	8,079	8,356	6,965

Note:Others include department of marchant marine.
Source:Ministry of Education, "Report of Basic Survey on Schools", various editions.

Table 2-2-2 Number of Students in Colleges and Universities by category of department (2)

(Unit:Person)

	1976	1977	1978	1979	1980	1981	1982	1983
Total	1,702,235	1,747,057	1,769,331	1,754,343	1,741,504	1,725,814	1,716,956	1,729,632
Male	1,327,371	1,356,603	1,373,482	1,361,590	1,351,614	1,339,491	1,329,489	1,332,748
Female	374,864	390,454	395,849	392,753	389,890	386,323	387,467	396,884
Humanities	223,462	230,923	235,720	239,359	239,990	239,624	239,486	243,684
Male	88,347	90,891	93,776	98,036	99,974	101,170	101,489	102,146
Female	135,115	140,032	141,944	141,323	140,016	138,454	137,997	141,538
Social sciences	707,314	723,996	729,506	716,171	704,737	692,268	681,046	680,141
Male	650,687	664,445	669,598	657,584	647,251	635,970	625,012	622,630
Female	56,627	59,551	59,908	58,587	57,486	56,298	56,034	57,511
Natural sciences	51,543	53,005	54,525	54,578	54,579	55,033	55,188	57,597
Male	43,980	44,965	46,124	46,079	45,900	46,189	45,914	47,588
Female	7,563	8,040	8,401	8,499	8,679	8,844	9,274	10,009
Engineering	339,713	345,680	347,988	341,790	337,767	334,009	333,387	338,990
Male	336,610	342,130	343,959	337,301	332,602	328,153	326,689	331,161
Female	3,103	3,550	4,029	4,489	5,165	5,856	6,698	7,829
Agriculture	59,922	60,431	60,146	59,569	59,558	59,149	59,072	59,562
Male	54,378	54,586	54,075	53,216	52,699	51,926	51,387	51,348
Female	5,544	5,845	6,071	6,353	6,859	7,223	7,685	8,214
Health	98,253	103,380	107,545	109,748	112,058	113,100	114,457	115,861
Male	66,634	70,225	73,476	75,327	77,257	78,038	78,778	79,021
Female	31,619	33,155	34,069	34,421	34,801	35,062	35,679	36,840
Home economics	30,488	31,308	31,996	31,851	31,930	31,667	31,453	31,844
Male	127	146	164	191	215	249	256	274
Female	30,361	31,162	31,832	31,660	31,715	31,418	31,197	31,570
Education & teacher training	126,259	131,189	133,298	133,931	133,211	133,583	133,724	133,710
Male	52,605	55,192	58,123	60,672	62,592	64,309	65,126	64,893
Female	73,654	75,997	75,175	73,259	70,619	69,274	68,598	68,817
Arts	40,588	42,706	43,798	44,146	44,158	44,111	44,183	44,658
Male	16,503	16,631	16,606	16,530	16,427	16,354	16,395	16,362
Female	24,085	26,075	27,192	27,616	27,731	27,757	27,788	28,296
Others	24,693	24,439	24,809	23,200	23,516	23,270	24,960	23,585
Male	17,500	17,392	17,581	16,654	16,697	17,133	18,443	17,325
Female	7,193	7,047	7,228	6,546	6,819	6,137	6,517	6,260

Note:Others include department of marchant marine.
Source:Ministry of Education, "Report of Basic Survey on Schools", various editions.

Table 2-2-2 Number of Students in Colleges and Universities by category of department (3)

(Unit:Person)

	1984	1985	1986	1987	1988	1989
Total	1,734,080	1,734,392	1,758,635	1,806,024	1,861,306	1,929,137
Male	1,328,157	1,320,008	1,327,798	1,352,536	1,378,462	1,410,854
Female	405,923	414,384	430,837	453,488	482,844	518,283
Humanities	245,489	246,850	253,010	262,287	274,098	290,387
Male	101,697	100,117	99,707	99,545	99,043	101,997
Female	143,792	146,733	153,303	162,742	175,055	188,390
Social sciences	675,501	671,001	678,842	700,750	728,380	759,636
Male	615,550	608,561	611,727	626,176	642,933	660,659
Female	59,951	62,440	67,115	74,574	85,447	98,977
Natural sciences	58,446	59,678	60,306	61,076	61,932	63,997
Male	47,959	48,890	49,420	50,137	50,744	52,302
Female	10,487	10,788	10,886	10,939	11,188	11,695
Engineering	342,456	343,590	349,579	358,490	368,207	378,405
Male	333,717	334,215	339,514	347,942	356,738	365,565
Female	8,739	9,375	10,065	10,548	11,469	12,840
Agriculture	59,777	60,068	60,792	61,417	62,649	64,975
Male	51,183	51,240	51,664	51,882	52,023	52,730
Female	8,594	8,828	9,128	9,535	10,626	12,245
Health	117,071	117,809	118,456	118,948	118,438	117,712
Male	78,901	78,430	77,717	76,801	75,423	73,846
Female	38,170	39,379	40,739	42,147	43,015	43,866
Home economics	31,948	32,185	32,893	33,749	34,552	35,794
Male	260	247	255	313	395	455
Female	31,688	31,938	32,638	33,436	34,157	35,339
Education & teacher training	134,711	135,227	136,493	138,014	138,959	139,565
Male	65,328	65,217	64,997	64,946	64,443	64,462
Female	69,383	70,010	71,496	73,068	74,516	75,103
Arts	45,133	44,890	45,198	45,529	45,813	47,005
Male	16,305	16,195	16,244	16,365	16,315	16,437
Female	28,828	28,695	28,954	29,164	29,498	30,568
Others	23,548	23,094	23,066	25,764	28,278	31,661
Male	17,257	16,896	16,553	18,429	20,405	22,401
Female	6,291	6,198	6,513	7,335	7,873	9,260

Note:Others include department of marchant marine.
Source:Ministry of Education, "Report of Basic Survey on Schools", various editions.

Table 2-2-3 Expenditures for Education and Research in National and Public Colleges and Universities by Department

(1) Nominal (Unit:100 Million Yen)

Fiscal Year	1970	1975	1980	1985	1987
Science & engineering departments	2,331	1,466	2,074	2,362	2,705
Other natural science related department	-	1,186	1,591	1,960	2,796
Other departments	-	1,140	2,630	3,202	2,964
Head offices, farms, libraries, etc.	-	958	1,608	1,747	2,123
Research institute attached to univ.	215	462	765	698	822
Hospitals attached to univ.	774	1,861	3,751	5,161	5,535
Technical colleges	137	344	533	582	670
Total	3,457	7,417	12,952	15,712	17,615

Note : Expenditures for education and research for Science & Engineering departments of 1970 include totals of other natural science related departments.
Source : Ministry of Education, "Report of Basic Survey on Schools", various editions.

(2) Real (Unit:100 Million Yen of 1980 base year)

Fiscal Year	1970	1975	1980	1985	1987
Science & engineering departments	4,777	1,839	2,047	2,161	2,448
Other natural science related department	-	1,488	1,571	1,793	2,530
Other departments	-	1,430	2,596	2,930	2,682
Head offices, farms, libraries, etc.	-	1,202	1,587	1,598	1,921
Research institute attached to univ.	441	580	755	639	744
Hospitals attached to univ.	1,536	2,335	3,694	4,722	5,009
Technical colleges	281	432	526	532	606
Total	7,035	9,306	12,776	14,375	15,940

Note : Expenditures for education and research for Science & Engineering departments of 1970 include totals of other natural science related departments.
Real expenditures are calculted by using the GDP deflater from "Annual Report on National Accounts" (Economic Planning Agency).

(3) Shares (%)

Fiscal Year	1970	1975	1980	1985	1987
Science & engineering departments	67.4	19.8	16.0	15.0	15.4
Other natural science related department	-	16.0	12.3	12.5	15.9
Other departments	-	15.4	20.3	20.4	16.8
Head offices, farms, libraries, etc.	-	12.9	12.4	11.1	12.1
Research institute attached to univ.	6.2	6.2	5.9	4.4	4.7
Hospitals attached to univ.	22.4	25.1	29.0	32.8	31.4
Technical colleges	4.0	4.6	4.1	3.7	3.8
Total	100.0	100.0	100.0	100.0	100.0

Note : Expenditures for education and research for Science & Engineering departments of 1970 include totals of other natural science related departments.

Table 2-2-4 Expenditures for Education and Research in Private Colleges and Universities by Department

(1) Nominal (Unit:100 Million Yen)

Fiscal Year	1970	1975	1980	1985	1987
Science & engineering departments	509	1,121	2,121	3,001	3,369
Other natural science related departments	535	1,256	2,377	3,458	3,766
Other departments	1,009	2,721	5,079	7,101	8,840
Head offices, farms, libraries, etc.	-	53	98	69	149
Research institute attached to univ.	408	1,876	3,868	5,948	6,241
Hospitals attached to univ.	473	175	359	247	334
Technical colleges	14	20	22	30	28
Total	2,948	7,222	13,924	19,854	22,727

Note:Classificatory criterion for fiscal year 1970 is deferent from those for after fiscal year 1975. For example, expenditures for research institutes attached to universities are include for head-office, etc.
Source:Ministry of Education, "Report of Basic Survey on Scholls".

(2) Real (Unit:100 Million Yen of 1980 base year)

Fiscal Year	1970	1975	1980	1985	1987
Science & engineering departments	1,048	1,406	2,094	2,746	3,049
Other natural science related departments	1,096	1,571	2,346	3,164	3,048
Other departments	2,051	3,414	5,014	6,497	8,000
Head offices, farms, libraries, etc.	-	66	97	63	135
Research institute attached to univ.	836	2,345	3,818	5,442	5,648
Hospitals attached to univ.	969	220	354	226	300
Technical colleges	29	25	22	27	25
Total	6,029	9,047	13,745	18,165	20,205

Note:Classificatory criterion for fiscal year 1970 is deferent from those for after fiscal year 1975. For example, expenditures for research institutes attached to universities are include for head-office, etc.
Real expenditures are calculted by using the GDP deflater from "Annual Report on National Accounts"(Economic Planning Agency).

(3) Shares (%)

Fiscal Year	1970	1975	1980	1985	1987
Science & engineering departments	17.3	15.5	15.2	15.1	14.8
Other natural science related departments	18.1	17.4	17.1	17.4	16.6
Other departments	34.2	37.7	36.5	35.8	38.9
Head offices, farms, libraries, etc.	-	0.7	0.7	0.3	0.7
Research institute attached to univ.	13.8	26.0	27.8	30.0	27.5
Hospitals attached to univ.	16.0	2.4	2.6	1.2	1.5
Technical colleges	0.5	0.3	0.2	0.2	0.1
Total	100.0	100.0	100.0	100.0	100.0

Note:Classificatory criterion for fiscal year 1970 is deferent from those for after fiscal year 1975. For example, expenditures for research institutes attached to universities are include for head-office, etc.

Table 2-3-1 Employment of Science and Engineering Graduates by Industrial Sector

(Percentage)

Industrial	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Manufacturing	64.40	65.02	65.64	66.26	66.88	67.50	63.96	60.42	56.88	53.34
Financial & Insurance	0.60	0.62	0.64	0.66	0.68	0.70	0.88	1.06	1.24	1.42
Services	0.80	0.88	0.96	1.04	1.12	1.20	2.08	2.96	3.84	4.72

Industrial	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Manufacturing	49.80	49.90	51.20	49.50	43.20	48.20	52.90	55.30	55.30	54.10
Financial & Insurance	1.60	1.60	1.60	1.30	1.10	0.90	0.60	0.50	0.60	0.80
Services	5.60	5.00	5.90	6.00	7.30	7.20	7.90	8.40	9.10	12.10

Industrial	1985	1986	1987	1988	1989	1990
Manufacturing	57.10	57.10	56.00	50.50	52.30	54.61
Financial & Insurance	0.90	0.90	1.20	2.20	2.10	2.78
Services	11.50	13.00	14.20	15.80	14.50	15.82

Source:National Institute of Science and Technology Policy, "Employment Trends of Science and Engineering Students (NISTEP Report No.1), 1989.

Table 2-3-2 Number of Students in Graduate Courses

(1) Master's degree courses (Unit:Person)

Category of department	1977	1978	1979	1980	1981	1982	1983	1984
Humanities	5,733	5,542	5,461	5,469	5,513	5,542	5,651	5,605
Social science	4,638	4,565	4,565	4,050	3,865	3,959	4,105	4,228
Natural science	3,627	3,633	3,630	3,741	3,853	4,040	4,223	4,361
Engineering	15,846	15,354	14,433	14,864	15,581	16,600	17,521	18,868
Agriculture	2,994	2,802	2,682	2,546	2,662	3,558	4,516	4,801
Health	1,152	1,166	1,325	1,497	1,596	1,706	1,807	1,943
Other	2,881	3,102	3,256	3,614	4,143	4,476	4,702	5,299
Total	36,871	36,164	35,352	35,781	37,213	39,881	42,525	45,105

Category of department	1985	1986	1987	1988	1989
Humanities	5,645	5,787	5,896	5,923	5,926
Social science	4,373	4,643	4,988	5,370	5,749
Natural science	4,598	4,982	5,388	5,815	6,185
Engineering	20,668	22,220	23,862	25,528	26,777
Agriculture	4,893	5,031	5,472	4,763	3,849
Health	2,053	2,144	2,272	2,410	2,563
Other	5,917	6,287	6,474	6,787	7,179
Total	48,147	51,094	54,352	56,596	58,228

(2) Doctorate cources (Unit:Person)

Category of department	1977	1978	1979	1980	1981	1982	1983	1984
Humanities	2,673	2,704	2,793	2,860	2,926	2,937	3,086	3,157
Social science	2,286	2,358	2,456	2,430	2,384	2,376	2,385	2,453
Natural science	2,624	2,695	2,672	2,589	2,471	2,403	2,366	2,485
Engineering	2,606	2,598	2,515	2,358	2,218	2,151	2,165	2,223
Agriculture	1,070	1,076	1,104	1,095	1,050	1,030	1,013	1,033
Health	4,508	5,021	5,673	6,191	6,630	7,104	7,690	8,442
Other	613	651	679	688	711	760	770	794
Total	16,380	17,103	17,892	18,211	18,390	18,761	19,475	20,587

Category of department	1985	1986	1987	1988	1989
Humanities	3,227	3,361	3,297	3,359	3,459
Social science	2,437	2,476	2,533	2,531	2,582
Natural science	2,472	2,524	2,678	2,829	2,962
Engineering	2,403	2,820	3,196	3,639	3,859
Agriculture	1,096	1,225	1,318	1,475	1,554
Health	9,062	9,904	10,581	11,044	11,523
Other	844	867	959	1,003	1,096
Total	21,541	23,177	24,562	25,880	27,035

Source:Ministry of Education, "Report of Basic Survey on Schools", various editions.

Table 2-3-3 Number of Master's Degrees Conferred

Fiscal Year	1971	1972	1973	1974	1975	1976	1977	1978
Interdisciplinaty Studies	-	-	-	-	-	-	10	86
Arts, Humanities & Social science	3,502	3,706	4,077	4,039	3,917	4,046	3,971	3,992
Natural science	1,419	1,481	1,532	1,427	1,482	1,663	1,630	1,676
Medicine	-	-	-	-	-	-	-	-
Dentistry	-	-	-	-	-	-	-	-
Pharmacolgy and other health	435	445	457	457	446	474	479	523
Engineering	4,927	5,401	6,084	6,024	5,821	6,925	7,655	7,581
Agriculture	821	976	1,053	974	988	1,147	1,199	1,064
Others	501	550	624	660	768	807	838	931
Total	11,605	12,562	13,827	13,581	13,422	15,062	15,782	15,853

Fiscal Year	1979	1980	1981	1982	1983	1984	1985	1986
Interdisciplinaty Studies	130	180	174	191	187	206	233	271
Arts, Humanities & Social science	3,928	4,003	4,164	4,333	4,574	4,759	5,121	5,336
Natural science	1,667	1,710	1,896	1,916	2,006	2,082	2,133	2,261
Medicine	-	39	39	39	42	39	41	43
Dentistry	-	-	-	-	-	-	-	-
Pharmacolgy and other health	529	612	633	703	748	809	865	899
Engineering	7,101	6,949	7,349	7,708	8,262	8,588	9,586	10,361
Agriculture	1,043	955	954	1,074	1,189	1,305	1,383	1,379
Others	911	948	992	1,020	1,694	1,717	1,908	1,804
Total	15,309	15,396	16,201	16,984	18,702	19,505	21,270	22,354

Sources:Hiroshima University - University Education Center, "Compilation of Higher Education Statistical Data", 1989.

Table 2-3-4 Number of Doctorate Degrees Conferred

(1) Total number of doctorate degrees conferred

Fiscal Year	1971	1972	1973	1974	1975	1976	1977	1978
Interdisciplinary Studies	-	-	-	-	-	-	-	3
Arts, Humanities & Social science	153	171	134	162	174	212	185	152
Natural science	651	685	657	651	676	717	843	782
Medicine	1,922	1,786	1,549	1,729	1,837	2,023	2,154	2,496
Dentistry	318	301	286	319	324	370	359	367
Pharmacolgy and other health	162	147	196	211	210	247	220	240
Engineering	845	853	930	1,000	986	1,079	1,043	1,166
Agriculture	318	374	347	417	346	424	450	386
Others	38	35	49	40	39	66	68	56
Total	4,407	4,352	4,148	4,529	4,592	5,138	5,322	5,648

Fiscal Year	1979	1980	1981	1982	1983	1984	1985	1986
Interdisciplinary Studies	6	10	18	41	52	49	54	81
Arts, Humanities & Social science	167	187	172	197	208	214	236	260
Natural science	814	822	791	762	774	807	860	820
Medicine	2,557	2,796	3,038	3,128	3,577	3,584	3,781	4,215
Dentistry	419	492	536	565	531	550	593	688
Pharmacolgy and other health	224	249	279	315	286	368	353	330
Engineering	1,195	1,186	1,236	1,278	1,290	1,291	1,404	1,493
Agriculture	367	463	471	455	462	547	620	564
Others	63	64	58	69	53	67	77	82
Total	5,812	6,269	6,599	6,810	7,233	7,477	7,978	8,533

(2) Number of disseration doctorate degrees conferred

Fiscal Year	1971	1972	1973	1974	1975	1976	1977	1978
Interdisciplinary Studies	-	-	-	-	-	-	-	1
Arts, Humanities & Social science	127	137	108	132	136	167	149	120
Natural science	303	341	308	306	322	329	402	357
Medicine	1,126	1,150	1,125	1,304	1,389	1,540	1,695	1,944
Dentistry	195	170	181	210	184	220	200	222
Pharmacolgy and other health	86	95	113	111	127	149	128	126
Engineering	417	472	494	521	530	589	558	643
Agriculture	223	239	214	285	222	276	276	223
Others	27	28	30	26	27	54	55	38
Total	2,504	2,632	2,573	2,895	2,937	3,324	3,463	3,674

Fiscal Year	1979	1980	1981	1982	1983	1984	1985	1986
Interdisciplinary Studies	2	4	4	11	20	12	18	28
Arts, Humanities & Social science	133	147	128	147	161	167	185	203
Natural science	345	365	358	333	377	348	363	341
Medicine	1,922	2,054	2,188	2,170	2,491	2,417	2,463	2,713
Dentistry	222	276	311	323	279	313	335	358
Pharmacolgy and other health	119	136	153	184	180	230	226	202
Engineering	650	663	695	772	801	844	924	988
Agriculture	222	285	295	309	291	373	406	392
Others	43	49	43	45	32	48	54	56
Total	3,658	3,979	4,175	4,294	4,632	4,752	4,974	5,281

Sources:Hiroshima University - University Education Center, "Compilation of Higher Education Statistical Data", 1989.

Table 3-1-1 Trends of Budget for Science and Technology in Japan

	Nomianl (Million Yen)	Real (Million Yen)	GNP deflater
1971	295,290	651,854	45.3
1972	360,865	744,052	48.5
1973	441,853	789,023	56.0
1974	541,084	816,115	66.3
1975	677,321	963,472	70.3
1976	771,960	1,015,737	76.0
1977	870,604	1,080,154	80.6
1978	990,489	1,176,353	84.2
1979	1,153,259	1,337,887	86.2
1980	1,294,893	1,424,525	90.9
1981	1,403,148	1,500,693	93.5
1982	1,453,578	1,533,310	94.8
1983	1,461,859	1,518,026	96.3
1984	1,483,839	1,506,436	98.5
1985	1,532,869	1,532,869	100.0
1986	1,606,386	1,582,646	101.5
1987	1,662,336	1,637,769	101.5
1988	1,715,745	1,683,754	101.9
1989	1,815,196	1,742,031	104.2
1990	1,919,603		

Source:Science and Technology Agency

Table 3-1-2 Budget for Science and Technology in Japan by Item

(Unit:Million Yen)

	Government reseach institute	National universities	Public R&D coorperations	Administrative expenditures	Total
1985	221351	534251	755470	21795	1532867
1986	234655	563039	785597	23095	1606386
1987	245929	594243	798293	23871	1662336
1988	256189	621781	812952	24822	1715744
1989	275452	657517	856691	25956	1815616
1990	292719	689721	907023	30140	1919603

(Percentage)

	Government reseach institute	National universities	Public R&D coorperations	Administrative expenditures	Total
1985	14	35	49	1	100
1986	15	35	49	1	100
1987	15	36	48	1	100
1988	15	36	47	1	100
1989	15	36	47	1	100
1990	15	36	47	2	100

Source:Science and Technology Agency

Table 3-1-3 Budget for Science and Technology by Agency

(Unit:Million Yen)

Ministries and Agencies	1986	1987	1988	1989	1990
M. of Education	745,591	780,174	812,954	854,322	894,301
Science & Technology A.	427,754	432,525	440,193	466,623	494,775
MITI	217,557	221,409	221,226	233,649	249,832
Defence Agency	66,133	74,135	82,700	93,068	104,268
M. of Agri., F.& F.(*)	66,477	66,748	66,642	68,037	70,007
M. of Health & Welfare	36,121	39,761	44,059	48,371	51,242
M. of Posts & Telecom.	24,672	29,046	30,282	30,864	31,199
M. of Transport.	13,271	14,516	14,627	16,303	17,410
Environment Agency	8,320	7,914	7,752	7,882	9,217
M. of Foreign Affairs	6,594	6,298	6,417	6,408	7,095
M. of Construction	5,817	5,506	5,459	5,689	5,979
M. of Labour	2,970	3,635	3,708	4,557	4,190
M. of Finance	938	1,009	978	1,087	1,087
National Police Agency	899	925	972	1,020	1,055
Science Council	863	856	903	867	951
Ministry of Justice	808	806	849	871	939
Economic Planning A.	704	710	716	764	809
M. of Home Affairs	527	536	543	555	565
Diet	517	525	517	533	533
Hokkaido Develop. A.	142	143	143	147	149
National Land A.	210	160	105		
Total	1,606,386	1,662,336	1,715,746	1,815,616	1,919,603

(Percentage)

Ministries and Agencies	1986	1987	1988	1989	1990
M. of Education	46.41	46.93	47.38	47.05	46.59
Science & Technology A.	26.63	26.02	25.66	25.70	25.77
MITI	13.54	13.32	12.89	12.87	13.01
Defence Agency	4.12	4.46	4.82	5.13	5.43
M. of Agri., F.& F.(*)	4.14	4.02	3.88	3.75	3.65
M. of Health & Welfare	2.25	2.39	2.57	2.66	2.67
M. of Posts & Telecom.	1.54	1.75	1.76	1.70	1.63
M. of Transport.	0.83	0.87	0.85	0.90	0.91
Environment Agency	0.52	0.48	0.45	0.43	0.48
M. of Foreign Affairs	0.41	0.38	0.37	0.35	0.37
M. of Construction	0.36	0.33	0.32	0.31	0.31
M. of Labour	0.18	0.22	0.22	0.25	0.22
M. of Finance	0.06	0.06	0.06	0.06	0.06
National Police Agency	0.06	0.06	0.06	0.06	0.05
Science Council	0.05	0.05	0.05	0.05	0.05
Ministry of Justice	0.05	0.05	0.05	0.05	0.05
Economic Planning A.	0.04	0.04	0.04	0.04	0.04
M. of Home Affairs	0.03	0.03	0.03	0.03	0.03
Diet	0.03	0.03	0.03	0.03	0.03
Hokkaido Develop. A.	0.01	0.01	0.01	0.01	0.01
National Land A.	0.01	0.01	0.01		
Total	100	100	100	100	100

(*): Ministry of Agriculture, Forestry & Fisheries

Source: Science and Technology Agency

Table 3-1-4 Budget for Science and Technology in Japan by Socio-Economic Objectives

(Unit:Million Yen)

Socio-economic objective	1985	1986	1987	1988	1989	1990	1991
Agri., Forest. & Fish.	61,564	66,687	66,908	66,747	68,037	70,007	73,557
Industrial Development	75,021	77,835	79,320	82,497	85,839	84,908	88,256
Energy.	375,509	393,121	390,748	383,349	400,656	430,610	440,808
Transport & Telecom.	14,989	20,419	22,739	23,709	25,268	27,050	36,560
Urban & Rural Planning	5,841	6,486	6,185	6,145	6,391	6,693	7,388
Environment Protection	8,524	8,320	7,914	7,752	7,831	9,099	10,745
Health.	33,759	36,121	39,761	44,059	48,371	38,831	56,144
Social Dev. & Services	15,322	16,089	16,896	17,224	18,582	18,911	20,822
Earth and Atmosphere.	15,335	15,569	16,372	17,556	18,791	20,714	20,050
Advancement of Knowledge	113,384	113,983	120,139	130,191	141,162	150,703	160,500
Colleges & Universities	657,901	687,846	720,415	749,197	785,883	819,628	859,747
Civil Space.	97,043	97,778	100,805	104,619	115,737	125,770	138,176
Defence.	58,677	66,133	74,135	82,700	93,068	104,268	115,045

Source: Science and Technology Agency

Table 3-1-5 Component Ratio of Budget for Science and Technology by Socio-Economic Objectives in Selected Countries (1985)

(Percentage)

Socio-economic objective	Japan	U.S.	W.Germany	U.K.	France
Agri., Forest. & Fish.	4.0	2.3	2.0	4.2	3.6
Industrial Development	4.8	0.2	15.3	8.7	10.6
Energy.	23.2	3.6	6.7	3.5	6.7
Social Capital	1.8	1.8	1.9	1.5	3.2
Environment Protection	0.5	0.5	3.3	1.0	0.4
Health.	2.4	11.9	3.2	4.3	3.6
Social Dev. & Services	1.0	1.0	2.3	1.5	2.7
Earth and Atmosphere.	1.0	0.7	1.9	1.7	1.4
Advancement of Knowledge	50.8	3.6	43.8	20.2	26.6
Civil Space.	6.1	6.0	4.9	2.7	5.9
Defence.	4.5	68.6	12.5	50.3	34.1
Others	0.0	0.0	0.1	0.3	1.0

Source: OECD, "OECD Science and Technology Indicators No.3," 1989.

Table 3-2-1 Activity of Science and Technology Related Support Foundation

			1986	1987	1988
Number of support foundations			171	199	253
Number of programs					
	By field	Natural science & Agriculture	66	147	172
		Engineering	76	179	219
		Medicine	68	162	192
		Humanities	43	91	116
		Social science	46	111	140
		Environment	24	44	56
		Education	44	74	106
		Welfare	29	54	80
		Others	18	34	52
		All fields	171	482	642
	By execution from	R&D Subsidizing	126	188	250
		Subsidizing for sending researcher to abroad	50	67	82
		Subsidizing for inviting foreign researcher	21	32	41
		Subsidizing for conference	36	44	63
		Subsidizing for pubbishing	19	28	34
		Subsidizing for equipment	21	33	39
		Other subsidizings	43	60	85
		foreign direct subsidizing	39	56	14
		Scholarship for Japanes researcher	32	37	62
		Scholarship for foreigner researcher	23	23	49
		Awarding	9	9	64
		All fields	171	482	642
	R&D subsidizing activities by execution from	Natural science & Agriculture	45	55	72
		Engineering	55	73	95
		Medicine	51	72	92
		Humanities	28	35	46
		Social science	27	40	54
		Environment	15	18	25
		Education	23	27	38
		Welfare	17	17	25
		Others	6	10	13
		All fields	126	188	250
Operating expenses					
Total (Million Yen)			9748	11462	16867
R&D subsidizing expenses (Million Yen)				5467	7271
(Reference) Budget for Grant-in-Aid for scientific Research of Ministry of Education (100 Million Yen)			421.8	437.1	473.2

Source:Support foundation reference center

Table 3-2-2 Public Trust Providing Support for Research

Project field		Scientific research	Medical research and education	International cooperation	Protection of enviroment
Trust	FY 1986	11	23	33	11
(Number)	FY 1988	1.9	33	39	15
Trust fund	FY 1986	560.5	1,743.5	1,629.9	1,779.2
(Million Yen)	FY 1988	1,173.1	2,353.8	2,173.7	2,355.0
Recipient	FY 1986	29	103	178	69
(Number of	FY 1987	44	183	264	76
person)	FY 1988	84	164	280	88
Providing	FY 1986	13.5	60.5	72.0	19.1
(Million Yen)	FY 1987	20.9	86.3	129.2	45.8
	FY 1988	30.5	88.3	137.7	64.8

Project field		Scholarship	Promotion of school education	Others	Total
Trust	FY 1986	64	9	54	205
(Number)	FY 1988	74	13	64	257
Trust fund	FY 1986	2,970.1	179.0	1,253.6	10,115.8
(Million Yen)	FY 1988	3,406.6	314.3	1,693.7	13,470.2
Recipient	FY 1986	965	138	559	2,041
(Number of	FY 1987	1,014	107	532	2,220
person)	FY 1988	1,064	106	585	2,371
Providing	FY 1986	119.5	9.0	57.5	186.0
(Million Yen)	FY 1987	131.0	8.7	50.4	190.1
	FY 1988	139.1	10.4	51.0	200.5

Source:Support foundation reference center

Table 3-2-3 Number of Learned Societies

Subject	1966	1970	1975	1980	1986
Humanities	382	302	209	271	357
Law & Politics	68	55	39	46	50
Economics	102	91	36	46	71
Natural science	81	75	91	137	151
Engineering	135	129	148	164	143
Agriculture	40	36	56	67	122
Medicine	232	210	206	272	342
Total	1040	898	785	1003	1236

Source:The Science Council of Japan, "Directory of The Scientific Research Organizatio in Japan".

Table 3-2-4 Number of Personal Members of Learned Societies

Subject	1966	1970	1975	1980	1986
Humanities	56465	192296	152923	190206	250270
Law & Politics	7455	87831	17109	21274	24680
Economics	11606	173861	18436	36764	45627
Natural science	82796	44380	133542	168973	222525
Engineering	319497	435088	523203	531841	515457
Agriculture	40546	53732	86828	87723	165558
Medicine	259569	401406	407796	1022113	871735
Total	777934	1388594	1339837	2058894	2095852

Source:The Science Council of Japan, "Directory of The Scientific Research Organizatio in Japan".

Table 3-2-5 Number of Personal Members per Learned Society

Subject	1966	1970	1975	1980	1986
Humanities	148	637	732	702	701
Law & Politics	110	1597	439	462	494
Economics	114	1911	512	799	643
Natural science	1022	592	1467	1233	1474
Engineering	2367	3373	3535	3243	3605
Agriculture	1014	1493	1551	1309	1357
Medicine	1119	1911	1980	3758	2549
Total	748	1546	1707	2053	1696

Source:The Science Council of Japan, "Directory of The Scientific Research Organizatio in Japan".

Table 3-2-6 Number of Learned Societies by Founder's Year

	~1900	1910	1930	1940	1946	1950	1955
Agriculture	1	1	7	1	0	2	5
Medicine	13	3	9	6	1	4	4
Natural science	7	1	6	3	2	4	3
Engineering	7	0	4	5	2	8	1
Total	34	8	37	22	10	45	23

	1960	1965	1970	1975	1980	1985	1987
Agriculture	2	5	1	3	1	3	1
Medicine	14	9	4	9	13	7	0
Natural science	4	2	2	7	3	3	0
Engineering	1	3	2	3	2	3	1
Total	34	30	19	35	25	25	2

Source:The Science Council of Japan, "Directory of The Scientific Research Organizatio in Japan".

Table 4-1-1(A) Trends of R&D Expenditures in Selected Countries

	Japan Million Yen	U.S. Million Doller	W.Germany Million Mark	France Million Franc	U.K. Million Pound
1970	1355505	26134	15910.0	14955	776.7
1971	1532372	26676	17210.0	16621	1065.6
1972	1791871	28477	18510.0	18277	1354.6
1973	2215836	30718	19810.0	19789	1643.6
1974	2716032	32864	21760.0	23031	1932.5
1975	2974573	35213	23710.0	29203	2221.5
1976	3320685	39018	25275.0	29774	2688.4
1977	3651319	42783	26840.0	33185	3155.4
1978	4045864	48129	30099.0	37671	3622.3
1979	4583630	54933	33358.0	44123	4388.6
1980	5246248	62594	35818.0	51014	5154.8
1981	5982356	71866	38278.0	62471	5921.1
1982	6528700	79364	40494.5	74836	6252.1
1983	7180782	87280	42711.0	84671	6583.0
1984	7893931	97793	46790.5	96198	7251.1
1985	8890299	107757	50870.0	105917	7919.1
1986	9192932	112497	54319.0	113260	8777.9
1987	9836640	118782	57768.0	121364	9452.3
1988	10627572	126115	61294.0	130500	
1989	11815482	132350	64820.0	141000	

Sources:Science and Tehnology Agency,"White Paper on Science and Tehnology",Statistic Bureau, Management and Coordination Agency,Japan, "Report on the Survey of Research and Development".

Note:

(1) For international comparison, Humanities and Social Sciences are included in R&D Expenditures for Japan.

Table 4-1-1(B) Trends in Purchasing Power Parities

	U.S. Yen/Doller	W.Germany Yen/Mark	France Yen/Franc	U.K. Yen/Pound
1970	256	78	54	892
1971	257	76	53	860
1972	259	76	53	835
1973	274	81	55	884
1974	304	91	59	930
1975	298	93	56	788
1976	300	96	54	733
1977	298	98	53	682
1978	291	98	50	642
1979	275	97	47	578
1980	262	96	44	502
1981	247	96	41	465
1982	236	93	37	439
1983	230	91	34	418
1984	225	90	32	409
1985	222	90	31	389
1986	220	89	30	386
1987	213	86	29	368
1988	207	86	28	345
1989	200	85	28	328

Sources : OECD, "Main Economic Indicators, " 1989.
OECD, "International Sectoral Databank," 1991.

Table 4-1-1(C) Trends of R&D Expenditures in Selected Countries

(Unit:Trillion Yen)

	Japan	U.S.	W.Germany	France	U.K.
1970	1.36	6.69	1.24	0.80	0.69
1971	1.53	6.86	1.31	0.89	0.92
1972	1.79	7.38	1.41	0.96	1.13
1973	2.22	8.42	1.60	1.08	1.45
1974	2.72	9.99	1.98	1.36	1.80
1975	2.97	10.49	2.19	1.64	1.75
1976	3.32	11.71	2.41	1.61	1.97
1977	3.65	12.75	2.62	1.75	2.15
1978	4.05	14.01	2.96	1.89	2.33
1979	4.58	15.11	3.24	2.06	2.54
1980	5.25	16.40	3.45	2.23	2.59
1981	5.98	17.75	3.66	2.53	2.75
1982	6.53	18.73	3.78	2.76	2.74
1983	7.18	20.07	3.88	2.86	2.75
1984	7.89	22.00	4.23	3.07	2.97
1985	8.89	23.92	4.55	3.23	3.08
1986	9.19	24.75	4.81	3.35	3.39
1987	9.84	25.30	4.99	3.48	3.48
1988	10.63	26.11	5.25	3.64	
1989	11.82	26.47	5.50	3.88	

Source:Science and Technology Agency, "White Paper on Science and Technology".

Note:

(1) Each country currency is converted to Yen using Purchasing Power Parities (PPP).

Table 4-1-2(A) Trends in Gross National Product for Selected Countries

	Japan 100 Million Yen	U.S. 100 Million Doller	W.Germany 100 Million Mark	France 100 Million Franc	U.K. 100 Million Pound
1970	751520	10155	6757	7978	521.9
1971	828063	11027	7518	8916	585.0
1972	965391	12128	8251	9946	647.3
1973	1166792	13593	9189	11369	752.5
1974	1381558	14728	9857	13091	856.8
1975	1522094	15984	10294	14708	1072.4
1976	1711525	17828	11262	17060	1282.7
1977	1900348	19905	11993	19244	1461.9
1978	2087809	22497	12916	21895	1692.4
1979	2254526	25082	13965	24910	1983.4
1980	2451627	27320	14852	28261	2310.1
1981	2596688	30526	15451	31806	2560.4
1982	2723829	31660	15971	36252	2790.5
1983	2740583	34057	16805	39948	3071.8
1984	3030160	37745	17699	43384	3286.2
1985	3212903	40149	18444	46745	3581.0
1986	3346013	42403	19452	50358	3861.4
1987	3513661	45267	20178	52856	4218.2
1988	3725000	48806	21218	56453	
1989	3981533	52340	22575		

Source:Science and Technology Agency, "White Paper on Science and Technology".

Table 4-1-2(B) Trends in Ratio of GNP to R&D Expenditures for Selected Countries

(Unit:Percent)

	Japan	U.S.	W.Germany	France	U.K.
1970	1.80	2.57	2.35	1.87	1.49
1971	1.85	2.42	2.29	1.86	1.82
1972	1.86	2.35	2.24	1.84	2.09
1973	1.90	2.26	2.16	1.74	2.18
1974	1.97	2.23	2.21	1.76	2.26
1975	1.95	2.20	2.30	1.99	2.07
1976	1.94	2.19	2.24	1.75	2.10
1977	1.92	2.15	2.24	1.72	2.16
1978	1.94	2.14	2.33	1.72	2.14
1979	2.03	2.19	2.39	1.77	2.21
1980	2.14	2.29	2.41	1.81	2.23
1981	2.30	2.35	2.48	1.96	2.31
1982	2.40	2.51	2.54	2.06	2.24
1983	2.62	2.56	2.54	2.12	2.14
1984	2.61	2.59	2.64	2.22	2.21
1985	2.77	2.68	2.76	2.27	2.21
1986	2.75	2.65	2.79	2.25	2.27
1987	2.80	2.62	2.86	2.30	2.24
1988	2.85	2.58	2.89	2.31	
1989	2.97	2.53	2.87		

Sources: Science and Technology Agency, "White Paper on Science and Technology", Statistic Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development".

Note:

(1) For international comparison, Humanities and Social Sciences are included in R&D Expenditures for Japan.

Table 4-1-3(A) Trends in Defense R&D Expenditures for Selected Countries

	Japan Million Yen	U.S. Million Doller	W.Germany Million Mark	France Million Franc	U.K. Million Pound
1970	11,065	8,021	1,151.0	3,455	242.6
1971	12,305	8,108	1,178.9	3,900	285.0
1972	14,096	8,837	1,018.7	3,900	327.3
1973	15,575	9,139	1,352.0	4,350	431.8
1974	16,156	9,406	1,411.1	4,650	436.1
1975	16,649	9,715	1,405.0	5,050	549.9
1976	18,825	9,819	1,490.0	5,610	705.3
1977	21,826	10,874	1,596.0	6,100	825.1
1978	24,272	12,077	1,731.3	7,740	875.2
1979	27,649	12,129	1,847.4	9,660	1,160.5
1980	29,599	14,643	1,730.1	13,610	1,493.4
1981	32,573	16,937	1,572.3	15,670	1,743.3
1982	36,487	19,809	1,646.8	17,300	1,763.1
1983	39,452	22,298	1,834.5	18,160	1,984.0
1984	44,607	25,765	1,936.7	20,240	2,176.0
1985	58,677	30,360	2,058.9	22,370	2,340.9
1986	66,133	35,656	2,590.4	24,460	2,264.2
1987	74,135	37,097	2,807.4	26,620	2,237.5
1988	82,700	38,032	2,759.1	29,150	
1989	93,068	40,366	3,069.6	31,000	

Source: Science and Technology Agency, "White Paper on Science and Technology".

Table 4-1-3(B) Trends in Civilian R&D Expenditures for Selected Countries (Domestic Currncies)

	Japan Million Yen	U.S. Million Doller	W.Germany Million Mark	France Million Franc	U.K. Million Pound
1970	1,344,440	18,113	14,759	11,500	534
1971	1,520,067	18,568	16,031	12,721	781
1972	1,777,775	19,640	17,491	14,377	1,027
1973	2,200,261	21,579	18,458	15,439	1,212
1974	2,699,876	23,458	20,349	18,381	1,496
1975	2,957,924	25,498	22,305	24,153	1,672
1976	3,301,860	29,199	23,785	24,164	1,983
1977	3,629,493	31,909	25,244	27,085	2,330
1978	4,021,592	36,052	28,368	29,931	2,747
1979	4,555,981	42,804	31,511	34,463	3,228
1980	5,216,649	47,951	34,088	37,404	3,661
1981	5,949,783	54,929	36,706	46,801	4,178
1982	6,492,213	59,555	38,848	57,536	4,489
1983	7,141,330	64,982	40,877	66,511	4,599
1984	7,849,324	72,028	44,854	75,958	5,075
1985	8,831,622	77,397	48,811	83,547	5,578
1986	9,126,799	76,841	51,729	88,800	6,514
1987	9,762,505	81,685	54,961	94,744	7,215
1988	10,544,872	88,083	58,535	101,350	
1989	11,722,414	91,984	61,750	110,000	

See Table 4-1-1(A), Table 4-1-3(A)

Table 4-1-3(C) Trends in Civilian R&D Expenditures for Selected Countries (Yen Conversion)

(Unit:Trillion Yen)

	Japan	U.S.	W.Germany	France	U.K.
1970	1.34	4.64	1.15	0.62	0.48
1971	1.52	4.77	1.22	0.68	0.67
1972	1.78	5.09	1.33	0.75	0.86
1973	2.20	5.91	1.49	0.84	1.07
1974	2.70	7.13	1.85	1.08	1.39
1975	2.96	7.60	2.06	1.36	1.32
1976	3.30	8.76	2.27	1.31	1.45
1977	3.63	9.51	2.47	1.43	1.59
1978	4.02	10.49	2.79	1.50	1.76
1979	4.56	11.77	3.06	1.61	1.87
1980	5.22	12.56	3.28	1.63	1.84
1981	5.95	13.57	3.51	1.90	1.94
1982	6.49	14.05	3.62	2.12	1.97
1983	7.14	14.95	3.72	2.25	1.92
1984	7.85	16.21	4.05	2.42	2.08
1985	8.83	17.18	4.37	2.55	2.17
1986	9.13	16.91	4.58	2.63	2.51
1987	9.76	17.40	4.75	2.72	2.66
1988	10.54	18.23	5.01	2.83	
1989	11.72	18.40	5.24	3.03	

See Table 4-1-3(A), Table 4-1-3(B).

Note:

(1) Each country currency is converted to Yen using Purchasing Power Parities(PPP)

Table 4-1-3(D) Trends in Ratio of Civilian R&D Expenditures to GNP for Selected Countries

Percentage

	Japan	U.S.	W.Germany	France	U.K.
1970	1.79	1.78	2.18	1.44	1.02
1971	1.84	1.68	2.13	1.43	1.33
1972	1.84	1.62	2.12	1.45	1.59
1973	1.89	1.59	2.01	1.36	1.61
1974	1.95	1.59	2.06	1.40	1.75
1975	1.94	1.60	2.17	1.64	1.56
1976	1.93	1.64	2.11	1.42	1.55
1977	1.91	1.60	2.10	1.41	1.59
1978	1.93	1.60	2.20	1.37	1.62
1979	2.02	1.71	2.26	1.38	1.63
1980	2.13	1.76	2.30	1.32	1.58
1981	2.29	1.80	2.38	1.47	1.63
1982	2.38	1.88	2.43	1.59	1.61
1983	2.61	1.91	2.43	1.66	1.50
1984	2.59	1.91	2.53	1.75	1.54
1985	2.75	1.93	2.65	1.79	1.56
1986	2.73	1.81	2.66	1.76	1.69
1987	2.78	1.80	2.72	1.79	1.71
1988	2.83	1.80	2.76	1.80	
1989	2.94	1.76	2.74		

Table 4-1-4(A) R&D Expenditures for Japan(1989)

Unit:100 Million Yen

	Sources	(%)	Performers	(%)
Industry	85,382	72.3	82,338	69.7
Government	22,024	18.6	9,538	8.1
College/Univ.	9,893	8.4	21,294	18.0
Private R&D institute	758	0.6	4,985	4.2
Foreign	97	0.1	—	—
Total	118,155	100.0	118,155	100.0

Note: Government sources include central government, local government, national and public research institutions, semigovernmental research institutions and national and public colleges and universities.

College/Univ. sources are for private colleges and universities.

Government performers include national, public and semigovernmental research institutions

College/Univ. performers include national, public and private colleges and universities.

R&D expenditures include natural sciences, humanities, and social sciences.

Table 4-1-4(B) R&D Expenditures for the United States (1989)

Unit:Million Yen

	Sources	(%)	Performers	(%)
Industry	12,807,000	48.4	19,070,000	72.0
Government	12,540,000	47.4	2,950,000	11.1
College/Univ.	760,000	2.9	3,710,000	14.0
Private R&D institute	363,000	1.4	740,000	2.8
Foreign	—	—	—	—
Total	26,470,000	100.0	26,470,000	100.0

Note: Govirnment sources include federal government and federal government research institutions.

College/Univ. sources are for private colleges and universities.

Goverment performer is for federal government research institues.

College/Univ. performers include states and private colleges and universities.

R&D expendirures include natural sciences, humanities, and social sciences.

Talbe 4-1-4(C) R&D Expenditures for West Germany (1989)

Unit:Million Yen

	Sources	(%)	Performers	(%)
Industry	3,588,736	65.3	4,013,160	73.0
Government	1,827,440	33.2	189,952	3.5
College/Univ.	—	0.0	770,832	14.0
Private R&D institute	included in industry	—	522,792	9.5
Foreign	80,560	1.5	—	—
Total	5,496,736	100.0	5,496,736	100.0

Note:Government sources include federal government and states governments.
Government performers include federal governmental, states' and local governmental research institutions.
College/Univ. performers are for states colleges and universities.
R&D expenditures include natural sciences, humanities and social science.
Mark amounts are converted to Yen using Puchasing Power Parities (PPP).
Sources:Science and Technology Agency, "White Paper on Science and Technology".

Table 4-1-4(D) R&D Expenditures for the United Kingdom (1987)

Unit:Million Yen

	Sources	(%)	Performers	(%)
Industry	1,728,422	49.7	2,332,016	67.0
Government	1,345,114	38.7	524,694	15.1
College/Univ.	20,240	0.6	492,936	14.2
Private R&D institute	66,498	1.9	128,800	3.7
Foreign	318,173	9.1	—	—
Total	3,478,446	100.0	3,478,446	100.0

Note:Gevernment sources include contral and locol governments.
College/Univ. sources are for private universities.
Government performers include national and local governmental research institutes.
College/Univ. performers include national and private colleges and universities.
R&D expenditures are for natural sciences only.
Pound amounts are converted to Yen using Puchasing Power Parities (PPP).
Sources:Science and Technology Agency, "White Paper on Science and Technology".

Table 4-1-4(E) R&D Expenditures for France (1983)

Unit:Million Yen

	Sources	(%)	Performers	(%)
Industry	1,200,745	42.0	1,625,712	56.8
Government	1,540,469	53.8	756,207	26.4
College/Univ.	6,557	0.2	453,427	15.8
Private R&D institute	12,269	0.4	26,533	0.9
Foreign	101,839	3.6	—	—
Total	2,861,880	100.0	2,861,880	100.0

Note:R&D expenditures include natural sciences, humanities and social sciences.
Franc amounts are converted to Yen using Purchasing Power Parities (PPP).

Table 4-1-5 Trends in R&D Expenditures by sectors for Japan and the United States

Year	R&D Expenditures by sectors for Japan (Millon Yen) Industry	College /Univ.	Governmental research inst.	Private research inst.	Total
1970	823,265	365,877	147,525	18,838	1,355,505
1971	895,020	423,441	190,586	23,325	1,532,372
1972	1,044,928	478,684	242,836	25,424	1,791,872
1973	1,301,927	574,163	307,659	32,088	2,215,837
1974	1,589,053	717,585	325,158	84,236	2,716,032
1975	1,684,847	839,798	364,005	85,923	2,974,573
1976	1,882,231	934,016	402,536	101,902	3,320,685
1977	2,109,500	1,012,297	440,691	88,831	3,651,319
1978	2,291,002	1,151,074	502,957	100,831	4,045,864
1979	2,664,913	1,258,326	565,787	94,604	4,583,630
1980	3,142,256	1,340,074	618,378	145,540	5,246,248
1981	3,629,793	1,445,645	661,397	245,521	5,982,356
1982	4,039,018	1,540,422	673,082	276,178	6,528,700
1983	4,560,127	1,649,646	691,359	279,651	7,180,783
1984	5,136,634	1,724,187	725,685	307,425	7,893,931
1985	5,939,947	1,789,780	810,759	349,812	8,890,299
1986	6,120,163	1,832,575	840,223	399,971	9,192,932
1987	6,494,268	1,957,921	943,179	441,273	9,836,641
1988	7,219,318	2,014,073	935,255	458,925	10,627,571
1989	8,233,820	2,129,372	953,755	498,535	11,815,482

Year	R&D Expenditures by sectors for U.S. (Millon Yen) Industry	College /Univ.	Governmental research inst.	Private research inst.	Total
1970	4,625,152	786,432	1,044,224	234,496	6,690,304
1971	4,708,240	826,512	1,086,596	234,384	6,855,732
1972	5,063,968	876,197	1,188,810	246,568	7,375,543
1973	5,822,226	1,014,074	1,304,788	275,644	8,416,732
1974	6,957,648	1,181,952	1,492,944	358,112	9,990,656
1975	7,207,726	1,310,008	1,595,492	380,248	10,493,474
1976	8,099,100	1,462,800	1,730,700	412,800	11,705,400
1977	8,887,850	1,624,398	1,791,576	445,510	12,749,334
1978	9,691,464	1,845,522	1,982,001	486,552	14,005,539
1979	10,512,150	2,006,400	2,039,675	548,350	15,106,575
1980	11,660,310	2,176,434	1,999,584	563,300	16,399,628
1981	12,797,070	2,300,805	2,081,222	568,100	17,747,197
1982	13,841,400	2,309,260	2,157,276	572,300	18,880,236
1983	15,011,640	2,438,230	2,433,860	615,250	20,498,980
1984	16,830,000	2,642,400	2,603,700	675,000	22,751,100
1985	18,701,058	2,927,292	2,873,790	749,250	25,251,390
1986	19,477,700	3,255,780	2,977,700	737,000	26,448,180
1987	20,046,921	3,468,918	2,856,969	745,500	27,118,308
1988	20,580,354	3,716,271	2,956,167	740,025	27,992,817
1989	20,600,000	3,860,000	3,160,000	780,000	28,400,000

Sources:Statistic Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development".
NSF, "National Patterns of R&D Resources:1990", USA.
OECD, "Main Economic Indicators", 1989.

Note:R&D expenditures include for natural sciences, humanities and social sciences. Doller amounts for U.S. R&D expenditures are converted to Yen using Pachasing Power Parities (PPP).
Governmental research inst. include local government(for Japan) or states governments(for U.S.). College/Univ. of U.S. include Federal Funded Research and Development Centers (FFRDCs).

Table 4-1-6(A) Sectorial Flows of R&D Expenditures by Source and Performer for Japan (FY1989)

Unit:100 Million Yen

Sources	Performers				Total
	Industry	Government	College/Univ.	Private R&D institute.	
Industry	81,161	707	458	3,055	85,382
Government	1,028	8,827	10,921	1,247	22,024
College/Univ.	2	0	9,889	2	9,893
Private R&D institute.	68	3	22	665	758
Foreign	79	0	3	15	97
Total	82,338	9,538	21,294	4,985	118,155

Note:R&D expenditures include natural sciences, humanities and social sciences.

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

Table 4-1-6(B) Sectorial Flows of R&D Expenditures by Source and Performer for U.S. (FY1989)

Unit:100 Million Yen

Sources	Performers				Total
	Industry	Government	College/Univ.	Private R&D institute.	
Industry	125,200	—	1,840	1,030	128,070
Government	65,500	29,500	25,800	4,600	125,400
College/Univ.	—	—	7,600	—	7,600
Private R&D institute.	—	—	1,860	1,770	3,630
Total	190,700	29,500	37,100	7,400	264,700

Note:R&D expenditures include natural sciences, humanities and social sciences.
Dollar amounts are converted to Yen using Purchasing Power Parities (PPP).

Source:NSF, "National Patterns of Science and Technology Resources"

Table 4-1-7 R&D Expenditures by Characteristic of Work for Selected Countries

Year	Japan:R&D expenditures (Million Yen)			Total	Percentage		
	Basic research	Applied research	Development		Basic research	Applied research	Development
1980	707,641	1,164,869	2,726,504	4,599,014	15.4	25.3	59.3
1981	768,152	1,349,650	3,150,661	5,268,463	14.6	25.6	59.8
1982	861,300	1,509,826	3,490,056	5,861,183	14.7	25.8	59.5
1983	944,858	1,642,246	3,891,265	6,478,368	14.6	25.3	60.1
1984	1,009,651	1,793,723	4,349,565	7,152,938	14.1	25.1	60.8
1985	1,080,846	2,014,856	4,993,118	8,088,820	13.4	24.9	61.7
1986	1,157,250	2,044,128	5,192,495	8,393,873	13.8	24.4	61.9
1987	1,306,645	2,181,749	5,506,339	8,994,733	14.5	24.3	61.2
1988	1,347,078	2,361,349	6,051,139	9,759,566	13.8	24.2	62.0
1989	1,452,953	2,604,269	6,859,136	10,916,358	13.3	23.9	62.8

Year	U.S.:R&D expenditures (Million Dollar)			Total	Percentage		
	Basic research	Applied research	Development		Basic research	Applied research	Development
1981	9,580	16,607	45,664	71,851	13.3	23.1	63.6
1982	10,415	18,512	51,074	80,001	13.0	23.1	63.8
1983	11,618	20,698	56,810	89,126	13.0	23.2	63.7
1984	12,883	22,850	65,383	101,116	12.7	22.6	64.7
1985	14,178	25,830	73,737	113,745	12.5	22.7	64.8
1986	16,570	27,550	75,743	120,219	13.8	22.9	63.0
1987	17,780	28,976	80,560	127,316	14.0	22.8	63.3
1988	18,460	30,897	85,874	135,231	13.7	22.8	63.5
1989	19,880	32,290	89,830	142,000	14.0	22.7	63.3

Year	W.Germany:R&D expenditures (Million Mark)		Total	Percentage	
	Basic research	Applied research and development		Basic research	Applied research and development
1981	6,271	27,052	33,324	18.8	81.2
1983	7,664	29,756	37,420	20.5	79.5

Sources:Statistic Bureau, Management and Coodination Agency, Japan, "Report on the Survey of Research and Development".
NSF, National Patterns of R&D Resources:1990", USA.
OECD, "Science & Technology Indicators",1990.

Note:R&D expenditures include totals for natural sciences, humanities and social sciences. But R&D expenditures for West Germany for 1981 are for natural sciences only. Futhermore , for West Germany there is no distinction between applied research and development.

Table 4-1-8 Basic research expenditures by sector for Japan and U.S.

	Japan:Basic research expenditures (Million Yen)				Total
Year	Industry	College /Univ.	National institute	Others	
1975	82,721	215,640	48,882	11,954	359,197
1980	151,474	443,722	76,848	35,597	707,641
1985	348,474	596,060	77,320	58,992	1,080,846
1986	368,837	626,930	85,582	75,902	1,157,251
1987	427,062	673,897	108,283	97,403	1,306,645
1988	471,194	679,331	96,271	100,281	1,347,077
1989	521,705	720,057	97,099	114,093	1,452,954
	U.S.:Basic research expenditures (Million Yen)				**Total**
Year	Industry	College /Univ.	National institute	Others	
1975	217,540	849,002	218,732	126,650	1,411,924
1980	347,150	1,347,466	309,684	199,120	2,203,420
1985	635,364	1,839,936	426,906	245,310	3,147,516
1986	890,120	2,053,700	444,180	257,400	3,645,400
1987	883,737	2,205,615	435,798	261,990	3,787,140
1988	825,516	2,296,044	424,350	275,310	3,821,220
1989	810,000	2,410,000	470,000	286,000	3,976,000

Sources:Statistic Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development".
NSF, "National Patterns of R&D Resources:1990", USA.
OECD, "Main Economic Indicators",1989.

Note:Basic research expenditures include totals for natural sciences, humanities and social sciences. Basic research expenditures for U.S. are converted to Yen using Puchasing Power Parities (PPP).

Table 4-1-9 Trends of R&D Scientists and Engineers in Selected Countries

Unit:Person

Year	Japan	U.S.	W.Germany	U.K.	France
1970	218,339	543,800	—	—	58,500
1971	242,155	523,500	90,206	—	60,100
1972	247,309	515,000	—	77,385	61,200
1973	279,186	514,600	101,019	—	62,700
1974	292,097	520,600	—	—	64,100
1975	310,111	527,400	103,736	81,300	65,300
1976	316,860	535,200	—	—	67,000
1977	329,447	560,600	110,972	—	67,981
1978	331,467	586,600	—	87,245	—
1979	341,488	614,500	116,888	—	72,889
1980	363,534	651,200	—	—	—
1981	379,405	683,300	124,678	95,400	85,500
1982	392,625	702,500	—	—	90,076
1983	406,042	722,500	130,843	94,000	92,682
1984	435,340	745,900	—	—	98,205
1985	447,719	772,700	143,627	97,974	102,336
1986	473,296	791,100	—	101,745	104,953
1987	487,779	806,200	165,614	101,413	109,359
1988	513,267	—	—	—	—
1989	535,008	—	—	—	—

Note:R&D scientists and engineers for U.S. industries are for natural sciences only, whereas for other countries are totals for natural sciences, humanities and social sciences.

Sources:Science and Technology Agency, "White Papar on Science and Technology", Statistic Bureau, Management and Coordination Agency, Japan, "Report on the Survey of Research and Development".

Table 4-1-10(A) R&D Scientists and Engineers in Selected Countries

(Unit:Person)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Japan	341488	363534	379405	392625	406042	435340	447719	473296	487779	513267
U.S.	576900	603300	629700	683300	702500	722500	745900	772700	791100	806200
W.Germany		116888		124678		130843		147639		165614
France		72889	85500	90076	92682	98210	102336	104953	109359	
U.K.			95400		94000		97974	101745	101413	

Sources:Statistic Bureau, Management and Coodination Agency, Japan, "Report on the Survey of Research and Development".
OECD, "Main Science and Technology Indicators," 1989.

Note:

(1) For international comparison, R&D scientists and engineers for Japan include natural sciences, humanities and social sciences.

Table 4-1-10(B) Labor Force in Selected Countries

(Unit:10 Thousands Person)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Japan	5596	5650	5707	5774	5889	5927	5963	6020	6084	6166
U.S.	10656	10854	11032	11187	11323	11524	11717	11954	12160	12338
W.Germany	2692	2722	2742	2754	2759	2763	2784	2802	2822	
France	2324	2337	2353	2374	2371	2387	2392	2399	2407	
U.K.	2663	2684	2674	2668	2661	2727	2780	2798	2821	2809

Sources : OECD, "Main Science and Technology Indicators," 1989.

Table 4-1-10(C) Population in Selected Countries

(Unit:Million Person)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Japan	116	117	118	119	120	120	121	122	122	123
U.S.	225	228	230	232	235	237	239	242	244	246
W.Germany	61	62	62	62	61	61	61	61	61	61
France	54	54	54	54	55	55	55	55	56	56
U.K.	56	56	56	56	56	56	56	56		

Sources : OECD, "Main Science and Technology Indicators," 1989.

Table 4-1-10(D) R&D scientists and engineers per 10 thousands labor force

(Unit:Person)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Japan	61	64	66	68	69	73	75	79	80	83
U.S.	54	56	57	61	62	63	64	65	65	65
W.Germany		43		45		47		53		
France		31	36	38	39	41	43	44	45	
U.K.			36		35		35	36	36	

Table 4-1-10(E) R&D scientists and engineers per 10 thousands population

(Unit:Person)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Japan	29	31	32	33	34	36	37	39	40	42
U.S.	26	26	27	29	30	30	31	32	32	33
W.Germany		19		20		21		24		27
France		14	16	17	17	18	19	19	20	
U.K.			17		17		17	18		

Table 4-2-1 Trends of R&D Expenditures in Industry (by selected industry)

Fiscal Year	R&D expenditures (Million Yen)						All industries
	Manufacturing					Sub-total	
	Chemical products	Iron and steel	General machinery	Electrical machinery	Transport equipment		
1970	175,132	36,565	72,352	227,817	94,882	760,870	823,265
1971	193,682	40,881	75,195	229,168	112,951	810,719	895,020
1972	199,235	41,379	67,370	276,729	163,911	953,194	1,044,928
1973	238,189	59,595	86,925	341,492	215,088	1,193,515	1,301,927
1974	304,235	80,424	146,208	397,388	242,250	1,459,385	1,589,053
1975	322,099	89,211	115,524	400,495	289,465	1,536,514	1,684,847
1976	351,886	99,835	138,624	491,667	286,635	1,727,415	1,882,231
1977	385,952	103,681	171,252	501,291	357,724	1,923,105	2,109,500
1978	404,208	107,921	160,535	580,521	404,155	2,098,741	2,291,002
1979	489,829	119,992	185,749	694,212	445,614	2,447,099	2,664,913
1980	558,252	147,064	218,877	817,224	510,454	2,895,571	3,142,256
1981	617,354	169,653	242,096	1,006,225	627,433	3,374,224	3,629,793
1982	687,493	182,772	281,024	1,176,356	671,923	3,755,536	4,039,018
1983	774,532	186,088	311,678	1,416,231	714,511	4,257,191	4,560,127
1984	852,793	192,091	337,492	1,634,539	808,177	4,776,501	5,136,634
1985	936,360	240,409	382,698	1,938,183	935,661	5,543,618	5,939,947
1986	983,585	255,290	379,095	1,979,973	989,796	5,739,603	6,120,163
1987	1,095,887	245,176	418,769	2,163,544	969,615	6,101,202	6,494,268
1988	1,190,226	249,734	450,979	2,451,594	1,086,442	6,754,620	7,219,318
1989	1,313,882	268,131	558,974	2,808,123	1,244,625	7,706,193	8,233,820

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

Table 4-2-2 R&D Expenditures by Product Categories (FY1989)

Product field	R&D expenditures (Million Yen)	From corresponding industries	From non-corresponding industries	Penetrated ratio [%]
Agri., Forest & Fish. (1)	21,244	2,097	19,147	90.1
Mining	12,126	8,713	3,413	28.1
Building construction	186,502	143,499	43,003	23.1
Food	121,181	104,777	16,404	13.5
Textile	33,466	27,204	6,262	18.7
Pulp & paper	41,294	32,137	9,157	22.2
Printing & publishing	16,229	12,764	3,465	21.4
Industrial chemical (2)	452,454	276,751	175,703	38.8
Oils and paints	74,238	61,656	12,582	16.9
Drugs and medicines	566,890	414,891	151,999	26.8
Other chemical products	335,588	118,837	216,751	64.6
Petroleum products	46,900	39,973	6,927	14.8
Rubber products	92,075	84,827	7,248	7.9
Ceramic products	133,477	102,611	30,866	23.1
Iron and steel	137,629	132,846	4,783	3.5
Non-ferrous metals	85,988	57,883	28,105	32.7
Fabricated metal products	94,345	54,070	40,275	42.7
General machinery	642,538	317,075	325,463	50.7
Electronics (3)	2,258,036	1,365,968	892,068	39.5
Electric equipment (4)	840,447	264,451	575,996	68.5
Motor vehicles	1,194,162	1,028,079	166,083	13.9
Ships	14,614	-	-	-
Aircraft	40,969	-	-	-
Rolling stock	12,570	-	-	-
Other transport equip.	21,523	-	-	-
Precision instruments	184,238	102,540	81,698	44.3
Other manufacturing	108,653	50,791	57,862	53.3
Electricity and Gas	76,922	74,692	2,230	2.9
Others	23,172	-	-	-

(1) Agricultural, forest and fishing products
(2) Inorganic and organic chemical products, chemical fertilizers, and chemical fiber
(3) Communication and electronics equipment
(4) Household electric appliances and other equipment

Note: These data are totals for intramural expenditures on R&D for companies with capital of 100 million yen or more.

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

Table 4-2-3 Trends of R&D Expenditures by Product Categories

Fiscal Year	R&D expenditures (Million Yen) Communication and electonics equipment	Inorganic and organic chemical products, chemical fertilizers, and chemical fiber	Drugs and medicines	General machinery	Household electric appliances and other equipment	Motor vehicles	Others	Total
1969	71,485	71,235	25,314	44,225	67,732	57,470	129,110	466,571
1970	106,417	87,181	41,395	71,250	92,759	74,747	216,660	690,409
1971	139,644	88,205	51,561	78,388	106,184	89,207	265,936	819,125
1972	166,350	92,450	54,946	90,605	129,934	113,895	306,629	954,809
1973	203,640	95,928	66,048	126,047	154,525	156,332	401,863	1,204,383
1974	237,926	133,437	83,455	156,227	181,172	187,724	466,402	1,446,343
1975	231,568	128,377	96,505	149,593	192,898	187,222	533,320	1,519,483
1976	271,408	136,740	115,710	189,564	222,697	220,083	573,129	1,729,331
1977	315,415	145,613	125,673	204,136	223,089	276,710	637,437	1,928,073
1978	361,603	144,158	139,668	206,022	256,118	337,381	677,520	2,122,470
1979	422,348	155,537	182,821	240,051	308,455	378,301	776,335	2,463,848
1980	503,948	206,487	207,949	282,889	354,488	428,436	929,386	2,913,583
1981	604,221	216,593	242,975	304,560	451,915	521,821	1,030,648	3,372,733
1982	729,643	210,029	281,296	355,806	530,448	584,034	1,118,837	3,810,093
1983	906,778	224,501	334,371	407,143	555,054	652,772	1,231,143	4,311,762
1984	1,106,482	265,169	346,519	461,540	620,289	726,659	1,353,611	4,880,269
1985	1,372,511	304,025	386,281	496,757	687,485	853,317	1,535,023	5,635,399
1986	1,490,484	340,780	398,572	505,549	650,551	902,650	1,554,487	5,843,073
1987	1,613,089	357,952	460,189	521,239	698,145	890,673	1,653,345	6,194,632
1988	1,910,708	409,086	498,023	549,075	744,165	1,037,060	1,760,125	6,908,242
1989	2,258,036	452,454	566,890	642,538	840,447	1,194,162	1,914,945	7,869,472

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

Table 4-2-4 R&D Expenditures and Non-core Bisiness Ratio by Industry (FY1989)

Industries	R&D expenditures (Million Yen)	R&D expenditures for core bisiness field	R&D expenditures for non-core bisiness field	Non-core business ratio of R&D [%]
All industry	7,869,472	-	-	-
Agri., Forest. & Fish. (1)	4,247	2,097	2,150	50.6
Mining	24,446	8,713	15,733	64.4
Construction	167,598	143,499	24,099	14.4
Food	187,970	104,777	83,193	44.3
Textiles	72,186	27,204	44,982	62.3
Pulp & paper products	42,266	32,137	10,129	24.0
Printing & publishing	33,667	12,764	20,903	62.1
Chemical products	1,251,847	-	-	-
Industrial chemical (2)	539,660	276,751	262,909	48.7
Oils & paints	118,939	61,656	57,283	48.2
Drugs & medicines	437,576	414,891	22,685	5.2
Other chemicals	155,672	118,837	36,835	23.7
Petroleum & coal products	81,813	39,973	41,840	51.1
Plastic products	114,624	-	-	-
Rubber products	107,776	84,827	22,949	21.3
Cheramics	210,078	102,611	107,467	51.2
Iron & steel	266,696	132,846	133,850	50.2
Non-ferrous netals	121,251	57,883	63,368	52.3
Fabricated metal products	87,945	54,070	33,875	38.5
General machinery	487,957	317,075	170,882	35.0
Electrical machinery	2,729,972	-	-	-
Elect. machin. ect (3)	825,550	264,451	561,099	68.0
Electronics (4)	1,904,422	1,365,968	538,454	28.3
Transport equipment	1,231,118	-	-	-
Motor vehicles	1,074,333	1,028,079	46,254	4.3
Other transport equip.	156,785	42,432	114,353	72.9
Precision instruments	244,789	102,540	142,249	58.1
Other manufacturing	87,734	50,791	36,943	42.1
Transport, communication	313,492	74,692	238,800	76.2

(1) Agriculture, forestry and fisheries
(2) Industrial chemicals and chemical fibers
(3) Electrical machinery ,equipment and supplies
(4) Communication and electronics equipment

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

Table 4-2-5 Trends of Non-core Business Ratio of R&D Expenditures in Industry (by selected industry)

	Non-core business ratio R&D expenditures [%]					
Fiscal Year	Chemical products manufacturing	Iron and steel manufacturing	General machinery manufacturing	Electrical machinery manufacturing	Transportation equipment manufacturing	Precision instruments manufacturing
1969	6.5	28.5	30.6	10.4	13.4	22.6
1970	7.9	25.5	22.9	11.0	15.0	38.5
1971	7.9	26.8	25.7	8.4	14.2	32.9
1972	7.4	23.3	20.2	8.1	19.3	28.5
1973	9.1	24.9	20.3	9.1	19.4	28.3
1974	9.8	23.5	19.5	10.2	18.1	33.4
1975	7.1	22.5	24.3	10.9	21.9	41.1
1976	7.1	24.3	23.4	11.0	19.6	27.3
1977	7.5	24.4	25.4	11.6	18.4	21.7
1978	6.0	24.5	22.1	10.5	13.9	24.6
1979	7.3	22.5	24.4	11.0	13.4	29.2
1980	6.3	21.0	26.1	10.4	15.0	24.2
1981	6.4	20.5	24.5	8.2	14.7	34.9
1982	7.3	24.2	24.9	8.3	13.0	45.1
1983	7.9	26.6	28.9	10.3	12.1	43.1
1984	8.8	28.5	28.7	10.8	14.0	45.9
1985	8.9	33.8	33.2	10.3	13.6	46.7
1986	8.7	49.1	34.8	8.9	14.1	45.1
1987	9.7	46.9	34.8	8.9	13.9	43.0
1988	9.7	48.6	35.7	8.8	13.1	48.2
1989	10.2	50.2	35.0	8.3	11.3	58.1

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

Fig 4-2-6 Numerical Trends of R&D Scientists and Engineers in Industries (by selected industry)

Fiscal Year	R&D scientists and engineers (Number of person) Chemical products manufacturing	General machinery manufacturing	Electrical machinery manufacturing	Transportation equipment manufacturing	Precision instruments manufacturing	Other manufacturing	manufacturing	All industries
1960	8,651	2,993	9,942	2,633	1,754	13,951	39,924	42,938
1961	9,149	4,350	8,685	2,685	960	14,514	40,343	43,608
1962	9,874	3,029	9,525	3,794	1,217	15,104	42,543	46,110
1963	12,063	4,568	11,643	4,546	1,028	15,866	49,714	54,073
1964	15,292	4,033	14,707	4,572	1,266	16,112	55,982	60,009
1965	14,520	5,963	13,460	3,447	1,508	16,016	54,914	58,997
1966	15,824	6,733	15,897	3,468	2,062	16,929	60,913	65,357
1967	16,859	5,470	17,801	4,391	2,166	18,752	65,439	69,164
1968	19,075	7,123	19,915	5,151	2,548	22,911	76,723	81,664
1969	19,451	7,503	21,780	5,927	2,167	20,671	77,499	82,516
1970	21,565	8,192	25,722	6,419	2,757	22,978	87,633	94,060
1971	24,669	10,600	31,227	7,740	3,367	25,299	102,902	111,244
1972	25,232	9,754	33,183	8,423	3,283	25,392	105,267	112,763
1973	26,207	10,242	36,789	10,587	5,193	28,526	117,544	124,795
1974	25,876	10,561	38,738	12,184	4,351	30,496	122,206	130,690
1975	27,220	20,934	42,645	12,329	3,799	30,198	137,125	146,604
1976	27,614	11,749	43,873	16,089	3,950	32,541	135,816	145,216
1977	28,259	13,426	49,465	13,705	4,590	32,394	141,839	151,437
1978	29,228	14,375	47,939	13,855	4,935	33,686	144,018	153,706
1979	29,506	12,642	51,174	15,132	5,685	34,111	148,250	157,279
1980	31,556	15,273	55,467	16,169	6,188	39,214	163,867	173,244
1981	32,847	15,390	58,873	17,682	7,061	43,235	175,088	184,889
1982	33,970	15,666	63,193	18,158	8,096	44,400	183,483	192,942
1983	35,822	17,024	68,243	18,615	8,270	42,634	190,608	201,137
1984	37,594	19,588	78,427	21,036	10,107	46,551	213,303	223,882
1985	38,888	19,694	80,077	22,123	10,791	47,868	219,441	231,097
1986	42,523	21,313	89,824	23,892	11,545	50,695	239,792	251,771
1987	43,503	21,146	94,067	25,148	11,522	53,063	248,449	260,846
1988	46,914	23,184	104,416	26,348	11,049	55,331	267,242	279,298
1989	49,170	24,677	112,387	27,993	12,374	54,646	281,247	294,202
1990	52,196	27,382	119,386	29,383	13,796	58,234	300,377	313,948

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

Table 4-2-7 Numerical Trends of R&D Scientists and Engineers in Industry (by speciality of academic field)

Fiscal Year	R&D scientists and engineers (Number of person)							Total
	All natural sciences and engineering fields						Humanities and social sciences	
	Natural sciences	Engineering	Agricaltural	Health sciences	Others	Sub-total		
1960	16,036	19,525	1,252	1,544	1,567	39,924	-	39,924
1961	18,071	17,651	1,859	1,695	1,067	40,343	-	40,343
1962	16,686	20,654	1,073	2,101	2,029	42,543	-	42,543
1963	19,956	24,281	1,537	2,264	1,676	49,714	-	49,714
1964	22,534	25,946	1,834	3,054	2,520	55,982	-	55,982
1965	22,903	25,877	1,687	2,491	1,956	54,914	-	54,914
1966	24,035	29,983	1,696	2,683	2,516	60,913	-	60,913
1967	26,856	30,768	2,347	2,926	2,542	65,439	-	65,439
1968	31,393	37,132	2,343	2,893	2,962	76,723	-	76,723
1969	29,464	39,644	3,342	3,135	1,914	77,499	-	77,499
1970	34,219	45,488	2,997	3,044	1,585	87,333	300	87,633
1971	38,514	55,325	2,825	3,767	1,977	102,408	494	102,902
1972	39,326	56,150	3,216	3,847	2,304	104,843	424	105,267
1973	43,900	64,056	3,463	3,774	1,948	117,141	403	117,544
1974	42,675	68,398	3,891	4,176	2,653	121,793	413	122,206
1975	48,004	77,947	3,702	4,103	2,856	136,612	513	137,125
1976	46,888	75,959	4,479	4,216	3,615	135,157	659	135,816
1977	45,141	83,104	4,518	4,620	3,534	140,916	924	141,839
1978	46,476	83,777	4,326	4,859	3,793	143,230	788	144,018
1979	46,836	85,792	4,789	5,029	4,767	147,213	1,037	148,250
1980	50,056	96,255	5,551	5,776	4,920	162,558	1,309	163,867
1981	54,565	101,303	5,831	5,805	6,145	173,649	1,439	175,088
1982	53,702	108,624	5,921	6,101	7,262	181,610	1,873	183,483
1983	55,880	112,585	6,384	6,439	7,623	188,911	1,697	190,608
1984	60,110	126,878	6,354	7,266	9,894	210,502	2,801	213,303
1985	60,723	131,882	7,163	7,527	9,350	216,645	2,796	219,441
1986	66,249	144,421	7,417	8,033	10,608	236,728	3,064	239,792
1987	68,500	149,406	8,278	8,103	11,203	245,490	2,959	248,449
1988	70,774	162,896	9,342	9,123	11,862	263,997	3,245	267,242
1989	74,148	172,159	9,085	9,560	13,038	277,990	3,257	281,247
1990	80,227	183,538	8,501	10,159	14,748	297,173	3,204	300,377

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

Table 4-2-8 Trends of Ratio of R&D Expenditures to Sales (Percentage)

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
All industry	1.17	1.26	1.33	1.41	1.42	1.49	1.48	1.45	1.48	1.55	1.64
Agri., Forest. & Fish.	0.49	0.28	0.44	0.18	0.18	0.15	0.41	0.32	0.24	0.31	0.60
Mining	0.62	0.60	0.57	0.79	0.59	0.54	0.60	0.61	0.59	0.54	0.61
Construction	0.35	0.46	0.30	0.37	0.31	0.41	0.39	0.50	0.49	0.54	0.43
Manufacturing	1.37	1.42	1.55	1.62	1.64	1.65	1.66	1.61	1.64	1.71	1.83
Food	0.58	0.57	0.58	0.47	0.48	0.54	0.50	0.49	0.49	0.50	0.51
Textiles	0.62	0.58	0.61	0.72	0.66	0.73	0.78	0.71	0.66	0.56	0.77
Pulp & paper products	0.43	0.58	0.51	0.55	0.54	1.00	0.54	0.49	0.47	0.46	0.49
Printing & publishing	0.24	0.33	0.44	0.30	0.51	0.39	0.42	0.43	0.46	0.41	0.36
Chemical products	2.27	2.22	2.42	2.56	2.44	2.35	2.33	2.46	2.39	2.62	2.71
Industrial chemical	2.09	1.99	2.02	2.05	1.88	1.86	1.83	1.84	1.69	1.87	1.92
Oils & paints	1.94	1.91	2.03	2.15	2.34	2.19	2.38	2.40	2.40	2.71	2.73
Drugs & medicines	3.30	3.62	4.13	4.66	4.62	4.11	4.37	4.91	5.05	4.84	5.00
Other chemicals	2.22	2.24	2.81	3.01	2.69	2.94	2.78	2.76	2.88	3.12	3.03
Petroleum & coal products	0.35	0.36	0.41	0.45	0.45	0.28	0.18	0.18	0.18	0.23	0.27
Plastic products											
Rubber products	1.34	1.25	1.40	1.59	1.73	1.79	1.85	2.20	2.25	1.96	2.60
Cheramics	0.96	1.01	1.14	1.09	1.06	1.06	1.10	1.25	1.40	1.22	1.29
Iron & steel	0.71	0.71	0.75	0.83	0.81	0.84	1.01	1.05	1.02	1.11	1.08
Non-ferrous metals	1.05	0.91	1.07	1.12	1.22	0.87	1.07	1.01	0.96	1.01	1.00
Fabricated metal products	0.91	0.78	0.89	0.69	1.06	0.95	1.01	1.10	1.00	1.18	1.08
General machinery	1.45	1.45	1.52	1.78	1.49	1.55	1.93	1.74	1.79	2.01	1.93
Electrical machinery	2.82	2.99	3.31	3.37	3.41	3.64	3.72	3.75	3.66	3.61	3.74
Elect. machin. ect.	2.40	2.75	3.10	2.96	2.78	3.22	3.10	3.29	3.49	3.49	3.59
Electronics	3.09	3.21	3.48	3.77	4.04	4.04	4.28	4.17	3.80	3.71	3.89
Transport equipment	1.50	1.52	1.74	1.86	2.10	2.18	2.14	1.95	2.08	2.27	2.44
Motor vehicles	1.79	1.71	1.90	2.01	2.21	2.51	2.38	1.77	2.20	2.32	2.60
Other transport equip.	0.73	0.98	1.24	1.39	1.88	1.57	1.61	2.48	1.76	2.12	1.90
Precision instruments	1.51	1.88	2.26	2.49	2.76	2.68	2.66	2.74	2.37	2.91	3.15
Other manufacturing	0.74	0.77	0.76	0.90	1.00	1.09	1.31	1.29	1.38	1.28	1.30
Transport, communication	0.46	0.62	0.66	0.72	0.27	1.51	1.17	1.13	1.08	1.21	1.20

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
All industry	1.55	1.54	1.67	1.84	2.03	2.00	2.32	2.57	2.59	2.61	2.72
Agri., Forest. & Fish.	0.45	0.17	0.26	0.27	0.26	0.24	0.24	0.24	0.31	0.38	0.21
Mining	0.53	0.63	0.53	0.71	0.66	0.68	1.11	1.40	1.18	1.58	1.17
Construction	0.41	0.47	0.38	0.43	0.54	0.48	0.50	0.56	0.52	0.50	0.53
Manufacturing	1.72	1.74	1.92	2.15	2.31	2.34	2.69	3.03	3.14	3.15	3.29
Food	0.51	0.58	0.35	0.63	0.70	0.60	0.77	0.85	0.99	0.89	1.07
Textiles	0.82	0.77	1.09	1.13	0.90	1.16	1.18	1.23	1.42	1.50	1.71
Pulp & paper products	0.42	0.41	0.43	0.52	0.63	0.66	0.71	0.80	0.77	0.87	0.79
Printing & publishing	0.27	0.26	0.21	0.39	0.43	0.61	0.68	0.64	0.80	0.63	0.71
Chemical products	2.54	2.55	2.63	3.05	3.34	3.46	3.79	4.31	4.53	4.63	4.84
Industrial chemical	1.71	1.85	2.01	2.17	2.32	2.47	2.80	3.56	3.76	3.92	4.09
Oils & paints	2.17	2.48	2.56	2.66	2.83	3.09	3.14	3.42	3.85	3.74	3.93
Drugs & medicines	5.53	5.45	5.85	5.56	6.59	6.49	7.04	6.89	6.96	6.94	7.50
Other chemicals	2.88	2.19	3.03	3.43	6.40	3.76	3.61	3.87	4.00	4.11	4.11
Petroleum & coal products	0.18	0.30	0.18	0.20	0.26	0.27	0.38	0.62	0.64	0.83	0.72
Plastic products						1.94	1.75	2.09	2.16	2.21	2.73
Rubber products	2.44	2.10	2.33	2.47	2.40	2.62	2.86	2.92	3.25	3.19	3.25
Cheramics	1.27	1.30	1.39	1.64	1.82	1.96	2.61	2.87	2.82	2.73	2.75
Iron & steel	1.04	1.14	1.30	1.50	1.60	1.52	1.94	2.54	2.40	2.13	2.21
Non-ferrous metals	0.87	1.03	1.30	1.57	1.49	1.64	1.92	2.11	1.90	2.00	1.91
Fabricated metal products	1.28	1.15	1.22	1.43	1.31	1.46	1.53	1.61	1.50	1.48	1.36
General machinery	1.85	1.90	2.10	2.34	2.57	2.59	2.74	2.77	2.99	2.60	2.83
Electrical machinery	3.55	3.71	4.06	4.52	4.70	4.55	5.10	5.50	5.61	5.53	5.89
Elect. machin. ect.	3.19	3.35	3.80	4.17	4.40	4.45	4.82	5.23	5.26	5.25	5.47
Electronics	3.91	3.94	4.21	4.72	4.85	4.60	5.25	5.63	5.78	5.66	6.10
Transport equipment	2.36	2.34	2.62	2.69	2.66	2.76	2.90	3.21	3.22	3.31	3.40
Motor vehicles	2.51	2.38	2.82	3.02	2.89	2.90	2.96	3.20	3.17	3.31	3.48
Other transport equip.	1.85	2.15	1.94	1.67	1.86	2.20	2.61	3.28	3.45	3.31	2.93
Precision instruments	2.96	3.02	3.47	3.97	4.02	4.08	4.49	4.59	4.91	4.85	5.16
Other manufacturing	1.00	1.26	1.20	1.42	1.40	0.92	0.97	1.07	1.12	1.14	1.19
Transport, communication	1.20	0.89	0.94	0.80	1.04	0.92	1.07	1.00	0.87	0.98	1.09

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

Table 4-2-9 Trends of Ratio of R&D Scientists and Engineers to 10,000 Employees

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
All industry	130	147	160	188	206	197	222	209	237	240	254
Agri., Forest. & Fish.	40	102	65	32	41	38	65	146	102	192	79
Mining	60	77	60	81	80	117	102	90	95	88	135
Construction	60	88	125	85	86	99	107	109	129	109	122
Manufacturing	160	180	194	211	230	246	277	258	296	301	320
Food	120	144	140	113	149	142	146	145	146	146	145
Textiles	70	80	81	83	72	119	110	104	113	78	112
Pulp & paper products	90	111	92	123	125	157	132	97	131	133	151
Printing & publishing	60	89	83	63	59	69	72	76	81	65	93
Chemical products	340	345	385	409	441	445	453	472	507	550	980
Industrial chemical	280	284	316	338	365	360	373	384	419	473	493
Oils & paints	530	590	615	594	683	661	765	720	349	816	905
Drugs & medicines	410	417	439	520	519	508	535	562	610	592	622
Other chemicals	380	380	411	449	428	512	404	460	479	539	534
Petroleum & coal products	150	139	137	467	168	190	193	212	218	214	231
Plastic products											
Rubber products	140	129	133	144	155	137	173	215	223	206	284
Cheramics	110	112	113	128	142	163	158	148	187	172	166
Iron & steel	80	83	87	94	99	107	108	103	108	121	126
Non-ferrous metals	130	134	156	171	179	174	180	185	189	209	222
Fabricated metal products	100	115	120	97	157	146	166	164	205	218	177
General machinery	130	145	159	177	186	203	336	231	251	261	268
Electrical machinery	250	278	316	367	367	422	484	495	554	584	617
Elect. machin. ect.	210	228	263	320	338	409	426	455	498	508	550
Electronics	280	330	363	414	398	434	542	531	604	659	681
Transport equipment	120	132	144	162	168	178	188	177	219	225	251
Motor vehicles	150	151	158	182	192	224	212	167	240	249	272
Other transport equip.	70	95	113	121	138	122	151	200	185	183	208
Precision instruments	190	180	210	230	344	323	300	326	324	383	394
Other manufacturing	100	116	114	132	160	192	191	196	200	210	208
Transport, communication	20	25	27	25	28	32	36	32	33	36	34

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
All industry	261	277	287	301	340	345	382	426	441	456	476
Agri., Forest. & Fish.	181	78	63	100	75	71	124	119	138	183	171
Mining	143	117	107	150	19	173	235	249	280	279	252
Construction	119	111	115	112	141	121	122	151	152	149	135
Manufacturing	323	348	359	390	421	432	468	508	537	556	577
Food	154	191	190	202	200	185	225	241	232	215	230
Textiles	177	125	145	149	159	162	213	186	237	208	280
Pulp & paper products	147	149	162	174	216	192	172	200	204	202	201
Printing & publishing	74	67	77	99	74	133	108	130	134	165	136
Chemical products	567	588	637	656	697	719	784	808	849	899	938
Industrial chemical	499	527	557	598	628	654	711	746	804	839	853
Oils & paints	717	809	864	901	907	962	964	989	1090	1145	1172
Drugs & medicines	628	638	662	645	703	725	796	784	819	829	875
Other chemicals	527	536	656	662	718	715	821	874	847	1013	1088
Petroleum & coal products	242	356	262	283	315	312	394	426	461	488	455
Plastic products						384	338	388	365	420	377
Rubber products	327	311	359	360	357	377	392	413	418	418	481
Cheramics	228	209	214	234	277	276	355	335	362	381	372
Iron & steel	128	142	143	150	159	168	177	197	224	232	247
Non-ferrous metals	231	242	249	301	280	320	316	317	329	356	349
Fabricated metal products	189	227	206	236	209	246	260	303	293	273	255
General machinery	309	299	320	333	388	407	425	418	469	452	472
Electrical machinery	553	609	632	698	727	714	767	830	862	935	978
Elect. machin. ect.	462	531	542	604	617	621	647	664	682	701	770
Electronics	656	659	691	756	793	768	836	921	958	1065	1094
Transport equipment	257	275	279	281	318	335	325	394	438	437	445
Motor vehicles	273	296	298	303	344	354	331	402	453	450	458
Other transport equip.	218	223	236	231	256	282	304	362	382	382	388
Precision instruments	406	405	437	515	541	650	664	666	670	704	831
Other manufacturing	159	249	252	236	289	217	257	288	358	320	315
Transport, communication	36	36	35	39	39	44	56	71	51	54	64

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

Table 4-2-10 Number of R&D Laboratories in Majour Enterprises

[Industry]	Number of R&D laboratories by subject field												All fields	Number of R&D laboratories				Number of enterprises
	Electricity	Information	Machinery	Chemistry	Bio	Natural resources	Metal	Aerospace	Const. & Civil eng.	Physics	Others	Social science			Under the direct control	Financing (com-pany)	(corpo-ration)	
Agriculture				1	6				2		1		10	8	7	1	0	5
Mining			1	1		1	2						5	5	5	0	0	2
Construction	10	6	14	6	11	5	11	4	64	4	6	3	144	78	68	6	4	61
Food			3	16	46		1			3	23	1	93	69	64	2	3	36
Textiles	8	3	7	25	11		3	1	1	1	19	2	81	59	53	6	0	23
Pulp & paper	1		3	12	7	1	1		1	4	7		37	21	18	3	0	11
Chemical products	64	18	14	189	114	9	6	5	7	14	45	2	487	325	295	23	7	94
Industrial chemical	47	14	8	127	52	7	5	3	5	7	9		284	168	149	17	2	49
Drugs & medicines	14	1		23	35					1	20	1	95	96	91	2	3	26
Oil,paints,detergent,ink	1	3	5	20	14	2	1	2	2	6	2	1	59	28	27	0	1	9
Other chemicals	2		1	19	13						14		49	33	28	4	1	10
Petroleum				5	4		5				2	1	17	5	5	0	0	4
Rubber products			1	3					1		1		6	5	5	0	0	5
Cheramics	10	1	4	12	6	3	3	3	7	2	16	3	70	37	32	3	2	20
Iron & steel	12	3	10	8	4	30	4	1	1	5	8		86	54	45	8	1	18
Non-ferrous metals	21	9	14	16	7	24	12	3	5	8	7		126	62	52	8	2	27
General machinery	26	9	47	13	7	18	7	5	2	7	7	2	150	62	56	5	1	39
Electrical machinery	137	80	46	24	18	13	17	7	1	14	16	4	377	120	102	15	3	59
Ship building	5	5	9	7	6	6	5	4	4	3	4	1	59	13	12	0	1	5
Other transport equip.			1								1		2	1	1	0	0	1
Motor vehicles	11	4	18	7	3	6	2	1	1	3	11	1	68	33	21	8	4	21
Precision instruments	15	14	17	8	4	1		1	1	6	4		71	33	29	4	0	15
Other manufacturing	9	6	5	10	3	4	2		2	6	5	1	53	21	21	0	0	9
Transport, communication	5	17			3			1	1		11	1	39	29	14	14	1	3
Electric power	7	5	5	6	5	5	11		6	3	4	1	58	14	13	1	0	8
Gas	1	1	1	1	3	1	4				6	2	20	12	11	1	0	4
Total	406	199	234	559	382	136	102	41	114	97	249	27	2,546	1,066	929	108	29	564

Note: Number of laboratories by subject field are counted across each subject field repeatedly.

Source: Nihon Keizai Shinbun Inc., "NIKKEI Company Information" 1990

Table 4-3-1 Trends of R&D Expenditures in Colleges and Universities (by establishing academic body and by academic field)

Fiscal Year	R&D expenditures (Million Yen) National college/Univ.	Local government college/Univ.	Private	Total	All natural sciences and engineering fields	Natural sciences	Engineering	Agricaltural	Health sciences	Arts,humanities,social sciences and others
1959	30,454	3,730	14,513	48,696	27,563	5,296	8,312	3,649	10,306	21,079
1960	31,400	5,027	16,057	52,485	30,637	4,951	11,013	4,476	10,198	21,847
1961	40,200	6,346	23,195	69,741	41,454	7,079	15,408	5,490	13,439	28,259
1962	50,771	7,887	31,353	90,012	54,131	9,217	21,349	6,645	16,919	35,877
1963	59,360	8,629	39,141	107,130	62,661	10,220	25,030	7,718	19,693	44,469
1964	71,019	9,379	49,165	129,563	77,304	10,469	34,853	9,419	22,562	52,259
1965	87,059	13,242	83,342	183,643	105,048	16,071	42,047	11,408	35,522	78,595
1966	105,573	12,577	83,765	201,914	118,856	17,795	49,986	13,244	37,832	83,058
1967	121,235	14,109	94,093	229,436	138,865	18,402	57,095	15,136	48,231	90,572
1968	131,890	17,540	109,033	258,463	155,831	17,456	61,049	16,437	60,889	102,632
1969	147,823	20,205	131,206	299,233	177,449	21,904	71,411	19,576	64,558	121,785
1970	179,040	25,369	161,468	365,877	217,444	25,705	83,709	22,967	85,062	148,433
1971	195,487	29,461	198,494	423,441	250,433	28,415	95,396	26,400	100,222	173,009
1972	215,131	32,368	231,185	478,684	288,896	30,291	105,271	29,314	124,020	189,788
1973	254,889	36,791	282,483	574,163	358,229	38,098	122,200	33,409	164,522	215,934
1974	333,171	44,029	340,385	717,585	445,241	54,798	156,415	41,638	192,390	272,344
1975	381,472	48,788	409,538	839,798	516,281	65,465	185,149	45,604	220,063	323,517
1976	415,654	51,406	466,955	934,016	587,654	76,786	201,839	50,058	258,970	346,362
1977	455,191	57,578	499,528	1,012,297	629,698	95,016	222,007	55,602	257,073	382,600
1978	518,622	58,042	574,411	1,151,074	712,618	105,288	249,097	60,477	297,756	438,456
1979	560,089	64,970	633,268	1,258,326	777,683	116,618	274,836	66,220	320,009	480,644
1980	594,339	67,734	678,001	1,340,074	823,900	109,394	301,575	70,946	341,985	516,174
1981	643,472	72,582	729,591	1,445,645	885,359	131,467	319,279	72,245	362,368	560,286
1982	675,850	75,986	788,586	1,540,422	948,211	142,574	330,106	75,731	399,800	592,212
1983	711,364	78,097	860,184	1,649,646	1,028,356	147,985	358,749	80,672	440,951	621,290
1984	749,826	81,964	892,398	1,724,187	1,063,775	155,118	370,732	86,935	450,990	660,412
1985	756,686	88,645	944,449	1,789,780	1,075,410	162,031	371,364	85,337	456,678	714,369
1986	786,462	90,608	955,505	1,832,575	1,121,864	163,376	393,056	88,030	477,403	710,711
1987	843,900	96,756	1,017,264	1,957,921	1,209,579	175,609	431,438	91,551	510,982	748,342
1988	860,678	97,888	1,055,508	2,014,073	1,239,551	179,200	444,840	92,435	523,076	774,523
1989	899,221	114,331	1,115,819	2,129,372	1,311,631	187,047	481,826	99,800	542,957	817,741

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

Table 4-3-2 Numerical Trends of R&D Scientists and Engineers in Colleges and Universities (by establishing academic body and academic field)

Fiscal Year	R&D scientists and engineers: National college/Univ.	Local government college/Univ.	Private	Total	All natural sciences and engineering fields	Natural sciences	Engineering	Agricaltural	Health sciences	Arts, humanities, social sciences and others
1961	28,550	5,552	24,267	58,369	28,255	3,533	7,677	3,906	13,121	30,114
1962	27,818	5,672	18,931	52,421	28,337	3,769	8,037	3,880	12,642	24,055
1963	31,446	5,941	22,992	60,379	33,421	4,078	9,403	3,869	16,097	26,928
1964	33,538	5,975	25,401	64,914	36,430	4,693	10,601	4,172	16,956	28,484
1965	35,416	6,208	27,072	68,696	39,133	4,245	13,606	4,281	17,001	29,563
1966	36,473	7,192	31,846	75,511	43,625	5,114	13,923	4,221	20,367	31,886
1967	41,781	6,747	36,823	85,351	48,549	5,833	16,058	4,564	22,094	36,802
1968	46,425	7,538	39,926	93,889	54,280	5,607	18,466	4,994	25,213	39,609
1969	45,182	6,865	40,750	92,797	52,373	5,469	18,045	4,925	23,934	40,424
1970	47,323	7,286	44,804	99,413	55,240	6,717	20,001	5,438	23,084	44,173
1971	49,563	7,491	48,139	105,193	59,747	6,686	21,119	5,721	26,221	45,446
1972	50,650	7,328	49,140	107,118	60,503	6,505	22,178	5,783	26,037	46,615
1973	59,031	10,128	55,983	125,142	75,159	7,964	23,716	6,296	37,183	49,983
1974	62,079	9,838	58,350	130,267	79,199	8,362	24,587	6,562	39,688	51,068
1975	63,129	10,144	61,185	134,458	81,908	8,246	24,896	6,663	42,103	52,550
1976	66,842	10,639	64,348	141,829	88,024	9,313	27,048	6,797	44,866	53,805
1977	69,167	11,068	67,119	147,354	92,779	10,135	27,515	6,906	48,223	54,575
1978	68,119	10,682	68,161	146,962	91,508	10,845	27,149	6,636	46,878	55,454
1979	70,856	10,589	71,812	153,257	96,724	10,634	27,501	7,170	51,419	56,533
1980	74,586	10,915	72,945	158,446	100,700	10,994	27,820	7,175	54,711	57,746
1981	75,002	10,870	74,991	160,863	102,592	10,659	28,272	7,068	56,593	58,271
1982	76,050	11,094	76,120	163,264	104,112	10,996	27,592	7,065	58,459	59,152
1983	79,148	11,751	79,204	170,103	109,930	11,177	28,102	7,213	63,438	60,173
1984	81,622	12,008	82,211	175,841	114,183	11,365	28,519	7,210	67,089	61,658
1985	83,576	12,206	84,824	180,606	118,018	11,491	28,805	7,241	70,481	62,588
1986	84,988	12,342	87,740	185,070	121,324	11,572	29,354	7,452	72,946	63,746
1987	86,915	12,651	90,031	189,597	124,234	11,534	30,094	7,409	75,197	65,363
1988	89,413	12,847	93,168	195,428	128,109	11,857	30,983	7,518	77,751	67,319
1989	91,417	13,256	96,057	200,730	131,722	12,214	32,282	7,696	79,530	69,008
1990	93,751	13,423	98,335	205,509	134,133	12,528	33,279	7,779	80,547	71,376

Sources:Statistic Bureau, Management and Coodination Agency, Japan, "Report on the Survey of Research and Development".

Table 4-3-3 Trends of R&D Expenditures per R&D Scientists and Engineers in Colleges and Universities (by establishement academic body by academic field)

Fiscal Year	R&D expenditures per R&D S/E (Thousand Yen/Person) National college/Univ.	Local government college/Univ.	Private	Total	All natural sciences and engineering fields	Natural sciences	Engineering	Agricaltural	Health sciences	Arts, humanities, social sciences and others
1961	1,408	1,143	956	1,195	1,467	2,004	2,007	1,406	1,024	938
1962	1,825	1,391	1,656	1,717	1,910	2,445	2,656	1,713	1,338	1,491
1963	1,888	1,452	1,702	1,774	1,875	2,506	2,662	1,995	1,223	1,651
1964	2,118	1,570	1,936	1,996	2,122	2,231	3,288	2,258	1,331	1,835
1965	2,458	2,133	3,079	2,673	2,684	3,786	3,090	2,665	2,089	2,659
1966	2,895	1,749	2,630	2,674	2,724	3,480	3,590	3,138	1,858	2,605
1967	2,902	2,091	2,555	2,688	2,860	3,155	3,556	3,316	2,183	2,461
1968	2,841	2,327	2,731	2,753	2,871	3,113	3,306	3,291	2,415	2,591
1969	3,272	2,943	3,220	3,225	3,388	4,005	3,957	3,975	2,697	3,013
1970	3,783	3,482	3,604	3,680	3,936	3,827	4,185	4,223	3,685	3,360
1971	3,944	3,933	4,123	4,025	4,192	4,250	4,517	4,615	3,822	3,807
1972	4,247	4,417	4,705	4,469	4,775	4,657	4,747	5,069	4,763	4,071
1973	4,318	3,633	5,046	4,588	4,766	4,784	5,153	5,306	4,425	4,320
1974	5,367	4,475	5,834	5,509	5,622	6,553	6,362	6,345	4,848	5,333
1975	6,043	4,810	6,693	6,246	6,303	7,939	7,437	6,844	5,227	6,156
1976	6,218	4,832	7,257	6,586	6,676	8,245	7,462	7,365	5,772	6,437
1977	6,581	5,202	7,442	6,870	6,787	9,375	8,069	8,051	5,331	7,011
1978	7,613	5,434	8,427	7,832	7,787	9,708	9,175	9,113	6,352	7,907
1979	7,905	6,136	8,818	8,211	8,040	10,967	9,994	9,236	6,224	8,502
1980	7,969	6,206	9,295	8,458	8,182	9,950	10,840	9,888	6,251	8,939
1981	8,579	6,677	9,729	8,987	8,630	12,334	11,293	10,221	6,403	9,615
1982	8,887	6,849	10,360	9,435	9,108	12,966	11,964	10,719	6,839	10,012
1983	8,988	6,646	10,860	9,698	9,355	13,240	12,766	11,184	6,951	10,325
1984	9,187	6,826	10,855	9,805	9,316	13,649	12,999	12,058	6,722	10,711
1985	9,054	7,262	11,134	9,910	9,112	14,101	12,892	11,785	6,479	11,414
1986	9,254	7,341	10,890	9,902	9,247	14,118	13,390	11,813	6,545	11,149
1987	9,709	7,648	11,299	10,327	9,736	15,225	14,336	12,357	6,795	11,449
1988	9,626	7,620	11,329	10,306	9,676	15,113	14,358	12,295	6,728	11,505
1989	9,836	8,625	11,616	10,608	9,958	15,314	14,926	12,968	6,827	11,850

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

Table 4-4-1 Trends of R&D Expenditures in Governmental Institutes and R&D Foundations

Fiscal Year	R&D expenditures (Million Yen) National	Local governmental	Private	Semi-governmental	Total	Shares [%] National	Local governmental	Private	Semi-governmental
1959	12,432	8,345	6,028	-	26,804	46.4	31.1	22.5	-
1960	16,875	8,522	4,022	4,589	34,008	49.6	25.1	11.8	13.5
1961	19,090	12,102	4,492	6,266	41,950	45.5	28.8	10.7	14.9
1962	20,507	16,267	6,040	7,001	49,815	41.2	32.7	12.1	14.1
1963	22,584	18,024	6,957	6,264	53,829	42.0	33.5	12.9	11.6
1964	27,197	22,269	8,680	6,573	64,720	42.0	34.4	13.4	10.2
1965	31,101	24,875	9,295	7,322	72,593	42.8	34.3	12.8	10.1
1966	36,182	29,291	10,303	6,765	82,540	43.8	35.5	12.5	8.2
1967	38,768	33,700	11,286	10,324	94,078	41.2	35.8	12.0	11.0
1968	44,338	38,885	11,987	19,462	114,673	38.7	33.9	10.5	17.0
1969	47,349	45,342	17,842	26,535	137,068	34.5	33.1	13.0	19.4
1970	54,562	57,481	18,838	35,482	166,363	32.8	34.6	11.3	21.3
1971	61,362	67,648	23,325	61,575	213,911	28.7	31.6	10.9	28.8
1972	71,736	76,303	25,424	94,797	268,260	26.7	28.4	9.5	35.3
1973	86,959	95,527	32,088	125,174	339,747	25.6	28.1	9.4	36.8
1974	108,784	115,215	84,236	101,158	409,394	26.6	28.1	20.6	24.7
1975	124,132	118,750	85,923	121,124	449,928	27.6	26.4	19.1	26.9
1976	130,195	124,922	101,902	147,420	504,438	25.8	24.8	20.2	29.2
1977	148,171	139,287	88,831	153,232	529,522	28.0	26.3	16.8	28.9
1978	164,070	145,281	100,831	193,606	603,788	27.2	24.1	16.7	32.1
1979	186,925	159,938	94,604	218,924	660,391	28.3	24.2	14.3	33.2
1980	194,293	177,176	145,540	246,908	763,918	25.4	23.2	19.1	32.3
1981	201,256	191,162	245,521	268,979	906,918	22.2	21.1	27.1	29.7
1982	203,343	189,702	276,178	280,038	949,260	21.4	20.0	29.1	29.5
1983	208,767	191,567	279,651	291,025	971,010	21.5	19.7	28.8	30.0
1984	215,853	199,622	307,425	310,209	1,033,110	20.9	19.3	29.8	30.0
1985	235,950	206,935	349,812	367,874	1,160,571	20.3	17.8	30.1	31.7
1986	244,828	209,212	399,971	386,183	1,240,194	19.7	16.9	32.3	31.1
1987	308,246	215,583	441,273	419,348	1,384,452	22.3	15.6	31.9	30.3
1988	272,506	223,677	458,925	439,072	1,394,180	19.5	16.0	32.9	31.5
1989	284,261	240,902	498,535	428,592	1,452,290	19.6	16.6	34.3	29.5

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

Table 4-4-2 Trends of R&D Scientists and Engineers in Governmental Institutions and R&D Foundations

Fiscal Year	R&D S/E (Number of person) National	Local governmental	Private	Semi-governmental	Total	Shares [%] National	Local governmental	Private	Semi-governmental
1961	7,506	6,710	1,930	710	16,856	44.5	39.8	11.4	4.2
1962	7,838	7,749	1,357	730	17,674	44.3	43.8	7.7	4.1
1963	8,275	8,787	1,545	783	19,390	42.7	45.3	8.0	4.0
1964	8,383	8,933	1,521	841	19,678	42.6	45.4	7.7	4.3
1965	8,878	9,687	1,647	933	21,145	42.0	45.8	7.8	4.4
1966	8,896	10,045	1,781	838	21,560	41.3	46.6	8.3	3.9
1967	9,127	10,645	1,673	1,119	22,564	40.4	47.2	7.4	5.0
1968	9,174	11,171	1,881	1,193	23,419	39.2	47.7	8.0	5.1
1969	9,353	11,467	1,910	1,350	24,080	38.8	47.6	7.9	5.6
1970	9,308	11,951	2,166	1,441	24,866	37.4	48.1	8.7	5.8
1971	9,668	12,282	2,294	1,474	25,718	37.6	47.8	8.9	5.7
1972	9,701	13,424	2,566	1,737	27,428	35.4	48.9	9.4	6.3
1973	9,800	14,116	2,619	2,714	29,249	33.5	48.3	9.0	9.3
1974	9,730	15,099	2,726	3,585	31,140	31.2	48.5	8.8	11.5
1975	9,817	14,581	2,641	2,010	29,049	33.8	50.2	9.1	6.9
1976	9,897	14,762	3,043	2,113	29,815	33.2	49.5	10.2	7.1
1977	9,948	14,743	3,883	2,082	30,656	32.5	48.1	12.7	6.8
1978	10,262	14,835	3,551	2,151	30,799	33.3	48.2	11.5	7.0
1979	10,281	14,785	3,637	2,249	30,952	33.2	47.8	11.8	7.3
1980	10,465	15,204	3,771	2,404	31,844	32.9	47.7	11.8	7.5
1981	10,706	15,497	4,861	2,589	33,653	31.8	46.0	14.4	7.7
1982	10,704	15,655	7,408	2,652	36,419	29.4	43.0	20.3	7.3
1983	10,795	15,269	5,971	2,767	34,802	31.0	43.9	17.2	8.0
1984	10,777	15,287	6,856	2,697	35,617	30.3	42.9	19.2	7.6
1985	10,641	15,464	7,198	2,713	36,016	29.5	42.9	20.0	7.5
1986	10,770	15,340	7,565	2,780	36,455	29.5	42.1	20.8	7.6
1987	10,697	15,294	8,427	2,918	37,336	28.7	41.0	22.6	7.8
1988	10,766	15,004	9,632	3,139	38,541	27.9	38.9	25.0	8.1
1989	10,899	15,215	10,788	3,174	40,076	27.2	38.0	26.9	7.9

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

Table 5-1-1 Regional Distribution of Private R&D Facilities

Region	Number of facilities	Shares (%)
Hokkaido	33	1.0
Tohoku	54	1.7
Kanto	472	14.8
TRA(*)	1180	37.1
Hokuriku	94	3.0
Tokai	407	12.8
Kinki	675	21.2
Chugoku	129	4.1
Sikoku	35	1.1
Kyusyu	100	3.1
All Japan	3179	100

(*)TRA:Tokyo Regional Area

Source:NISTEP

Table 5-1-2 Number of Private R&D Facilities by Founder's Year

	Hokkaido	Tohoku	Kanto	TRA(*)	Hokuriku	Tokai	Kinki	Chugoku	Sikoku	Kyusyu	Total
Before 1940	0	1	7	17	5	4	14	4	0	1	53
1940's	2	4	6	26	2	9	15	1	5	1	71
1950's	4	1	14	45	2	21	29	8	0	3	127
1960's	4	2	39	61	1	37	51	13	1	2	211
1970's	3	2	25	45	5	25	29	6	2	8	150
1980's	1	7	50	73	6	33	27	10	5	7	219
Total	14	17	141	267	21	129	165	42	13	22	831

(*)TRA:Tokyo Regional Area

Source:NISTEP

Table 5-2-1 Regional Distribution of Engineering Faculties of College/Univ. by Size of Teaching Staff

Number of departments	Less than 50 persons	50～100 persons	100～200 persons	200～300 persons	More than 300 persons	Total
Hokkaido	2	0	3	0	1	6
Tohoku	0	2	4	0	1	7
Kanto	1	1	7	1	0	10
TRA(*)	5	5	11	5	3	29
Hokuriku	0	1	6	0	0	7
Tokai	1	2	6	0	2	11
Kinki	0	4	8	2	2	16
Chugoku	1	4	3	1	0	9
Sikoku	0	0	2	0	0	2
Kyusyu	2	14	5	0	1	22
All Japan	12	33	55	9	10	119

Percentage	Less than 50 persons	50～100 persons	100～200 persons	200～300 persons	More than 300 persons	Total
Hokkaido	16.7	0.0	5.5	0.0	10.0	5.0
Tohoku	0.0	6.1	7.3	0.0	10.0	5.9
Kanto	8.3	3.0	12.7	11.1	0.0	8.4
TRA(*)	41.7	15.2	20.0	55.6	30.0	24.4
Hokuriku	0.0	3.0	10.9	0.0	0.0	5.9
Tokai	8.3	6.1	10.9	0.0	20.0	9.2
Kinki	0.0	12.1	14.5	22.2	20.0	13.4
Chugoku	8.3	12.1	5.5	11.1	0.0	7.6
Sikoku	0.0	0.0	3.6	0.0	0.0	1.7
Kyusyu	16.7	42.4	9.1	0.0	10.0	18.5
All Japan	100	100	100	100	100	100

(*)TRA:Tokyo Regional Area

Source:NISTEP

Table 5-2-2 Regional Distribution of Teaching Stuff of Engineering Faculties of College/Unive

Number of teaching stuff	Less than 50 persons	50～100 persons	100～200 persons	200～300 persons	More than 300 persons	Total
Hokkaido	62	0	421	0	405	888
Tohoku	0	170	563	0	403	1140
Kanto	36	90	944	219	0	1290
TRA(*)	192	402	1610	1110	1380	4700
Hokuriku	0	85	862	0	0	947
Tokai	45	177	831	0	713	1770
Kinki	0	282	1160	451	954	2850
Chugoku	22	273	337	250	0	882
Sikoku	0	0	222	0	0	222
Kyusyu	60	1010	709	0	417	2200
All Japan	417	2490	7660	2030	4270	16900

Percentage	Less than 50 persons	50～100 persons	100～200 persons	200～300 persons	More than 300 persons	Total
Hokkaido	14.9	0.0	5.5	0.0	9.5	5.3
Tohoku	0.0	6.8	7.3	0.0	9.4	6.7
Kanto	8.6	3.6	12.3	10.8	0.0	7.6
TRA(*)	46.0	16.1	21.0	54.7	32.3	27.8
Hokuriku	0.0	3.4	11.3	0.0	0.0	5.6
Tokai	10.8	7.1	10.8	0.0	16.7	10.5
Kinki	0.0	11.3	15.1	22.2	22.3	16.9
Chugoku	5.3	11.0	4.4	12.3	0.0	5.2
Sikoku	0.0	0.0	2.9	0.0	0.0	1.3
Kyusyu	14.4	40.6	9.3	0.0	9.8	13.0
All Japan	100	100	100	100	100	100

(*)TRA:Tokyo Regional Area

Source:NISTEP

Table 5-3-1 Regional Distribution of R&D Scientists and Engineers

	Number of R&E S/E	Shares(%)
Hokkaido	161	0.3
Tohoku	401	0.6
Kanto	9440	14.8
TRA(*)	26200	41.1
Hokuriku	860	1.4
Tokai	8820	13.8
Kinki	12900	20.3
Chugoku	2750	4.3
Sikoku	470	0.7
Kyusyu	1700	2.7
All Japan	63700	100

(*)TRA:Tokyo Regional Area

Source:NISTEP

Table 5-3-2 Regional Distribution of R&D Expenditures

	R&D expenditures (Million Yen)	Shares(%)
Hokkaido	2610	0.2
Tohoku	14600	1.0
Kanto	257000	16.9
TRA(*)	551000	36.3
Hokuriku	12100	0.8
Tokai	221000	14.5
Kinki	303000	19.9
Chugoku	106000	7.0
Sikoku	11900	0.8
Kyusyu	38000	2.5
All Japan	1520000	100

(*)TRA:Tokyo Regional Area

Source:NISTEP

Table 5-3-3 Correlation between R&D S/E and R&D Expenditures by Region

	Shares of R&D S/E (%)	Shares of R&D expenditures (%)
Hokkaido	0.3	0.2
Tohoku	0.7	1.0
Kanto	12.1	13.8
TRA(*)	42.5	37.6
Hokuriku	1.4	0.8
Tokai	14.3	15.1
Kinki	20.9	20.7
Chugoku	4.4	7.3
Sikoku	0.8	0.8
Kyusyu	2.7	2.6
All Japan	100	100

(*)TRA:Tokyo Regional Area

Source:NISTEP

Table 5-3-4 Distribution of the Age of R&D S/E

	Under 25 years of age	The age of 25～34	The age of 35～44	The age of 45～54	The age of 55 and over	Total
Kanto	946	3770	2690	1310	185	8901
TRA(*)	3090	10800	7160	3330	562	24942
Tokai	979	3220	2180	882	155	7416
Kinki	1580	5230	3930	1780	320	12840
All Japan	7460	25600	17600	8260	1390	60310

Percentage	Under 25 years of age	The age of 25～34	The age of 35～44	The age of 45～54	The age of 55 and over	Total
Kanto	10.6	42.4	30.2	14.7	2.1	100
TRA(*)	12.4	43.3	28.7	13.4	2.3	100
Tokai	13.2	43.4	29.4	11.9	2.1	100
Kinki	12.3	40.7	30.6	13.9	2.5	100
All Japan	12.4	42.4	29.2	13.7	2.3	100

(*)TRA:Tokyo Regional Area

Source:NISTEP

Table 5-3-5 Number of R&D S/E by Characteristics of Work

	Basic research	Applied research	Development	Total
Kanto	878	2940	4800	8618
TRA(*)	2750	10100	12800	25650
Tokai	640	2280	4500	7420
Kinki	937	4450	7350	12737
All Japan	5830	21700	33100	60630

Percentage	Basic research	Applied research	Development	Total
Kanto	10.2	34.1	55.7	100
TRA(*)	10.7	39.4	49.9	100
Tokai	8.6	30.7	60.6	100
Kinki	7.4	34.9	57.7	100
All Japan	9.6	35.8	54.6	100

(*)TRA:Tokyo Regional Area

Source:NISTEP

Table 5-3-6 R&D Expenditures by Characteristics of Work

(Unit:100 Million Yen)

	Basic research	Applied research	Development	Total
Kanto	280	833	1,300	2,413
TRA(*)	546	2,090	2,820	5,456
Tokai	132	602	1,470	2,204
Kinki	263	973	1,790	3,026
All Japan	1,221	4,498	7,380	13,099

Percentage	Basic research	Applied research	Development	Total
Kanto	11.6	34.5	53.9	100
TRA(*)	10.0	38.3	51.7	100
Tokai	6.0	27.3	66.7	100
Kinki	8.7	32.2	59.2	100
All Japan	9.3	34.3	56.3	100

(*)TRA:Tokyo Regional Area

Source:NISTEP

Table 5-3-7 Number of R&D S/E by Field

	Chemical /Fiber	Biol./Medical /Medicine	Material	Machanical engineering	Electric /Electronics	Construction	Multiple fields	Others	Total
Kanto	1220	1760	1480	1090	2320	355	498	300	9023
TRA(*)	2280	2290	2710	4440	9370	1800	1440	1270	25600
Tokai	1470	836	130	1430	1950	106	191	135	6248
Kinki	1880	929	1900	2500	3930	543	400	565	12647
All Japan	7620	6780	8200	11100	18900	2940	2730	2780	61050

Percentage	Chemical /Fiber	Biol./Medical /Medicine	Material	Machanical engineering	Electric /Electronics	Construction	Multiple fields	Others	Total
Kanto	13.5	19.5	16.4	12.1	25.7	3.9	5.5	3.3	100
TRA(*)	8.9	8.9	10.6	17.3	36.6	7.0	5.6	5.0	100
Tokai	23.5	13.4	2.1	22.9	31.2	1.7	3.1	2.2	100
Kinki	14.9	7.3	15.0	19.8	31.1	4.3	3.2	4.5	100
All Japan	12.5	11.1	13.4	18.2	31.0	4.8	4.5	4.6	100

(*)TRA:Tokyo Regional Area

Source:NISTEP

Table 5-3-8 R&D Expenditures by Field

(Unit:100 Million Yen)

	Chemical /Fiber	Biol./Medical /Medicine	Material	Machanical engineering	Electric /Electronics	Construction	Multiple fields	Others	Total
Kanto	479	345	432	234	478	88	95	68	2219
TRA(*)	476	504	554	650	1980	432	350	180	5126
Tokai	231	143	225	389	457	36	106	41	1628
Kinki	572	172	620	426	912	95	109	123	3029
All Japan	1980	1350	2010	2310	4160	679	763	520	13772

Percentage	Chemical /Fiber	Biol./Medical /Medicine	Material	Machanical engineering	Electric /Electronics	Construction	Multiple fields	Others	Total
Kanto	21.6	15.5	19.5	10.5	21.5	4.0	4.3	3.1	100
TRA(*)	9.3	9.8	10.8	12.7	38.6	8.4	6.8	3.5	100
Tokai	14.2	8.8	13.8	23.9	28.1	2.2	6.5	2.5	100
Kinki	18.9	5.7	20.5	14.1	30.1	3.1	3.6	4.1	100
All Japan	14.4	9.8	14.6	16.8	30.2	4.9	5.5	3.8	100

(*)TRA:Tokyo Regional Area

Source:NISTEP

Table 5-3-9 Correlation between Industrial Outputs and R&D Expenditures

	Share of industrial outputs (%)	Share of R&D expenditures (%)
Hokkaido	2.0	0.1
Tohoku	4.7	0.4
Kanto	17.5	18.5
TRA(*)	16.3	33.5
Hokuriku	3.9	0.9
Tokai	21.6	14.9
Kinki	18.2	21.4
Chugoku	7.3	7.9
Sikoku	2.5	0.7
Kyushu	5.9	2.0
All Japan	100	100

(*)TRA:Tokyo Regional Area

Source:NISTEP

Table 6-1-1 Trends in the Output of Scientific Papers of Selected Countries

Year	Number of scientific papers								World
	U.S.	Japan	U.K.	W.Ger	France	USSR	Canada	Others	
1973	103,778	14,265	25,001	16,400	15,082	24,418	11,905	60,664	271,513
1974	100,066	13,884	24,526	17,105	14,830	21,806	11,621	61,291	265,130
1975	97,277	14,081	24,780	16,604	15,020	20,649	11,321	61,177	260,908
1976	99,970	15,470	24,503	17,099	14,639	21,129	11,566	62,978	267,354
1977	97,853	15,767	23,527	16,693	14,873	20,750	11,578	62,656	263,699
1978	99,207	16,878	23,156	18,044	13,728	22,175	11,329	65,609	270,127
1979	99,378	17,167	22,289	16,811	14,212	21,401	11,656	65,041	267,954
1980	98,394	18,379	22,362	16,796	14,550	21,158	11,123	66,793	269,556
1981	132,864	25,105	30,861	23,230	18,584	29,615	14,511	95,137	369,907
1982	134,278	25,858	30,934	23,054	18,308	30,361	14,695	95,336	372,822
1983	133,055	26,391	31,309	22,532	17,839	30,900	15,146	97,505	374,678
1984	131,604	27,014	30,241	22,038	17,938	29,392	15,660	96,846	370,733
1985	137,771	29,617	32,256	23,859	18,421	30,293	16,655	100,972	389,845
1986	137,770	29,757	31,711	22,607	18,846	29,257	16,823	100,256	387,027

Year	Share of scientific papers [%]								World
	U.S.	Japan	U.K.	W.Ger	France	USSR	Canada	Others	
1973	38.2	5.3	9.2	6.0	5.6	9.0	4.4	22.3	100.0
1974	37.7	5.2	9.3	6.5	5.6	8.2	4.4	23.1	100.0
1975	37.3	5.4	9.5	6.4	5.8	7.9	4.3	23.4	100.0
1976	37.4	5.8	9.2	6.4	5.5	7.9	4.3	23.6	100.0
1977	37.1	6.0	8.9	6.3	5.6	7.9	4.4	23.8	100.0
1978	36.7	6.2	8.6	6.7	5.1	8.2	4.2	24.3	100.0
1979	37.1	6.4	8.3	6.3	5.3	8.0	4.3	24.3	100.0
1980	36.5	6.8	8.3	6.2	5.4	7.8	4.1	24.8	100.0
1981	35.9	6.8	8.3	6.3	5.0	8.0	3.9	25.7	100.0
1982	36.0	6.9	8.3	6.2	4.9	8.1	3.9	25.6	100.0
1983	35.5	7.0	8.4	6.0	4.8	8.2	4.0	26.0	100.0
1984	35.5	7.3	8.2	5.9	4.8	7.9	4.2	26.1	100.0
1985	35.3	7.6	8.3	6.1	4.7	7.8	4.3	25.9	100.0
1986	35.6	7.7	8.2	5.8	4.9	7.6	4.3	25.9	100.0

Source: Computer Horizons, Inc., "Science & Engineering Indicators Literature Data Base", 1989.

Note: Data for 1973-1980 are based on over 2,100 journals on the 1973 Science Citation Index Database, data for 1981-1986 are based on over 3,200 journals on the 1981 Science Citation Index Database.
· When an article is written by researchers from more than one country, that article is prorated across the number of author institutions in each country.

Table 6-1-2 Japan and U.S. Scientific and Technical Papers by Field (1): 1973-1980

	1973	1974	1975	1976	1977	1978	1979	1980
	Japan articles as a percent of all artcles							
All Fields	5.3	5.2	5.4	5.8	6.0	6.2	6.4	6.8
Clinical medicine	3.5	3.8	4.1	4.3	4.3	4.7	4.8	5.0
Biomedicine	4.0	4.2	4.3	4.8	5.3	5.4	5.3	5.9
Biology	5.3	4.9	5.3	5.5	5.7	6.3	6.0	6.5
Chemistry	9.4	8.9	8.8	9.5	10.0	9.6	10.9	10.9
Physics	6.5	6.5	6.7	7.1	7.3	7.9	8.0	8.6
Earth/space sciences	2.0	2.4	2.1	2.0	2.2	2.1	2.4	2.4
Engineering/technology	5.4	4.7	5.7	6.4	6.7	6.9	6.0	7.2
Mathematics	3.9	4.3	3.6	4.0	3.9	4.4	5.0	4.8
	Number of Japan articles							
All Fields	14,265	13,884	14,081	15,470	15,767	16,878	17,167	18,379
Clinical medicine	2,647	2,829	2,981	3,278	3,300	3,796	3,768	4,066
Biomedicine	1,632	1,718	1,781	2,017	2,195	2,312	2,318	2,618
Biology	1,284	1,158	1,244	1,312	1,346	1,469	1,472	1,486
Chemistry	4,226	3,957	3,745	4,072	4,060	4,208	4,708	4,833
Physics	2,339	2,329	2,338	2,618	2,649	2,846	2,945	3,246
Earth/space sciences	243	280	241	240	255	237	277	272
Engineering/technology	1,553	1,261	1,451	1,609	1,672	1,693	1,331	1,538
Mathematics	341	353	300	324	292	318	348	321
	U.S. articles as a percent of all artcles							
All Fields	38.2	37.7	37.3	37.4	37.1	36.7	37.1	36.5
Clinical medicine	42.8	42.5	42.6	43.0	43.2	43.1	43.1	43.0
Biomedicine	39.2	38.4	38.6	38.8	39.1	38.7	40.5	39.7
Biology	46.4	45.7	44.7	44.2	41.7	41.7	42.7	42.0
Chemistry	23.3	22.2	21.7	21.8	21.7	21.1	21.2	20.8
Physics	32.7	33.5	32.4	31.2	30.5	30.8	30.0	30.1
Earth/space sciences	46.7	46.8	43.8	46.1	45.1	44.9	44.6	42.4
Engineering/technology	41.8	41.7	40.6	41.1	40.2	39.4	40.7	39.4
Mathematics	47.9	46.0	44.0	42.9	41.1	40.4	40.5	39.7
	Number of U.S. articles							
All Fields	103,778	100,066	97,277	99,970	97,853	99,207	99,378	98,394
Clinical medicine	32,638	31,691	31,334	32,920	33,516	34,966	33,975	34,612
Biomedicine	16,115	15,607	15,901	16,271	16,197	16,611	17,649	17,582
Biology	11,150	10,700	10,401	10,573	9,904	9,664	10,553	9,594
Chemistry	10,474	9,867	9,222	9,337	8,852	9,266	9,182	9,250
Physics	11,721	11,945	11,363	11,502	10,995	11,015	10,996	11,415
Earth/space sciences	5,591	5,371	4,975	5,537	5,197	5,043	5,167	4,832
Engineering/technology	11,955	11,088	10,431	10,346	10,081	9,694	9,018	8,461
Mathematics	4,134	3,797	3,652	3,484	3,112	2,949	2,839	2,648
	Number of all articles							
All Fields	271,513	265,130	260,908	267,354	263,699	270,127	267,954	269,556
Clinical medicine	76,209	74,509	73,485	76,599	77,597	81,209	78,827	80,533
Biomedicine	41,155	40,632	41,244	41,891	41,388	42,968	43,631	44,267
Biology	24,047	23,414	23,260	23,905	23,757	23,176	24,734	22,838
Chemistry	45,004	44,529	42,502	42,773	40,734	43,850	43,273	44,448
Physics	35,864	35,708	35,104	36,902	36,057	35,815	36,700	37,944
Earth/space sciences	11,977	11,479	11,356	12,011	11,531	11,224	11,596	11,395
Engineering/technology	28,617	26,600	25,664	25,147	25,063	24,588	22,182	21,459
Mathematics	8,640	8,259	8,293	8,127	7,573	7,298	7,011	6,673

Source: Computer Horizons, Inc., "Science & Engineering Indicators Literature Data Base", 1989.

See note of table 6-1-1.

Table 6-1-2 Japan and U.S. Scientific and Technical Papers by Field (2): 1981-1986

	1981	1982	1983	1984	1985	1986
	Japan articles as a percent of all artcles					
All Fields	6.8	6.9	7.0	7.3	7.6	7.7
Clinical medicine	5.0	5.2	5.6	5.8	6.3	6.4
Biomedicine	6.0	6.3	6.4	6.6	6.7	7.1
Biology	6.3	6.5	6.4	6.8	7.0	6.5
Chemistry	10.8	10.8	10.3	10.7	10.7	10.7
Physics	8.5	8.5	8.8	8.2	8.8	8.6
Earth/space sciences	2.7	2.4	2.4	2.7	3.3	3.7
Engineering/technology	9.6	10.1	9.7	11.6	11.5	12.7
Mathematics	4.7	5.3	5.5	5.4	5.2	3.4
	Number of Japan articles					
All Fields	25,105	25,858	26,391	27,014	29,617	29,757
Clinical medicine	5,922	6,312	6,764	6,985	7,861	8,116
Biomedicine	3,648	3,904	4,003	4,018	4,339	4,568
Biology	2,286	2,351	2,251	2,374	2,456	2,223
Chemistry	5,721	5,746	5,496	5,700	5,887	5,951
Physics	4,097	4,172	4,295	4,008	4,775	4,640
Earth/space sciences	481	416	418	474	592	674
Engineering/technology	2,471	2,463	2,654	2,954	3,213	3,321
Mathematics	478	494	511	499	495	264
	U.S. articles as a percent of all artcles					
All Fields	35.9	36.0	35.5	35.5	35.3	35.6
Clinical medicine	41.3	41.0	40.2	40.9	40.3	40.0
Biomedicine	38.1	38.5	38.1	38.1	37.8	38.4
Biology	37.9	38.8	38.1	38.0	37.5	38.1
Chemistry	20.0	21.2	20.6	20.9	21.0	22.2
Physics	29.4	28.6	28.0	27.8	29.4	30.3
Earth/space sciences	45.0	44.8	44.0	42.9	43.0	42.6
Engineering/technology	40.4	40.5	41.1	39.5	38.6	37.3
Mathematics	39.2	40.0	39.7	38.0	38.3	40.3
	Number of U.S. articles					
All Fields	132,864	134,278	133,055	131,604	137,771	137,770
Clinical medicine	48,833	49,324	48,800	49,512	50,595	50,637
Biomedicine	23,021	24,029	23,685	23,194	24,461	24,765
Biology	13,820	14,100	13,349	13,285	13,083	13,000
Chemistry	10,559	11,307	10,950	11,133	11,585	12,313
Physics	14,200	14,062	13,737	13,500	15,903	16,360
Earth/space sciences	8,058	7,851	7,566	7,430	7,663	7,811
Engineering/technology	10,393	9,869	11,291	10,067	10,822	9,775
Mathematics	3,980	3,736	3,676	3,483	3,659	3,109
	Number of all articles					
All Fields	369,907	372,822	374,678	370,733	389,845	387,027
Clinical medicine	118,347	120,330	121,405	121,094	125,532	126,463
Biomedicine	60,356	62,391	62,187	60,816	64,717	64,551
Biology	36,421	36,301	35,041	34,997	34,896	34,127
Chemistry	52,766	53,332	53,126	53,253	55,268	55,558
Physics	48,242	49,252	49,006	48,599	54,044	54,056
Earth/space sciences	17,909	17,514	17,185	17,308	17,834	18,351
Engineering/technology	25,716	24,355	27,463	25,493	28,004	26,201
Mathematics	10,152	9,348	9,266	9,174	9,551	7,722

Source: Computer Horizons, Inc., "Science & Engineering Indicators Literature Data Base", 1989.

See note of table 6-1-1.

Table 6-1-3 Trends of Cited Counts for Selected Countries' Papers

Year(#)	Cited counts (Number of citations from world papsers) U.S.	Japan	U.K.	W. Ger	France	USSR	Canada	Others	World
1973	1,438,176	99,667	300,447	125,721	102,270	58,140	121,956	451,389	2,697,767
1974	1,405,931	104,375	295,540	130,816	96,901	52,276	112,967	446,417	2,645,222
1975	1,364,390	106,464	295,476	131,719	103,055	50,966	110,698	432,702	2,595,469
1976	1,305,750	106,867	263,040	130,428	97,254	45,895	111,577	422,115	2,482,926
1977	1,269,586	110,853	241,381	132,823	93,633	43,085	102,161	411,120	2,404,642
1978	1,175,798	110,769	219,709	129,824	89,282	41,312	94,997	392,278	2,253,969
1979	1,108,007	105,859	188,002	113,876	88,282	38,413	88,115	366,553	2,097,106
1980	1,013,469	107,174	174,899	106,676	81,626	34,110	80,517	327,930	1,926,401
1981	1,244,067	132,614	228,969	140,882	105,521	43,703	95,455	446,768	2,437,978
1982	1,030,802	117,070	187,856	117,620	87,480	35,599	82,339	375,971	2,034,736
1983	812,000	96,385	148,253	94,567	69,241	26,323	64,403	300,614	1,611,786
1984	541,477	69,643	99,002	64,689	46,807	17,144	44,035	197,998	1,080,794
1985	246,148	32,480	42,024	29,806	21,650	6,787	20,391	88,874	488,159
1986	37,979	5,731	6,436	5,009	3,409	971	2,795	13,890	76,221

Year(#)	Share of cited counts [%] U.S.	Japan	U.K.	W. Ger	France	USSR	Canada	Others	World
1973	53.3	3.7	11.1	4.7	3.8	2.2	4.5	16.7	100.0
1974	53.1	3.9	11.2	4.9	3.7	2.0	4.3	16.9	100.0
1975	52.6	4.1	11.4	5.1	4.0	2.0	4.3	16.7	100.0
1976	52.6	4.3	10.6	5.3	3.9	1.8	4.5	17.0	100.0
1977	52.8	4.6	10.0	5.5	3.9	1.8	4.2	17.1	100.0
1978	52.2	4.9	9.7	5.8	4.0	1.8	4.2	17.4	100.0
1979	52.8	5.0	9.0	5.4	4.2	1.8	4.2	17.5	100.0
1980	52.6	5.6	9.1	5.5	4.2	1.8	4.2	17.0	100.0
1981	51.0	5.4	9.4	5.8	4.3	1.8	3.9	18.3	100.0
1982	50.7	5.8	9.2	5.8	4.3	1.7	4.0	18.5	100.0
1983	50.4	6.0	9.2	5.9	4.3	1.6	4.0	18.7	100.0
1984	50.1	6.4	9.2	6.0	4.3	1.6	4.1	18.3	100.0
1985	50.4	6.7	8.6	6.1	4.4	1.4	4.2	18.2	100.0
1986	49.8	7.5	8.4	6.6	4.5	1.3	3.7	18.2	100.0

Source: Computer Horizons, Inc., "Science & Engineering Indicators Literature Data Base", 1989.

(#) : publication year of cited papers.
See note of table 6-1-1.

Table 6-1-4 Scientific Paper Contribution to World Literature and Carrying Papers on Journals : Total from 1984 to 1986

	Number of each countries' contribution				Number of carrying papers on each countries' journals			
	Total(a)	Domestic(b)	External(c)	External ratio(d)	Total(e)	Domestic(f)	Foreign(g)	Foreign ratio(h)
U.S.	407,145	311,072	96,072	23.6%	491,637	311,072	180,565	36.7%
U.K.	94,208	54,339	39,869	42.3%	166,866	54,339	112,527	67.4%
USSR	88,942	75,433	13,509	15.2%	76,252	75,433	819	1.1%
Japan	86,388	32,609	53,779	62.3%	36,404	32,609	3,795	10.4%
W. Germany	68,505	31,604	36,901	53.9%	81,855	31,604	50,252	61.4%
France	55,205	17,677	37,528	68.0%	26,455	17,677	8,778	33.2%
Canada	49,138	10,199	38,939	79.2%	16,450	10,199	6,251	38.0%
Netherland	20,723	5,845	14,878	71.8%	123,180	5,845	117,335	95.3%
Others	277,355	90,526	186,830	67.4%	128,510	90,526	37,985	29.6%
World	1,147,610	-	-	-	1,147,610	-	-	-
	Each countries' shares[%] of				Each countries' shares[%] of			
	(a)	(b)	(c)		(e)	(f)	(g)	
U.S.	35.5	27.1	8.4		42.8	27.1	15.7	
U.K.	8.2	4.7	3.5		14.5	4.7	9.8	
USSR	7.8	6.6	1.2		6.6	6.6	0.1	
Japan	7.5	2.8	4.7		3.2	2.8	0.3	
W. Germany	6.0	2.8	3.2		7.1	2.8	4.4	
France	4.8	1.5	3.3		2.3	1.5	0.8	
Canada	4.3	0.9	3.4		1.4	0.9	0.5	
Netherland	1.8	0.5	1.3		10.7	0.5	10.2	
Others	24.2	7.9	16.3		11.2	7.9	3.3	
World	100.0	-	-		100.0	-	-	

Source: Computer Horizons, Inc., "Science & Engineering Indicators Literature Data Base", 1989.

Note: Each values defined following,

(a): Total number of each countries' paper contribution
(b): Number of each countries' paper contribution to domestic journals
(c): Number of each countries' paper contribution to foreign journals
(d): (c)/(a)
(e): Total number of papers which carry on each countries' journals
(f): Number of domestic papers which carry on each countries' journals
(g): Number of foreign papers which carry on each countries' journals
(h): (g)/(e)

Note that (b) = (f)

Table 6-1-5 Japan's Scientific Paper Contribution and Carrying Papers on Journals

Year	Number of Japan's contribution to each countries' journals: Japan	U.S.	Nether-land	U.K.	West Germany	Europ rest	Others	Total (All Japan's)
1981	11,163	6,932	2,365	2,283	1,255	814	293	25,105
1982	11,022	7,168	2,536	2,528	1,248	1,057	299	25,858
1983	10,659	7,530	3,045	2,525	1,316	1,051	266	26,391
1984	10,811	8,067	2,813	2,565	1,347	1,050	361	27,014
1985	11,233	9,071	3,242	2,970	1,651	1,061	389	29,617
1986	10,565	9,405	3,532	3,037	1,585	1,266	367	29,757

Year	Percentage: Japan	U.S.	Nether-land	U.K.	West Germany	Europ rest	Others	Total (All Japan's)
1981	44.5	27.6	9.4	9.1	5.0	3.2	1.2	100.0
1982	42.6	27.7	9.8	9.8	4.8	4.1	1.2	100.0
1983	40.4	28.5	11.5	9.6	5.0	4.0	1.0	100.0
1984	40.0	29.9	10.4	9.5	5.0	3.9	1.3	100.0
1985	37.9	30.6	10.9	10.0	5.6	3.6	1.3	100.0
1986	35.5	31.6	11.9	10.2	5.3	4.3	1.2	100.0

Year	Number of each countries' contribution to Japan's journals: Japan	U.S.	West Europe	Asia	USSR & East Europe	Others	Total
1981	11,163	351	335	261	51	186	12,346
1982	11,022	333	278	225	44	179	12,080
1983	10,659	318	385	269	59	177	11,867
1984	10,811	338	318	282	51	196	11,995
1985	11,233	365	402	324	49	184	12,557
1986	10,565	377	357	304	69	181	11,852

Year	Percentage: Japan	U.S.	West Europe	Asia	USSR & East Europe	Others	Total
1981	90.4	2.8	2.7	2.1	0.4	1.5	100.0
1982	91.2	2.8	2.3	1.9	0.4	1.5	100.0
1983	89.8	2.7	3.2	2.3	0.5	1.5	100.0
1984	90.1	2.8	2.6	2.4	0.4	1.6	100.0
1985	89.5	2.9	3.2	2.6	0.4	1.5	100.0
1986	89.1	3.2	3.0	2.6	0.6	1.5	100.0

Source: Computer Horizons, Inc., "Science & Engineering Indicators Literature Data Base", 1989.

Table 6-1-6 Citing Counts and Cited Counts for Selected Countries (Total from 1984 to 1986)

	Citing counts				Cited counts			
	Total(a)	Domestic(b)	Foreign(c)	Foreign ratio(d)	Total(e)	Domestic(f)	Foreign(g)	Foreign ratio(h)
U.S.	2,696,463	1,931,488	764,976	28.4%	3,104,751	1,931,488	1,173,263	37.8%
U.K.	524,082	202,631	321,452	61.3%	563,000	202,631	360,369	64.0%
Japan	400,086	170,124	229,963	57.5%	357,836	170,124	187,713	52.5%
W.Germany	388,673	133,347	255,326	65.7%	350,159	133,347	216,812	61.9%
France	321,002	97,187	223,815	69.7%	262,723	97,187	165,536	63.0%
Canada	278,982	81,728	197,254	70.7%	246,946	81,728	165,218	66.9%
USSR	160,494	71,633	88,861	55.4%	100,389	71,633	28,756	28.6%
Others	1,336,813	563,938	772,874	57.8%	1,120,791	563,938	556,853	49.7%
World	6,106,594	-	-	-	6,106,594	-	-	-
	Shares[%] of citing counts of				Shares[%] of cited counts of			
	(a)	(b)	(c)		(e)	(f)	(g)	
U.S.	44.2	31.6	12.5		50.8	31.6	19.2	
U.K.	8.6	3.3	5.3		9.2	3.3	5.9	
Japan	6.6	2.8	3.8		5.9	2.8	3.1	
W.Germany	6.4	2.2	4.2		5.7	2.2	3.6	
France	5.3	1.6	3.7		4.3	1.6	2.7	
Canada	4.6	1.3	3.2		4.0	1.3	2.7	
USSR	2.6	1.2	1.5		1.6	1.2	0.5	
Others	21.9	9.2	12.7		18.4	9.2	9.1	
World	100.0	-	-		100.0	-	-	

Source: Computer Horizons, Inc., "Science & Engineering Indicators Literature Data Base", 1989.

Note: Each values defined following,
(a): Total of each countries' counts of citing to world papers
(b): Each countries' counts of citing to domestic papers
(c): Each countries' counts of citing to foreign papers
(d): (c)/(a)
(e): Total of each countries' counts of cited from world papers
(f): Each countries' counts of cited from domestic papers
(g): Each countries' counts of cited from foreign papers
(h): (g)/(e)
Note that (b) = (f), and "Total of (a)" = "Total of (e)".

Table 6-1-7 Citing and Cited Counts of Japan Origin Papers

Year	Japan's citing counts (by countries which Japan origin papers citing to)							Total
	Japan	U.S.	U.K.	W.Germar	France	Canada	Others	
1981	4,510	714	77	105	75	53	236	5,769
1982	18,290	7,221	1,032	927	642	469	2,266	30,846
1983	32,569	18,567	2,610	2,126	1,618	1,281	5,925	64,696
1984	43,421	30,068	4,453	3,464	2,536	2,007	9,767	95,716
1985	61,257	47,659	7,125	5,439	4,258	3,434	15,494	144,665
1986	65,446	54,874	7,973	5,992	4,554	3,925	16,943	159,706
Year	Percentage for							Total
	Japan	U.S.	U.K.	W.Germar	France	Canada	Others	
1981	78.2	12.4	1.3	1.8	1.3	0.9	4.1	100.0
1982	59.3	23.4	3.3	3.0	2.1	1.5	7.3	100.0
1983	50.3	28.7	4.0	3.3	2.5	2.0	9.2	100.0
1984	45.4	31.4	4.7	3.6	2.6	2.1	10.2	100.0
1985	42.3	32.9	4.9	3.8	2.9	2.4	10.7	100.0
1986	41.0	34.4	5.0	3.8	2.9	2.5	10.6	100.0
Year	Japan's cited counts (by countries which citing to Japan origin papers)							Total
	Japan	U.S.	U.K.	W.Germar	France	Canada	Others	
1981	4,510	489	92	122	77	33	190	5,514
1982	18,290	5,439	1,015	1,030	720	426	2,580	29,500
1983	32,569	13,366	2,486	2,203	1,812	1,167	7,469	61,071
1984	43,421	19,353	3,862	3,371	3,018	2,131	12,761	87,917
1985	61,257	29,672	5,401	5,168	4,330	3,062	18,791	127,680
1986	65,446	34,856	6,128	5,561	5,087	3,549	21,612	142,239
Year	Percentage of							Total
	Japan	U.S.	U.K.	W.Germar	France	Canada	Others	
1981	81.8	8.9	1.7	2.2	1.4	0.6	3.4	100.0
1982	62.0	18.4	3.4	3.5	2.4	1.4	8.7	100.0
1983	53.3	21.9	4.1	3.6	3.0	1.9	12.2	100.0
1984	49.4	22.0	4.4	3.8	3.4	2.4	14.5	100.0
1985	48.0	23.2	4.2	4.0	3.4	2.4	14.7	100.0
1986	46.0	24.5	4.3	3.9	3.6	2.5	15.2	100.0

Source: Computer Horizons, Inc., "Science & Engineering Indicators Literature Data Base", 1989.

Table 6-2-1 Trends of National Patent Applications and Grants in Japan

	Number of patent applications			Number of patent grants		
Year	Japanese	Foreigner	Total	Japanese	Foreigner	Total
1970	100,522	30,309	130,831	21,390	9,488	30,878
1971	78,425	27,360	105,785	24,795	11,652	36,447
1972	101,328	29,072	130,400	29,101	12,353	41,454
1973	115,221	29,593	144,814	30,937	11,391	42,328
1974	121,509	27,810	149,319	30,873	8,753	39,626
1975	135,118	24,703	159,821	36,992	9,736	46,728
1976	135,762	25,254	161,016	32,465	7,852	40,317
1977	135,991	25,015	161,006	43,047	9,561	52,608
1978	141,517	24,575	166,092	37,648	7,856	45,504
1979	150,623	23,946	174,569	34,863	9,241	44,104
1980	165,730	25,290	191,020	38,032	8,074	46,106
1981	191,645	26,616	218,261	42,080	8,824	50,904
1982	210,922	26,591	237,513	42,223	8,378	50,601
1983	227,743	27,213	254,956	45,578	9,123	54,701
1984	256,205	28,562	284,767	51,690	10,110	61,800
1985	274,373	28,622	302,995	42,323	7,777	50,100
1986	290,202	29,887	320,089	51,276	8,624	59,900
1987	311,006	30,089	341,095	54,087	8,313	62,400
1988	308,908	30,491	339,399	47,912	7,388	55,300
1989	317,566	33,641	351,207	54,743	8,558	63,301

Source: Patent Agency, "Patent Agency Annual Report 1989"

Table 6-2-2 Trends of National Patent Applications and Grants in Japan: by Field

Number of patent applications by field

Year	Electricity	Physics	Mechanical engineering	Construction	Chemical, Metallugy, Textile	Treatment, Manipulation, Transportation	Living utensiles
1980	41,693	41,123	19,520	5,418	31,572	37,711	12,063
1981	47,421	50,251	23,104	6,180	34,016	42,039	13,388
1982	53,385	54,963	24,899	6,347	35,638	45,552	14,435
1983	57,717	60,239	25,132	7,017	37,424	49,102	15,738
1984	65,957	69,138	27,364	7,292	40,405	53,621	18,163
1985	71,028	75,933	25,721	7,261	42,838	56,473	17,599
1986	75,235	82,267	25,457	7,617	44,862	57,340	18,944
1987	85,351	91,414	24,753	7,782	48,831	57,421	21,331
1988	83,510	90,954	24,978	8,436	48,703	58,382	21,269

Percentage

Year	Electricity	Physics	Mechanical engineering	Construction	Chemical, Metallugy, Textile	Treatment, Manipulation, Transportation	Living utensiles
1980	22.0	21.7	10.3	2.9	16.7	19.9	6.4
1981	21.9	23.2	10.7	2.9	15.7	19.4	6.2
1982	22.7	23.4	10.6	2.7	15.2	19.4	6.1
1983	22.9	23.9	10.0	2.8	14.8	19.5	6.2
1984	23.4	24.5	9.7	2.6	14.3	19.0	6.4
1985	23.9	25.6	8.7	2.4	14.4	19.0	5.9
1986	24.1	26.4	8.2	2.4	14.4	18.4	6.1
1987	25.3	27.1	7.3	2.3	14.5	17.0	6.3
1988	24.8	27.1	7.4	2.5	14.5	17.4	6.3

Number of patent grants by field

Year	Electricity	Physics	Mechanical engineering	Construction	Chemical, Metallugy, Textile	Treatment, Manipulation, Transportation	Living utensiles	Others
1980	8,365	7,216	3,984	2,082	10,204	11,153	3,037	65
1981	9,249	8,142	4,520	2,140	11,557	11,194	4,034	68
1982	9,426	8,503	4,207	1,838	11,682	10,405	4,508	32
1983	10,373	8,776	4,590	1,895	13,042	11,533	4,481	11
1984	11,779	11,005	5,614	2,238	13,738	13,607	3,819	0
1985	8,875	8,155	4,431	1,858	12,519	10,825	3,433	4
1986	10,055	10,664	5,800	1,991	14,924	11,964	4,501	1
1987	10,215	10,942	6,576	2,082	14,611	13,172	4,802	0
1988	10,306	9,710	5,279	1,717	12,442	11,708	4,138	0
1989	12,237	10,398	5,971	2,145	13,921	13,567	5,062	0

Percentage

Year	Electricity	Physics	Mechanical engineering	Construction	Chemical, Metallugy, Textile	Treatment, Manipulation, Transportation	Living utensiles	Others
1980	18.1	15.7	8.6	4.5	22.1	24.2	6.6	0.1
1981	18.2	16.0	8.9	4.2	22.7	22.0	7.9	0.1
1982	18.6	16.8	8.3	3.6	23.1	20.6	8.9	0.1
1983	19.0	16.0	8.4	3.5	23.8	21.1	8.2	0.0
1984	19.1	17.8	9.1	3.6	22.2	22.0	6.2	0.0
1985	17.7	16.3	8.8	3.7	25.0	21.6	6.9	0.0
1986	16.8	17.8	9.7	3.3	24.9	20.0	7.5	0.0
1987	16.4	17.5	10.5	3.3	23.4	21.1	7.7	0.0
1988	18.6	17.6	9.5	3.1	22.5	21.2	7.5	0.0
1989	19.3	16.4	9.4	3.4	22.0	21.4	8.0	0.0

Source: Patent Agency, "Patent Agency Annual Report 1989"

Table 6-2-3 Number of Domestic and External Patents for Selected Countries (1987)

Nationality of inventor	Number of applications: Domestic applications Total	(Applying to EPC)	External applications Total	(Applying to EPC)
Japan	311,006	-	82,824	34,832
U.S.	68,671	-	166,072	89,989
W.Germany	40,696	9,033	108,697	68,294
U.K.	22,965	2,772	45,897	24,934
France	14,527	1,832	43,259	27,171
Nationality of inventor	**Number of granted patents: Domestic granted patents Total**	**(Granted by EPC)**	**External granted patents Total**	**(Granted by EPC)**
Japan	54,087	-	41,751	11,163
U.S.	43,518	-	62,530	24,484
W.Germany	16,194	3,465	46,804	24,146
U.K.	4,609	734	15,201	6,393
France	8,523	807	21,540	12,253

Source: Patent Agency, "Patent Agency Annual Report 1989"
Note: The appointed country of EPC patents are counted as "one country"

Table 6-2-4 Number of Japan's External Patents (1987)

Countries	External patent applications: Number of applications	Percentage	External granted patents: Number of granted patents	Percentage
U.S.	25,526	30.8	16,557	39.7
W.Germany	10,736	13.0	6,012	14.4
U.K.	9,245	11.2	4,287	10.3
France	7,563	9.1	3,700	8.9
Korea	5,219	6.3	969	2.3
Canada	3,714	4.5	1,568	3.8
Netherland	2,910	3.5	1,260	3.0
Others	17,911	21.6	7,398	17.7
Total	82,824	100.0	41,751	100.0

Source: Patent Agency, "Patent Agency Annual Report 1989"
Note: EPO patents are included.

Table 6-2-5 Number of Patent Applications and Grants in Japan, U.S. and EPO by Nationality of Inventor (1987)

	Number of patent applications (Nationality of inventor)						Total
	Japan	U.S.	W.Germany	France	U.K.	Others	
Japan	311,006	12,843	5,841	1,950	1,927	7,528	341,095
	(91.2%)	(3.8%)	(1.7%)	(0.6%)	(0.6%)	(2.2%)	(100.0%)
U.S.	25,526	68,671	11,878	4,331	5,773	17,628	133,807
	(19.1%)	(51.3%)	(8.9%)	(3.2%)	(4.3%)	(13.2%)	(100.0%)
EPO (*)	7,177	12,206	10,032	3,760	3,453	9,332	45,960
	(15.6%)	(26.6%)	(21.8%)	(8.2%)	(7.5%)	(20.3%)	(100.0%)
	Number of patent grants (Nationality of inventor)						Total
	Japan	U.S.	W.Germany	France	U.K.	Others	
Japan	54,087	3,824	1,644	607	411	1,827	62,400
	(86.7%)	(6.1%)	(2.6%)	(1.0%)	(0.7%)	(2.9%)	(100.0%)
U.S.	16,557	43,518	7,821	2,874	2,779	9,403	82,952
	(20.0%)	(52.5%)	(9.4%)	(3.5%)	(3.4%)	(11.3%)	(100.0%)
EPO (*)	2,570	4,046	4,116	1,958	1,059	3,394	17,143
	(15.0%)	(23.6%)	(24.0%)	(11.4%)	(6.2%)	(19.8%)	(100.0%)

(*): European Patent Office

Source: Patent Agency, "Patent Agency Annual Report 1989"

Table 6-2-6 Trends of Share of U.S. Patent Grants by Selected Countries

Year	Shares of U.S. patent grants [%] U.S.	Japan	W.Germany	U.K.	France	Others
1975	64.7	8.8	8.4	4.2	3.3	10.6
1976	62.9	9.3	8.8	4.3	3.4	11.3
1977	63.4	9.5	8.5	4.1	3.2	11.3
1978	62.2	10.5	8.9	4.1	3.2	11.1
1979	61.4	10.8	9.3	3.9	3.3	11.4
1980	60.2	11.5	9.3	3.9	3.4	11.6
1981	59.4	12.8	9.6	3.8	3.3	11.1
1982	58.3	14.1	9.4	3.7	3.4	11.1
1983	57.6	15.5	9.6	3.4	3.3	10.6
1984	57.0	16.5	9.3	3.4	3.2	10.5
1985	55.2	17.8	9.3	3.5	3.4	10.9
1986	53.8	18.7	9.6	3.4	3.3	11.2
1987	52.4	20.0	9.4	3.4	3.5	11.4
1988	51.9	20.7	9.4	3.3	3.4	11.2

Source: Computer Horizons, Inc., "Science & Engineering Indicators Literature Data Base", 1989.

Table 6-2-7 Trends of Cited Counts of U.S. Patents for Selected Countries

	Shares[%] of cited counts of U.S. patents					
	U.S.	Japan	Others			
Year				W.Germany	U.K.	France
1975	70.5	9.9	19.6	6.6	3.9	2.1
1976	67.9	11.5	20.6	6.4	4.1	2.7
1977	68.4	12.3	19.3	6.0	3.7	2.6
1978	66.5	12.9	20.6	6.5	3.9	2.8
1979	66.9	13.5	19.7	6.6	3.9	2.5
1980	65.0	14.5	20.4	6.8	3.4	2.4
1981	62.4	18.0	19.6	7.0	3.6	2.3
1982	59.5	19.5	21.1	7.0	3.5	2.7
1983	59.9	21.8	18.3	6.6	2.8	2.7
1984	58.7	23.3	18.0	6.1	3.1	2.3
1985	54.1	27.6	18.3	6.6	2.7	2.3
1986	56.5	25.2	18.3	6.9	3.1	2.5

Source: Computer Horizons, Inc., "Science & Engineering Indicators Literature Data Base", 1989.

Table 6-2-8 Trends of Number of Botanical Species Registrations

Year	Number of botanical species registrations: Individuals	Nursery companies	Food companies	Agricultural cooperatives	Local governments	Central government	Total
1983	243	182	20	21	79	40	585
1984	341	262	38	22	108	50	821
1985	391	340	46	25	155	61	1,018
1986	491	459	68	27	192	76	1,313
1987	600	558	86	31	232	106	1,613
1988	685	695	97	40	267	127	1,911
1989	752	821	104	44	282	145	2,148

Year	Percentage: Individuals	Nursery companies	Food companies	Agricultural cooperatives	Local governments	Central government	Total
1983	41.5	31.1	3.4	3.6	13.5	6.8	100.0
1984	41.5	31.9	4.6	2.7	13.2	6.1	100.0
1985	38.4	33.4	4.5	2.5	15.2	6.0	100.0
1986	37.4	35.0	5.2	2.1	14.6	5.8	100.0
1987	37.2	34.6	5.3	1.9	14.4	6.6	100.0
1988	35.8	36.4	5.1	2.1	14.0	6.6	100.0
1989	35.0	38.2	4.8	2.0	13.1	6.8	100.0

Source: Ministry of Agriculture, Forestry and Fisheries, and NISTEP

Table 6-3-1 Number of "Japanese Industrial Standards" by Year

Fiscal Year	Enact	Revise	Confirm	Abrogate	Total
1949	187	1	0	0	187
1950	867	11	0	2	1,052
1951	698	42	0	4	1,746
1952	778	71	117	15	2,509
1953	690	476	365	51	3,148
1954	450	418	351	34	3,564
1955	416	547	567	32	3,948
1956	406	763	833	86	4,268
1957	352	624	656	59	4,561
1958	375	634	890	111	4,825
1959	337	680	1,140	88	5,074
1960	321	1,015	621	140	5,255
1961	406	367	1,242	110	5,551
1962	350	350	1,114	70	5,831
1963	317	504	1,147	74	6,074
1964	277	285	2,336	100	6,251
1965	221	382	1,009	50	6,422
1966	230	341	1,744	18	6,634
1967	164	201	1,946	117	6,681
1968	226	691	1,670	84	6,823
1969	179	37	1,679	89	6,913
1970	234	441	2,353	151	6,996
1971	209	429	1,756	77	7,128
1972	179	457	1,347	58	7,249
1973	154	306	2,515	26	7,377
1974	220	623	1,953	46	7,551
1975	230	1,213	2,000	103	7,678
1976	143	1,159	792	122	7,699
1977	113	754	1,430	125	7,687
1978	188	909	2,479	131	7,744
1979	134	616	1,983	232	7,646
1980	132	398	440	107	7,671
1981	137	404	53	55	7,753
1982	156	399	767	57	7,852
1983	130	384	2,022	87	7,895
1984	160	370	1,387	124	7,931
1985	124	349	1,020	77	7,978
1986	193	344	766	61	8,110
1987	197	481	1,018	84	8,223
1988	196	496	1,401	131	8,288
1989	180	343	1,002	54	8,414

Source: JIS Directories, 1990

Table 6-3-2 Number of "Japanese Industrial Standards" by Class

Class of Japanese Industrial Standerds	Number of standards	Percentage
Construction and civil engineering	532	6.3
General machinery	1,266	15.0
Electrical and electronics equipment	819	9.7
Motor vehicles	341	4.1
Railroad equipment	219	2.6
Ship building	541	6.4
Iron and steel	321	3.8
Non-ferrous metals	383	4.6
Chemistry	1,654	19.7
Textiles	307	3.6
Mining	225	2.7
Pulp and paper	95	1.1
Ceramics	240	2.9
Household utensils	276	3.3
Medical safety equipment	284	3.4
Aircraft	100	1.2
Information processing	152	1.8
Others	659	7.8
Total	8,414	100.0

Source: JIS Directories, 1990

Table 6-4-1 Number of Scientific and Technological Achievement which received the "Award for Persons of Scientific and Technological Merits"

Technological classification	Technological sub-classification	Number of award by period			Total Number
		1960's	1970's	1980's	
Machinery	Boilers, engines and turbines	3	0	5	8
	Machinery for agriculture, construction and mining	2	3	4	9
	Metal working machinery	7	7	7	21
	Textile machinery	3	3	3	9
	Special industry machinery	7	4	7	18
	Pumps, compressors and air blowers	1	1	2	4
	Power machinery	5	1	1	7
	Miscellaneous general industry machinery	0	3	3	6
	Miscellaneous machinery	1	5	9	15
	Transportation equipment	13	8	24	45
	Precision instruments	17	7	21	45
	Sub-total	59	42	86	187
Electricity	Electrical generating, transmission, distribution and industrial appliances	6	7	10	23
	Household electric appliances, electric bulbs and lighting fixtures	1	0	0	1
	Communication equipment and related products	10	8	13	31
	Television and radio receivers, and audio equipment	3	2	4	9
	Miscellaneous communication equipment	0	2	1	3
	Computers	2	4	11	17
	Miscellaneous electronics equipment	7	1	16	24
	Parts for electronic appliances and communication equipment	3	14	21	38
	Miscellaneous electrical machineries	4	1	1	6
	Sub-total	36	39	77	152
Chemistry	Industrial inorganic chemicals	3	1	2	6
	Industrial organic chemicals	16	12	19	47
	Chemical fibres	4	1	0	5
	Oils and fat products, soap, etc.	1	1	0	2
	Drugs and medicines	11	2	11	24
	Other chemical products	4	4	6	14
	Petroleum and coal products	1	0	2	3
	Machinery equipment for chemicals	7	11	7	25
	Sub-total	47	32	47	126
Metals	Iron and steel	11	10	17	38
	Non-ferrous metals	5	5	7	17
	Fabricated metal products	5	4	7	16
	Sub-total	21	19	31	71
Others	Agriculture, forestry and fisheries	3	1	6	10
	Mining	2	0	0	2
	Construction	5	10	11	26
	Food and tobacco	6	4	6	16
	Textiles	2	0	0	2
	Rubber products	0	0	2	2
	Leather, leather products, and fur skins	0	1	0	1
	Ceramics	5	5	17	27
	Plastic products	1	1	2	4
	Other manufacturing	3	0	0	3
	Other industries	3	0	5	8
	Sub-total	30	22	49	101
Total		193	154	290	637

Source: National Institute of Science and Technology Policy, "Trends of Science and Technology Activities in Using Science and Technology Awards Statistics," NISTEP Report No. 10, 1990.

Note: Data for 1960's include 1959 data.

Table 7-1-1 Dispatched Japanese Researchers and Engineers

(Unit:person)

Year	Total	Academic research or studies					Overseas studies, training or skills acquisition				
		Subtotal	Asia	Europe	North America	Others	Subtotal	Asia	Europe	North America	Others
1970	10,646	5,987	602	1,556	3,519	310	4,659	205	1,414	2,913	127
1971	7,945	2,244	403	785	946	110	5,701	415	1,676	3,488	122
1972	10,578	2,682	688	804	1,074	116	7,896	854	2,593	4,044	405
1973	14,484	5,218	809	2,156	2,018	235	9,266	1,726	2,756	4,543	241
1974	15,937	5,324	991	1,856	2,191	286	10,613	1,608	3,185	5,243	577
1975	16,420	5,594	937	2,185	2,291	181	10,826	780	3,425	6,285	336
1976	18,588	6,634	1,021	2,565	2,785	263	11,954	1,602	3,232	6,714	406
1977	17,788	7,069	1,191	2,662	2,917	299	10,719	943	3,083	6,395	298
1978	19,356	7,614	1,375	2,763	3,129	347	11,742	707	3,347	7,243	445
1979	23,093	9,386	1,839	3,107	4,012	428	13,707	705	3,592	9,059	351
1980	23,149	8,870	1,874	3,043	3,546	407	14,279	746	3,510	9,715	308
1981	23,690	9,143	1,998	2,884	3,799	462	14,547	816	3,538	9,889	304
1982	25,727	10,518	2,388	3,446	4,170	514	15,209	868	3,479	10,559	303
1983	29,057	12,322	3,013	3,978	4,630	701	16,735	1,068	3,770	11,518	379
1984	35,251	14,781	4,336	4,387	5,362	696	20,470	1,522	4,612	13,798	538
1985	41,123	17,293	5,364	5,001	6,194	734	23,830	2,288	5,696	15,180	666
1986	55,869	19,425	6,011	5,623	6,830	961	36,444	5,228	8,714	21,221	1,281
1987	81,407	23,923	7,722	6,864	8,226	1,111	57,484	10,116	13,684	31,044	2,640
1988	113,632	28,924	9,411	8,079	10,042	1,392	84,708	15,560	19,106	46,046	3,996
1989	146,488	33,254	10,200	9,535	12,034	1,485	113,234	20,025	24,752	62,520	5,937

Source:Ministry of Justice, "Statistics on Immigration Control"

Tabel 7-1-2 Received Foreign Researchers and Engineers

(Unit:person)

Year	Total	Purpose					Nationality			
		Overseas studies	Training	Teaching	Artistic or academic activities	Provision of high-grade technology	Asia	Europe	North America	Others
1970	3,104	2,457	—	200	402	45	2,058	207	738	101
1971	4,400	3,624	—	257	489	30	2,961	299	1,022	118
1972	4,663	3,839	—	216	577	31	3,079	376	1,062	146
1973	5,525	4,492	—	307	696	30	3,392	517	1,417	199
1974	6,386	5,225	—	389	739	33	4,039	590	1,537	220
1975	6,634	5,461	—	422	722	29	4,292	632	1,463	247
1976	7,164	5,842	—	539	764	19	4,584	757	1,548	275
1977	8,099	6,533	—	598	945	23	5,287	803	1,704	305
1978	8,624	6,782	—	735	1,080	27	5,717	800	1,788	319
1979	9,174	7,234	—	870	1,018	52	6,223	952	1,652	347
1980	10,370	8,275	—	946	1,090	59	7,249	972	1,761	388
1981	11,540	9,271	—	1,031	1,190	48	8,028	1,015	2,082	415
1982	24,270	10,864	10,328	1,211	1,743	124	17,167	1,849	2,876	2,378
1983	28,902	12,999	12,612	1,275	1,950	66	21,014	2,101	3,147	2,640
1984	34,184	16,335	14,268	1,513	2,027	41	25,219	2,296	3,717	2,952
1985	38,801	19,991	14,809	1,582	2,377	42	29,369	2,487	3,821	3,124
1986	43,686	23,927	15,550	1,675	2,499	35	33,485	2,796	4,348	3,057
1987	53,103	29,684	18,613	2,009	2,739	58	41,621	3,383	4,814	3,285
1988	68,304	37,445	25,274	2,317	3,208	60	55,617	3,807	5,271	3,609
1989	84,295	45,424	32,512	2,661	3,633	65	67,248	4,640	6,255	6,152

Source:Ministry of Justice, "Statistics on Immigration Control"

Table 7-1-3 Number of International conferences Held in Japan

Year	Total	natural science	others
1970	267	122	145
1971	165	91	74
1972	214	122	92
1973	227	107	120
1974	234	123	111
1975	236	123	113
1976	200	90	110
1977	236	115	121
1978	389	213	176
1979	315	157	158
1980	320	141	179
1981	371	204	167
1982	456	222	234
1983	384	210	174
1984	408	226	182
1985	438	235	203
1986	502	314	188
1987	549	292	257
1988	764	438	326
1989	865	446	419

Source:Japan Travel Promotion Association

Table 7-2-1 R&D Expenditure by Overseas Affiliates of Japanese Companies

Unit:Million Yen

	1983	1986	1989
North America	8,932	28,363	42,527
Asia	2,531	10,150	5,844
Europe	1,343	16,644	13,750
Ociana	638	208	2,037
Central/South America	693	1,218	463
World	14,207	57,653	64,646

Source:Ministry of International and Industry, "Statistics on Foreign Investment"

Table 7-2-2 Number of Research Laboratories Operated by Overseas Affiliates of Japanese Companies

	1986			1989		
	Total	Manufacturing	non-Manufacturing	Total	Manufacturing	non-Manufacturing
North America	46	25	21	98	67	31
Asia	43	42	1	81	74	17
Europe	17	14	3	25	18	7
Ociana	7	2	5	9	2	7
Central/South America	6	5	1	9	9	0
World	119	88	31	222	170	52

Source:MITI

Table 7-2-3 Japan's Technological Trade by Industry (FY 1989)

Unit:Million Yen

	Exports	Imports
All industries	329,348	329,925
Construction	12,448	2,043
Chemicals	53,616	56,866
Drugs and medicines	18,904	21,483
Irom and steel	21,572	4,776
General machinery	13,210	32,986
Electrical machinery	86,708	120,553
Communication and electronics equipment	58,544	92,036
Transport equipment	87,126	54,912
Motor vehicles	83,042	7,248

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

Table 7-2-4 Japan's Technological Trade by Region (FY 1989)

Unit:Million Yen

		Exports	Imports
World		329,348	329,925
North America		115,136	210,741
	Drugs and medicines	12,410	8,635
	Communication and electronics equipment	12,775	70,924
	Motor vehicles	41,595	38,617
Europe		65,067	118,163
	Drugs and medicines	6,088	12,848
	Communication and electronics equipment	16,894	21,095
	Motor vehicles	7,145	9,042
Asia		128,862	—
	Construction	9978	—
	Communication and electronics equipment	27623	—
	Motor vehicles	27163	—

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

Table 7-2-5 Technological Trade and Overall Trade Revenue-Expenditure Ratio

	Technological Trade				Overall Trade Revenue-Expenditure Ratio		yen-dollar exchange rate (yen/dollar)
	Statistics of Bank of Japan		Statistics of Management and Coordination Agency				
	Revenue (million dollar)	Expenditure (million dollar)	Revenue (million yen)	Expenditure (million yen)	Exports (million dollar)	Imports (million dollar)	
1975	161	712	66,594	169,131	56,004	50,161	296.8
1976	173	846	83,404	177,302	69,394	58,246	296.6
1977	233	1,027	93,325	190,066	83,363	63,028	268.5
1978	274	1,241	122,049	192,058	96,978	76,447	210.4
1979	342	1,260	133,145	240,984	105,059	107,497	219.1
1980	378	1,439	159,612	239,529	134,942	128,176	226.7
1981	537	1,711	175,106	259,632	149,592	129,234	220.5
1982	527	1,796	184,921	282,613	135,993	115,852	249.1
1983	624	2,079	240,887	279,280	150,740	116,194	237.5
1984	693	2,317	277,512	281,447	167,858	122,257	237.5
1985	746	2,522	234,220	293,173	180,664	119,063	238.5
1986	1,009	3,375	224,078	260,577	211,293	109,645	168.5
1987	1,385	4,177	215,575	283,245	233,435	139,401	144.6
1988	1,681	5,076	246,255	312,195	267,365	172,063	128.2
1989	2,189	5,455	329,348	329,925	268,085	198,086	138.0

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

Table 7-2-6 Introduction of Overseas Technology

Year	Number	Year	Number
1950	76	1970	1,768
1951	188	1971	2,007
1952	252	1972	2,403
1953	235	1973	2,450
1954	213	1974	2,093
1955	184	1975	1,836
1956	310	1976	1,893
1957	254	1977	1,914
1958	242	1978	2,139
1959	378	1979	2,116
1960	588	1980	2,142
1961	601	1981	2,076
1962	757	1982	2,229
1963	1,137	1983	2,212
1964	1,041	1984	2,378
1965	958	1985	2,436
1966	1,153	1986	2,361
1967	1,295	1987	2,709
1968	1,744	1988	2,834
1969	1,629	1989	2,898

Source:NISTEP

Table 7-2-7 Introduction of Overseas Technology by Techhological Field

	Categories					
Year	electronics	machinery	chemicals	metals	others	total
1985	900	457	331	85	663	2,436
1986	934	395	299	66	667	2,361
1987	1,274	386	287	65	697	2,709
1988	1,341	439	313	70	671	2,834
1989	1,604	383	308	60	543	2,898
	Percentage					
Year	electronics	machinery	chemicals	metals	others	total
1985	36.9	18.8	13.6	3.5	27.2	100.0
1986	39.6	16.7	12.7	2.8	28.3	100.0
1987	47.0	14.2	10.6	2.4	25.7	100.0
1988	47.3	15.5	11.0	2.5	23.7	100.0
1989	55.3	13.2	10.6	2.1	18.7	100.0

Source:NISTEP

Table 7-2-8 International Co-authorship of Scientific Literature

	1981	1982	1983	1984	1985	1986
	Ratio of international co-authorship [%] (A/B)					
U.S.	7.5	7.9	8.5	9.3	9.7	10.2
U.K.	13.5	13.9	14.3	15.6	15.7	16.6
W.Germany	14.2	15.0	16.4	17.6	18.8	20.9
France	15.2	16.7	18.0	18.9	20.5	21.3
USSR	2.8	2.9	3.0	2.9	3.2	3.3
Japan	5.2	5.7	6.1	6.7	7.1	7.5
	Number of international co-authored papers (A)					
U.S.	10,296	11,049	11,865	12,760	14,123	14,824
U.K.	4,499	4,638	4,858	5,158	5,545	5,789
W.Germany	3,560	3,771	4,060	4,297	4,999	5,323
France	3,069	3,348	3,555	3,765	4,220	4,507
USSR	836	900	929	869	994	982
Japan	1,337	1,517	1,649	1,881	2,196	2,309
	Total number of each countries' papers (B)					
U.S.	137,924	139,696	138,899	137,859	144,915	145,179
U.K.	33,239	33,404	33,893	33,013	35,227	34,812
W.Germany	25,133	25,083	24,718	24,354	26,565	25,511
France	20,172	20,064	19,702	19,918	20,629	21,208
USSR	30,050	30,835	31,385	29,851	30,823	29,778
Japan	25,793	26,643	27,247	27,997	30,768	30,956

Source:Computer Horizons, Inc., "Science & Engineering Indicators Literature Data Base", 1989.

Note

(1) Number of international co-authored papers are counted across each county repeatedly. Thereby paper for country A is wrtten by researchers include country A's researchers, even if only one person.

Table 7-2-9 International Co-authorship of Scientific Literature of Japan

	1981	1982	1983	1984	1985	1986
Total number	25,793	26,643	27,247	27,997	30,768	30,956
Single authored papers	18,086	18,302	18,245	18,267	19,556	19,087
Co-authored papers	7,707	8,341	9,002	9,730	11,212	11,869
Domestic co-authored papers	6,370	6,824	7,353	7,849	9,016	9,560
International co-authored papers	1,337	1,517	1,649	1,881	2,196	2,309
(Country of co-author)						
U.S.	794	912	890	1,039	1,178	1,269
W.Germany	95	143	182	181	215	237
U.K.	90	98	124	125	185	159
Canada	103	92	92	111	133	122
France	56	67	88	91	131	120
Australia	25	28	36	28	32	43
Italy	7	12	28	27	32	42
Netherlands	17	30	25	33	48	41
Sweden	10	23	43	35	37	41
Rest of Asia Pacific	125	137	157	219	277	298
Rest of West Europe	65	78	89	105	119	134
USSR & East Europe	42	55	43	51	59	69

Source:Same as Table 7-2-8

Table 8-1-1 R&D Expenditures and GDP in the Manufacturing Industry

(Units:billion yen)

	GDP	R&D Expenditures
1979	65454	2868
1980	71682	3147
1981	76126	3447
1982	77648	3695
1983	83847	4365
1984	93521	4520
1985	100064	5100
1986	100606	5095
1987	107902	5438
1988	116496	5973

Sources:Economic Planning Agency
Management and Coordination Agency

Table 8-1-2 R&D Expenditures in Selected Countries (billion 1980 dollars)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Japan	18.80	21.79	25.56	28.61	32.05	35.61	40.06	41.00	45.39		
U.S.	79.02	82.29	86.29	89.18	94.78	102.64	110.01	111.71	114.74	117.87	117.73
W.Germany	14.22		16.25		17.35		19.97	20.20	21.74	22.79	
France	12.98	13.20	14.26	14.58	14.15	14.44	14.57	14.48	15.10	15.77	16.80
U.K.			14.49		13.70		14.17	15.08	15.01		

Source : OECD, "Main Science and Technology Indicators," 1989.

Table 8-1-3 GDP in Selected Countries (billion 1980 dollars)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Japan	908.82	997.79	1099.69	1181.53	1250.92	1344.15	1425.43	1471.72	1583.91	1724.34	1867.24
U.S.	3447.28	3446.75	3523.97	3433.88	3567.52	3821.70	3967.47	4085.25	4231.70	4396.49	4527.00
W.Germany	602.18	635.20	671.08	679.86	690.29	721.02	738.10	752.27	773.19	815.83	861.43
France	730.03	726.78	722.59	706.44	669.54	654.72	646.51	646.15	659.43	683.96	717.19
U.K.	684.16	617.32	598.08	596.85	607.47	620.36	619.48	639.48	656.06	657.47	661.33

Source : OECD, "Main Science and Technology Indicators," 1989.

Table 8-1-4 Primary Energy Basic Unit (GDP Ratio)

(Unit:Mtoe/billion 1985 US dollars)

Year	Japan	U.S.	W.Germany	U.K.	France	OECD
1973	0.391	0.587	0.527	0.571	0.452	0.540
1974	0.400	0.580	0.510	0.558	0.430	0.530
1975	0.371	0.572	0.483	0.535	0.409	0.517
1976	0.375	0.584	0.501	0.524	0.411	0.525
1977	0.360	0.571	0.484	0.529	0.404	0.515
1978	0.348	0.562	0.489	0.508	0.413	0.509
1979	0.346	0.550	0.494	0.519	0.415	0.504
1980	0.324	0.530	0.467	0.486	0.409	0.483
1981	0.304	0.503	0.444	0.474	0.392	0.461
1982	0.288	0.497	0.431	0.465	0.372	0.450
1983	0.283	0.480	0.425	0.448	0.376	0.439
1984	0.288	0.466	0.430	0.437	0.381	0.434
1985	0.276	0.452	0.431	0.445	0.385	0.426
1986	0.272	0.440	0.424	0.437	0.381	0.418
1987	0.262	0.440	0.418	0.422	0.384	0.416
1988	0.266	0.436	0.408	0.407	0.370	0.411

Source:OECD," ENERGY BALANCES OF OECD COUNTRIES 1987-1988"

Table 8-1-5 Energy Consumpiton by Japan's Manufacturing Industry

(Units:trillion kcal)

	Manufacturing	Iron and steel	Chemicals	Pulp and paper products	Fobricated metal	Non-ferrous metals and products
1970	1258.4	430.8	368.5	80.5	45.9	38.2
1971	1312.4	444.9	382.2	83.6	45.7	38.5
1972	1389.7	465.5	398.6	90.5	46.3	41.9
1973	1536.2	544.9	413.3	98.9	50.1	46.9
1974	1474.0	535.9	383.1	92.3	43.8	43.5
1975	1380.8	497.0	353.5	86.6	38.2	38.9
1976	1460.4	506.5	385.8	88.6	42.3	40.8
1977	1414.6	464.9	387.6	86.2	41.9	41.7
1978	1418.5	443.5	397.2	90.2	44.1	42.8
1979	1445.5	467.4	396.5	95.0	44.5	46.1
1980	1329.8	447.7	326.5	84.7	46.5	44.1
1981	1261.2	416.1	294.4	79.9	57.9	35.6
1982	1182.8	380.9	283.5	78.6	56.8	29.9
1983	1194.0	380.8	289.1	80.3	62.5	29.5
1984	1251.9	402.6	316.7	82.3	67.7	31.4
1985	1250.6	394.3	323.7	79.9	72.4	31.4
1986	1217.7	366.2	328.9	82.3	71.7	31.3
1987	1278.0	385.3	349.2	87.1	75.7	28.3
1988	1357.6	403.3	363.7	99.8	83.0	29.2
1989	1394.9	414.5	380.2	99.6	87.5	32.2

Source:MITI

Table 8-1-6 Energy Consumption by Japan's Major Tronsport Means

	passenger(kcal/person km)			cargo(kcal/ton km)			
	passenger cars (private-use)	bus (business-use)	railways	trucks (private-use)	trucks (business-use)	railways	marine transport
1970	593.1	130.7	94.1	1666.6	542.7	214.4	226.7
1975	654.2	140.3	92.2	1993.1	649.6	144.5	286.0
1976	660.2	160.2	95.4	2227.0	678.7	148.6	279.2
1977	741.6	158.7	100.4	2303.9	670.3	162.8	264.4
1978	713.3	156.5	102.3	2123.9	712.9	151.9	233.8
1979	720.6	160.4	103.0	2015.9	690.1	139.9	220.5
1980	737.1	160.1	102.5	2008.6	656.1	149.9	188.7
1981	722.7	163.7	102.8	2057.1	631.4	158.7	135.0
1982	696.5	167.0	105.5	2073.4	603.2	167.1	135.0
1983	677.9	170.1	104.4	2131.4	590.8	169.6	135.2
1984	668.1	170.0	103.1	2099.0	605.9	172.6	117.9
1985	647.5	170.9	102.6	2084.9	614.1	170.3	123.0
1986	643.5	174.3	103.2	2105.8	603.8	163.6	129.4
1987	574.8	175.6	100.3	2152.8	623.9	118.4	120.7
1988	526.5	173.2	104.1	2009.3	613.4	119.7	120.2

Source:Ministry of Transport

Table 8-1-7 Consignment Number of Industrial robots

Year	Total	Manual manipulator	Fixed Sequence	Variable Sequence	Play-back robot	NC robot	Intelligent robot
1970	2,000	400	1,600	0	0	0	0
1971	1,150	250	900	0	0	0	0
1972	2,180	300	1,500	210	170	0	0
1973	3,110	350	2,600	100	60	0	0
1974	4,167	710	3,290	0	165	1	1
1975	4,207	770	3,300	0	137	0	0
1976	7,169	700	6,200	0	183	6	80
1977	8,612	1,130	6,490	425	357	11	199
1978	10,100	1,576	7,086	652	506	25	255
1979	14,555	1,051	10,721	1,244	662	89	788
1980	19,873	1,942	13,438	1,343	2,027	992	131
1981	22,069	964	12,923	2,478	3,928	1,138	638
1982	24,782	1,197	8,648	4,311	6,672	2,001	1,953
1983	30,544	935	11,032	4,457	7,873	3,947	2,300
1984	40,923	1,163	12,659	4,690	11,039	7,620	3,752
1985	48,490	1,177	13,289	6,263	14,384	10,469	2,908
1986	42,066	341	10,262	8,000	12,510	8,964	1,989
1987	45,050	118	11,151	7,201	13,027	10,909	2,644
1988	55,900	66	14,281	7,301	16,930	14,008	3,314

Source:Japan Industrial Robot Association

Table 8-1-8 Consignment Volue of Industrial Robots

Unit:Million yen

Year	Total	Manual manipulator	Fixed sequence	Variable sequence	Play-back robot	NC robot	Intelligent robot
1974	9,724	741	7,752	0	1,197	23	11
1975	10,135	866	8,103	0	1,132	23	11
1976	12,295	1,607	6,712	1,255	1,791	56	874
1977	18,893	1,879	8,424	2,354	3,924	86	2,225
1978	25,400	1,379	11,587	4,970	4,373	273	2,817
1979	40,398	1,936	19,011	7,356	6,653	1,745	3,698
1980	75,364	2,803	23,297	9,522	15,786	21,795	2,161
1981	101,531	3,016	23,947	14,398	33,388	16,080	10,702
1982	139,240	2,953	18,339	19,286	53,493	25,588	19,581
1983	166,909	3,424	18,746	19,503	58,304	47,690	19,242
1984	229,710	3,347	23,885	18,034	74,356	78,603	31,486
1985	269,992	3,296	30,137	23,221	90,978	95,498	26,862
1986	234,974	2,864	27,551	19,140	73,437	89,730	22,252
1987	255,438	3,355	22,537	18,565	72,176	108,443	30,362
1988	324,480	755	26,056	29,142	92,804	133,421	42,302

Source:Japan Industrial Robot Association

Table 8-1-9 Number of Industrial Robots in Use

	manufacturing	chemicals	Fabrical metal Products	General machinery	Electrical machinery	Transport equipment
1970	2,000	—	—	—	—	—
1971	3,150	—	—	—	—	—
1972	5,330	—	—	—	—	—
1973	8,440	—	—	—	—	—
1974	12,607	—	—	—	—	—
1975	16,814	—	—	—	—	—
1976	23,983	—	—	—	—	—
1977	30,595	—	—	—	—	—
1978	39,159	2,635	379	534	3,002	1,415
1979	51,207	6,367	889	1,227	7,650	3,672
1980	66,726	13,922	1,586	3,429	9,957	7,344
1981	83,438	21,222	2,421	6,156	13,645	11,459
1982	101,412	27,765	3,297	8,152	18,308	16,816
1983	120,329	36,552	4,629	9,823	24,979	21,720
1984	144,931	45,043	5,869	11,887	35,463	27,975
1985	174,716	51,922	7,097	14,753	44,216	34,563
1986	194,634	56,974	7,647	18,010	49,361	40,506
1987	212,588	57,647	8,203	20,821	56,808	45,370
1988	237,512	61,263	8,539	23,623	65,425	53,971

Source:Japan Industrial Robot Association

Table 8-1-10 Number of Industrial Robots in Use (per 1000 Workers)

Units:unit/1000 persons

	manufacturing	chemicals	Fabrical metal products	General machinery	Electrical machinery	Transport equipment
1970	0.18	—	—	—	—	—
1971	0.28	—	—	—	—	—
1972	0.48	—	—	—	—	—
1973	0.74	—	—	—	—	—
1974	1.16	—	—	—	—	—
1975	1.58	—	—	—	—	—
1976	2.28	—	—	—	—	—
1977	2.99	—	—	—	—	—
1978	3.83	6.38	0.51	0.53	2.45	1.61
1979	5.01	15.57	1.19	1.21	6.09	4.27
1980	6.48	34.04	2.13	3.34	7.42	8.26
1981	7.90	52.14	3.17	5.82	9.29	12.40
1982	9.68	68.56	4.36	7.72	12.25	18.44
1983	11.30	90.93	6.06	9.05	15.37	24.11
1984	13.50	113.74	7.76	10.94	19.76	30.28
1985	16.05	131.45	9.02	13.10	24.21	35.93
1986	17.87	143.87	9.78	16.09	26.44	44.22
1987	19.81	147.06	10.56	19.33	30.92	49.42

Source:Japan Industrial Robot Association

Table 8-1-11 Robot Price Index and Wage Index in the Manufacturing

Year	Robot Price Index(1980=1)	Wage Index (million yen)
1970	1.78	0.74
1971	1.19	0.86
1972	1.69	0.98
1973	1.76	1.21
1974	1.16	1.53
1975	1.31	1.71
1976	0.89	1.92
1977	0.87	2.09
1978	0.98	2.21
1979	0.95	2.37
1980	1.00	2.55
1981	0.94	2.69
1982	0.84	2.82
1983	0.77	2.93
1984	0.70	3.08
1985	0.68	3.18
1986	0.70	3.28
1987	0.68	3.34
1988	0.69	—

Source:S.Mori, "Macroeconomic Effects of Robotization in Japan"

Table 8-1-12 Sophisticated Robots Share (applied conversion)

	manufacturing	chemicals	Fabrical metal products	General machinery	Electrical machinery	Transport equipment
1974	-1.93	-3.32	-1.87	-1.76	-2.17	-1.49
1975	-2.04	—	-1.15	-0.80	-2.01	-1.27
1976	-1.26	-3.73	-2.51	-1.32	-0.29	-0.83
1977	-0.71	-3.18	-2.27	-0.81	0.02	-0.41
1978	-0.88	-4.09	-4.08	-1.40	0.18	-0.86
1979	-0.85	-2.81	-1.18	-1.05	-0.48	-1.22
1980	0.11	-2.97	0.16	-0.94	1.96	-0.28
1981	0.37	-1.79	0.59	-0.15	1.64	0.44
1982	0.89	-1.79	-0.07	0.56	1.99	0.72
1983	1.10	-1.73	-0.23	0.95	1.96	1.24
1984	1.40	-1.53	-0.44	1.55	2.18	1.25
1985	1.33	-1.55	0.68	1.95	2.09	1.14
1986	1.32	-1.47	0.14	1.82	2.23	1.40
1987	1.56	-0.92	0.62	2.14	2.55	1.52
1988	1.57	-0.85	0.58	1.39	2.57	1.31

Source:S.Mori, "Macroeconomic Effects of Robotization in Japan"

Table 8-1-13 Number of Directors of Companies Listed on the Stock Exchange by Graduate Department (1990)

Count object	Number of object company	Number of directors											
		Humanites and social sciences (HSS)				Natural science and engineering related (NSER)			Sub-total			Classification impossible	Total
		Economics	Law	Commerce	Others	Science and Engineering	Agri-culture	Medical & Pharmacy		HSS*	NSER*		
Whole	2,064	9,627 (30.2%)	6,591 (20.7%)	4,113 (12.9%)	1,467 (4.6%)	8,884 (27.9%)	961 (3.0%)	244 (0.8%)	31,887 (100.0%)	21,798 (68.4%)	10,089 (31.6%)	6,598	38,485
Manufacturing	1,196	4,626 (26.7%)	2,971 (17.2%)	2,015 (11.6%)	614 (3.5%)	6,240 (36.0%)	626 (3.6%)	221 (1.3%)	17,313 (100.0%)	10,226 (59.1%)	7,087 (40.9%)	3,200	20,513
Non-Manufacturing	868	5,001 (34.3%)	3,620 (24.8%)	2,098 (14.4%)	853 (5.9%)	2,644 (18.1%)	335 (2.3%)	23 (0.2%)	14,574 (100.0%)	11,572 (79.4%)	3,002 (20.6%)	3,398	17,972
Companies with capital of 10 billion yen or more	707	4,771 (31.1%)	3,557 (23.2%)	1,830 (11.9%)	685 (4.5%)	3,965 (25.8%)	413 (2.7%)	136 (0.9%)	15,357 (100.0%)	10,843 (70.6%)	4,514 (29.4%)	2,060	17,417
Number of company president	2,061	517 (29.8%)	384 (22.1%)	219 (12.6%)	47 (2.7%)	516 (29.7%)	46 (2.6%)	7 (0.4%)	1,736 (100.0%)	1,167 (67.2%)	569 (32.8%)	325	2,061

(*) NSER: Natural Science and Engineering Related
HSS: Humanities and Social Science

Source: Toyou-Keizai-shinpou-sha, "Exective Quarterly Database" 1990

Table 8-1-14 Distinction of Company Directors into Natural Science & Engineering Related Graduates and Humanities & Social Science Graduates (1990)

Industry	Number of company	Number of directors			(b)/(a) [%]
		(a) Total	(b) NSER* graduates	(c) HSS* graduates	
All industry	2,064	31,887	10,089	21,798	31.6
Agri., forest. & fish.	8	127	52	75	40.9
Mining	10	140	47	93	33.6
Construction	144	2,890	1,755	1,135	60.7
Food	101	1,428	408	1,020	28.6
Textiles	79	1,005	312	693	31.0
Polp and paper	32	508	187	321	36.8
Chemical	181	2,887	1,265	1,622	43.8
Petroleum and coal	12	200	49	151	24.5
Rubber	20	321	113	208	35.2
Ceramics	61	858	309	549	36.0
Iron and steel	58	957	406	551	42.4
Non-ferrous metals	39	654	281	373	43.0
Fabricated metal	58	716	267	449	37.3
General machinery	181	2,204	933	1,271	42.3
Electrical machinery	188	2,765	1,344	1,421	48.6
Transport equip.	87	1,551	763	788	49.2
Precision instruments	35	498	236	262	47.4
Other manufacturing	64	761	214	547	28.1
Commerce	250	3,488	399	3,089	11.4
Finance/insurance	204	4,267	119	4,148	2.8
Real estate	31	449	46	403	10.2
Land transportation	48	773	143	630	18.5
Marine transportation	25	314	27	287	8.6
Air transportation	5	113	30	83	26.5
Warehouse/other trans.	30	330	13	317	3.9
Communications	9	191	42	149	22.0
Electricity and gas	18	439	171	268	39.0
Services	86	1,053	158	895	15.0

(*) NSER: Natural Science and Engineering Related
HSS: Humanities and Social Science

Source: Toyou-Keizai-shinpou-sha, "Exective Quarterly Database" 1990

Table 8-2-1 Volume of Information Supplied and Consumed

	Supply (word)	Consume (word)	Consumption Ratio (%)
1975	1.88E+17	1.60E+16	8.5
1976	1.97E+17	1.66E+16	8.4
1977	2.06E+17	1.65E+16	8.0
1978	2.21E+17	1.67E+16	7.6
1979	2.31E+17	1.72E+16	7.4
1980	2.43E+17	1.75E+16	7.2
1981	2.61E+17	1.80E+16	6.9
1982	2.72E+17	1.74E+16	6.4
1983	2.92E+17	1.78E+16	6.1
1984	3.13E+17	1.78E+16	5.7
1985	3.48E+17	1.81E+16	5.2
1986	3.63E+17	1.88E+16	5.2
1987	3.85E+17	1.94E+16	5.0
1988	4.13E+17	1.99E+16	4.8

Source:Ministry of Posts and Telecommunications, "Cenxus on Informa Flows 1988"

Table 8-2-2 Information Supplied Through the Telecommunications Me

Unit:word

	Total	telephone	facsimill	Videotex	Data trans.	VAN/data communication	broadcast TV	satellite broadcasting	tele-text	CATV
1975	1.85E+17	1.06E+13	1.07E+10	—	—	2.36E+12	1.54E+17	—	—	1.11E+15
1976	1.94E+17	1.06E+13	2.04E+10	—	—	3.07E+12	1.57E+17	—	—	1.49E+15
1977	2.03E+17	1.06E+13	3.71E+10	—	—	3.64E+12	1.62E+17	—	—	1.81E+15
1978	2.17E+17	1.11E+13	6.05E+10	—	—	4.83E+12	1.68E+17	—	—	2.25E+15
1979	2.28E+17	1.19E+13	9.25E+10	—	6.48E+09	5.72E+12	1.73E+17	—	—	2.74E+15
1980	2.40E+17	1.23E+13	1.30E+11	—	1.12E+10	6.36E+12	1.95E+17	—	—	3.20E+15
1981	2.57E+17	1.33E+13	1.90E+11	—	5.53E+10	7.32E+12	1.91E+17	—	—	3.73E+15
1982	2.69E+17	1.44E+13	2.91E+11	—	1.14E+11	8.27E+12	1.99E+17	—	—	4.34E+15
1983	2.88E+17	1.60E+13	4.55E+11	—	2.44E+11	1.01E+13	2.13E+17	—	—	5.05E+15
1984	3.09E+17	1.81E+13	6.84E+11	1.54E+10	4.09E+11	2.19E+13	2.26E+17	2.21E+13	—	6.04E+15
1985	3.44E+17	2.06E+13	9.46E+11	9.61E+10	6.81E+11	1.24E+14	2.47E+17	4.23E+13	2.57E+11	7.15E+15
1986	3.59E+17	2.30E+13	1.31E+12	1.47E+11	1.09E+12	2.96E+14	2.57E+17	1.45E+14	5.65E+12	8.36E+15
1987	3.80E+17	2.41E+13	2.06E+12	1.99E+11	1.92E+12	5.61E+14	2.58E+17	6.84E+14	2.31E+13	1.06E+16
1988	4.08E+17	2.16E+13	3.05E+12	3.06E+11	1.58E+12	6.51E+14	2.75E+17	1.57E+15	4.14E+13	1.44E+16

Source:Ministry of Posts and Telecommunications, "Cenxus on Information Flows 1988"

Table 8-2-3 Volume of Information Consumed Through the Telecommunications Media

Unit:word

	Total	telephone	facsimile	Videotex	Data trans.	VAN/data communication	broadcast TV	satellite broadcasting	tele-text	CATV
1975	9.96E+15	1.06E+13	2.13E+10	—	—	2.36E+12	9.29E+15	—	—	6.11E+13
1976	1.05E+16	1.06E+13	4.08E+10	—	—	3.07E+12	9.71E+15	—	—	8.26E+13
1977	1.03E+16	1.06E+13	7.41E+10	—	—	3.64E+12	9.36E+15	—	—	9.29E+13
1978	1.04E+16	1.11E+13	1.21E+11	—	—	4.83E+12	9.34E+15	—	—	1.12E+14
1979	1.08E+16	1.19E+13	1.85E+11	—	6.48E+09	5.72E+12	9.64E+15	—	—	1.37E+14
1980	1.10E+16	1.23E+13	2.59E+11	—	1.12E+10	6.36E+12	9.65E+15	—	—	1.55E+14
1981	1.14E+16	1.33E+13	3.80E+11	—	5.53E+10	7.32E+12	9.94E+15	—	—	1.79E+14
1982	1.07E+16	1.44E+13	5.83E+11	—	1.14E+11	8.27E+12	9.23E+15	—	—	1.84E+14
1983	1.10E+16	1.60E+13	9.11E+11	—	2.44E+11	1.01E+13	9.25E+15	—	—	2.09E+14
1984	1.09E+16	1.81E+13	1.37E+12	3.86E+08	4.09E+11	2.19E+13	9.09E+15	1.22E+13	—	2.32E+14
1985	1.11E+16	2.06E+13	1.89E+12	2.40E+09	6.81E+11	1.24E+14	9.09E+15	2.32E+13	1.58E+09	2.69E+14
1986	1.16E+16	2.30E+13	2.61E+12	3.67E+09	1.09E+12	2.96E+14	9.28E+15	3.64E+13	1.73E+10	3.09E+14
1987	1.21E+16	2.41E+13	4.12E+12	5.48E+09	1.92E+12	5.61E+14	9.18E+15	1.54E+14	6.83E+10	3.61E+14
1988	1.23E+16	2.16E+13	6.10E+12	8.41E+09	1.58E+12	6.51E+14	9.11E+15	2.43E+14	1.08E+11	3.28E+14

Source:Ministry of Posts and Telecommunications

Table 8-2-4 Volume of Information Supplied Through the Conveyance Media

Unit:word

	conveyance media total	letter	postcard	electronic mail	hand Writing	word processor	newspaper	magazine	book	video software
1975	1.23E+15	2.34E+12	5.53E+11	—	3.81E+12	—	8.49E+14	2.60E+14	1.02E+14	—
1976	1.30E+15	1.97E+12	5.42E+11	—	3.92E+12	—	8.95E+14	2.77E+14	1.14E+14	—
1977	1.34E+15	2.05E+12	5.90E+11	—	4.00E+12	—	9.20E+14	2.79E+14	1.23E+14	—
1978	1.41E+15	2.13E+12	6.21E+11	—	4.07E+12	—	9.58E+14	2.95E+14	1.31E+14	—
1979	1.52E+15	2.22E+12	6.69E+11	—	4.25E+12	—	1.04E+15	3.23E+14	1.36E+14	—
1980	1.59E+15	2.33E+12	6.88E+11	—	4.37E+12	—	1.08E+15	3.41E+14	1.41E+14	1.76E+10
1981	1.63E+15	2.37E+12	6.19E+11	1.06E+06	4.49E+12	—	1.12E+15	3.41E+14	1.44E+14	4.71E+10
1982	1.69E+15	2.50E+12	6.42E+11	8.69E+06	4.61E+12	1.13E+10	1.17E+15	3.47E+14	1.49E+14	1.00E+11
1983	1.73E+15	2.65E+12	6.64E+11	1.28E+07	4.62E+12	3.82E+10	1.17E+15	3.68E+14	1.62E+14	2.64E+11
1984	1.81E+15	2.79E+12	6.68E+11	1.26E+08	4.89E+12	7.94E+10	1.21E+15	3.90E+14	1.71E+14	5.79E+12
1985	1.88E+15	2.97E+12	6.70E+11	1.19E+09	5.05E+12	3.02E+11	1.24E+15	4.25E+14	1.76E+14	1.07E+13
1986	1.94E+15	3.15E+12	7.06E+11	4.95E+09	4.97E+12	7.18E+11	1.28E+15	4.32E+14	1.77E+14	1.33E+13
1987	2.02E+15	3.46E+12	7.44E+11	5.83E+09	5.18E+12	9.59E+11	1.34E+15	4.36E+14	1.79E+14	1.98E+13
1988	2.13E+15	3.86E+12	8.09E+11	9.77E+09	5.35E+12	1.02E+12	1.41E+15	4.53E+14	1.82E+14	3.68E+13

Source:Ministry of Posts and Telecommunications

Table 8-2-5 Volume of Information Consumed Through the Conveyance Media

Unit:word

	conveyance media total	letter	postcard	electronic mail	hand Writing	word processor	newspaper	magazine	book	video software
1975	5.22E+14	2.06E+12	4.71E+11	—	1.02E+13	—	1.56E+14	1.34E+14	1.85E+14	—
1976	5.31E+14	1.76E+12	4.52E+11	—	1.05E+13	—	1.60E+14	1.36E+14	1.87E+14	—
1977	5.38E+14	1.83E+12	4.92E+11	—	1.07E+13	—	1.62E+14	1.37E+14	1.89E+14	—
1978	5.47E+14	1.90E+12	5.18E+11	—	1.08E+13	—	1.65E+14	1.39E+14	1.92E+14	—
1979	5.57E+14	1.93E+12	5.52E+11	—	1.13E+13	—	1.68E+14	1.41E+14	1.94E+14	—
1980	5.80E+14	2.03E+12	5.67E+11	—	1.16E+13	—	1.79E+14	1.43E+14	1.97E+14	5.02E+12
1981	5.91E+14	2.07E+12	5.11E+11	1.06E+06	1.19E+13	—	1.80E+14	1.44E+14	1.98E+14	1.08E+13
1982	6.03E+14	2.18E+12	5.29E+11	8.69E+06	1.21E+13	1.13E+10	1.83E+14	1.45E+14	2.00E+14	1.60E+13
1983	6.09E+14	2.31E+12	5.47E+11	1.28E+07	1.15E+13	3.82E+10	1.84E+14	1.37E+14	2.02E+14	2.54E+13
1984	6.34E+14	2.43E+12	5.50E+11	1.26E+08	1.28E+13	7.94E+10	1.86E+14	1.39E+14	2.04E+14	4.06E+13
1985	6.49E+14	2.54E+12	5.51E+11	1.19E+09	1.38E+13	3.02E+11	1.75E+14	1.40E+14	2.06E+14	6.09E+13
1986	6.74E+14	2.69E+12	5.80E+11	4.95E+09	1.29E+13	7.18E+11	1.77E+14	1.41E+14	2.07E+14	7.93E+13
1987	7.05E+14	2.95E+12	6.11E+11	5.83E+09	1.35E+13	9.59E+11	1.80E+14	1.42E+14	2.09E+14	1.01E+14
1988	7.42E+14	3.25E+12	6.54E+11	9.77E+09	1.39E+13	1.02E+12	1.82E+14	1.44E+14	2.11E+14	1.24E+14

Source:Ministry of Posts and Telecommunications

Table 8-2-6 Volume of Information Supplied Through the Space Media

Unit:word

	Space media total	movie
1975	1.85E+15	7.06E+11
1976	1.88E+15	7.09E+11
1977	1.90E+15	7.00E+11
1978	1.93E+15	6.91E+11
1979	1.96E+15	6.86E+11
1980	1.99E+15	6.83E+11
1981	2.02E+15	6.64E+11
1982	2.05E+15	6.55E+11
1983	2.08E+15	6.47E+11
1984	2.11E+15	6.33E+11
1985	2.14E+15	6.18E+11
1986	2.18E+15	6.03E+11
1987	2.23E+15	6.10E+11
1988	2.29E+15	5.93E+11

Table 8-2-7 Volume of Information Consumed Through the Space Media

Unit:word

	Space media total	movie
1975	5.48E+15	3.75E+13
1976	5.57E+15	3.68E+13
1977	5.65E+15	3.56E+13
1978	5.74E+15	3.58E+13
1979	5.84E+15	3.56E+13
1980	5.93E+15	3.54E+13
1981	6.01E+15	3.22E+13
1982	6.10E+15	3.35E+13
1983	6.18E+15	3.67E+13
1984	6.27E+15	3.24E+13
1985	6.34E+15	3.34E+13
1986	6.45E+15	3.44E+13
1987	6.60E+15	3.10E+13
1988	6.78E+15	3.21E+13

Table 8-2-8 Number of Newspaper Articles on Science and Technology

	special article	general article
1981	418	382
1982	362	469
1983	366	440
1984	573	576
1985	929	516
1986	1,096	459
1987	1,072	488
1988	1,004	485
1989	1,194	495

Source:Asahi Sinbun

Table 8-2-9 VTR and Video Camera Production

	V T R		Video Camera		VTR
	number	value (million yen)	number	value (million yen)	defusion rating(%)
1975	118,990	24,751	—	—	—
1976	287,825	57,088	—	—	—
1977	762,499	126,044	—	—	—
1978	1,470,439	204,121	—	—	1.3
1979	2,199,069	296,168	—	—	2.0
1980	4,441,212	562,825	—	—	2.4
1981	9,497,865	1,086,799	—	—	5.1
1982	13,134,106	1,284,987	885,332	87,815	7.5
1983	18,216,566	1,513,991	1,201,858	115,027	11.8
1984	28,611,090	2,090,021	1,570,929	154,891	18.7
1985	30,581,452	1,889,254	2,574,159	354,394	27.8
1986	33,879,475	1,659,435	3,258,192	417,228	33.5
1987	30,563,335	1,242,692	4,608,705	482,958	43.0
1988	31,660,444	1,212,004	6,681,510	644,970	53.0
1989	32,014,641	1,134,562	6,934,750	614,546	63.7

Sources:MITI
Economic Planning Agency

Table 8-2-10 Video Software Sales

	Total	Sales		Rental	
	million yen	million yen	number	million yen	number
1978	2,048	1,886	137,147	162	26,801
1979	2,165	2,007	134,335	158	6,447
1980	2,967	2,754	176,377	213	16,912
1981	5,273	5,165	474,423	108	1,552
1982	10,935	10,798	1,008,193	137	1,958
1983	22,516	22,335	1,936,997	181	11,113
1984	32,669	31,465	2,990,762	1,204	98,036
1985	37,364	34,019	3,746,906	3,345	263,642
1986	50,472	40,050	4,507,237	10,422	950,886
1987	87,739	68,695	7,625,177	19,044	1,901,186
1988	107,851	79,011	11,691,114	28,840	3,122,196
1989	129,507	93,043	16,989,816	36,464	4,441,522

Source:Japan Video Association

Table 8-2-11 Video Software Sales by Use

	personal use		business use	
	Sales (million yen)	[%]	Sales (million yen)	[%]
1978	693	35.3	1270	64.7
1979	873	40.5	1284	59.5
1980	1205	45.4	1447	54.6
1981	2596	55.4	2087	44.6
1982	8079	75.3	2655	24.7
1983	19099	86.0	3101	14.0
1984	27751	91.9	2431	8.1
1985	32451	89.4	3837	10.6
1986	45890	93.1	3408	6.9
1987	83638	95.3	4101	4.7
1988	102611	95.2	5204	4.8
1989	121925	94.1	7582	5.9

Source:Japan Video Association

Table 8-2-12 Video Software Sales by Genre (1989)

	Sales (million yen)	(%)
movie	47589	51.1
animation	20882	22.4
music	14359	15.4
amusement /sports	2770	3.0
hobby /culture	1443	1.6
education	1345	1.4
others	4655	5.0
total	93043	100

	Rental (million yen)	(%)
movie	28259	77.5
animation	6569	18.0
music	577	1.6
amusement /sports	214	0.6
hobby /culture	183	0.5
education	104	0.3
others	558	1.5
total	36464	100

Source:Japan Video Association

Table 8-2-13 Personal Computer Consigment

	number (thousand)			value (100 million yen)		
	total	domestic	export	total	domestic	export
1978	10	9	1	60	—	—
1979	46	36	10	159	—	—
1980	111	94	17	337	—	—
1981	282	229	53	1,070	—	—
1982	762	683	79	2,314	—	—
1983	1,141	885	256	3,416	2,668	748
1984	1,874	1,196	678	4,706	3,414	1,292
1985	1,983	1,187	796	5,552	3,748	1,804
1986	2,060	1,236	824	6,373	4,319	2,054
1987	1,976	1,203	773	7,381	5,263	2,118
1988	2,191	1,375	816	8,677	6,490	2,187
1989	2,405	1,657	748	10,771	7,881	2,890

Source:

Table 8-2-14 Personal Computer Software Consignment

Unit:thousand yen

	Total	CAD	specific-industry-oriented	game	Word processing	graphics	telecommunication	data base	others
1985	41,857,860	3,392,890	2,685,520	9,019,990	5,765,560	2,674,860	2,973,690	3,132,490	12,212,860
1986	60,521,950	6,164,940	3,270,860	11,085,660	7,062,810	3,615,930	3,769,680	4,206,650	21,345,420
1987	82,386,700	8,778,900	5,539,400	12,885,000	9,098,500	5,667,800	4,644,300	5,057,400	30,715,400
1988	116,133,900	13,870,700	11,767,800	14,563,700	10,651,700	9,498,500	6,586,800	7,480,900	41,713,800
1989	167,846,874	21,991,995	19,796,970	15,559,857	14,661,000	12,382,648	10,235,887	9,666,819	63,551,698

Sources:Japan Personal Computer Software Association
Japan Personal Computer Software Technology Research Institute

Table 8-3-1 Japan's Primary Energy Supply

Units:trillion kcal

	total	oil	coal	gas	nuclear	hydro/others
1960	1008.10	379.29	415.22	9.39	—	204.20
1961	1159.43	470.34	449.54	13.66	—	225.88
1962	1209.92	570.78	418.17	17.63	—	203.36
1963	1365.64	717.84	432.26	20.54	—	195.02
1964	1506.08	851.73	444.50	20.27	—	189.58
1965	1689.10	1006.78	456.54	20.27	0.08	205.42
1966	1851.53	1143.95	475.66	21.12	1.34	209.44
1967	2123.86	1380.55	533.22	22.34	1.45	186.30
1968	2431.90	1631.21	573.91	24.09	2.40	200.30
1969	2775.26	1923.44	615.46	28.47	2.49	205.41
1970	3197.08	2298.93	635.71	39.70	10.54	212.20
1971	3247.90	2404.97	558.52	40.02	18.02	226.35
1972	3470.37	2620.14	558.72	40.29	21.33	229.88
1973	3854.09	2982.35	595.87	59.14	21.84	194.89
1974	3846.79	2863.02	636.91	76.84	44.32	225.69
1975	3662.24	2686.42	599.93	92.31	56.53	227.05
1976	3873.33	2873.10	586.42	104.57	76.68	232.55
1977	3872.71	2896.79	558.63	138.60	71.23	207.46
1978	3864.55	2834.05	513.79	180.12	133.46	203.14
1979	4111.39	2939.84	566.77	214.84	158.38	231.56
1980	3971.65	2624.36	673.27	241.64	185.83	246.56
1981	3821.32	2434.52	704.06	242.59	197.60	242.55
1982	3642.86	2253.02	675.38	252.38	230.47	231.60
1983	3835.58	2357.69	689.21	289.24	257.15	242.28
1984	4031.12	2385.61	757.71	369.62	302.10	216.10
1985	4054.01	2280.41	788.10	382.13	359.05	244.32
1986	4023.18	2275.41	732.85	395.92	378.69	240.32
1987	4224.97	2403.17	761.25	408.61	422.46	229.49
1988	4455.02	2554.02	805.39	425.94	401.98	267.69
1989	4618.79	2674.29	796.70	461.58	411.46	274.76

Source:MITI

Table 8-3-2 Investment in Pollution Control Equipment

Unit:100 million yen

	Industry total	Irom and steel	Electric power	Chemicals	Machinery
1971	3,057	690	493	222	176
1972	3,311	859	605	229	207
1973	5,147	1,030	726	725	365
1974	9,170	1,671	1,417	1,600	528
1975	9,645	2,091	1,726	1,443	369
1976	7,819	2,654	2,260	607	330
1977	4,055	812	1,569	257	284
1978	3,265	629	1,375	144	242
1979	2,901	680	1,111	113	185
1980	3,128	321	1,699	84	228
1981	4,037	464	2,435	106	223
1982	4,516	694	2,751	112	230
1983	4,540	416	3,555	77	174
1984	3,475	254	2,439	191	197
1985	3,668	260	2,458	162	236
1986	2,672	178	1,913	132	109
1987	2,428	79	1,871	55	103
1988	2,815	159	2,077	89	189

Source:MITI

Table 8-3-3 Investment in Pollution Control Equipment (by Industry, Type)

	amount (100 million yen)	[%]
Total	2,815	100
Electric power	2,077	73.8
Machinery	189	6.7
Irom and steel	159	5.6
Pulp and paper products	101	3.6
Chemicals	89	3.2
Others	200	7.1

	amount (100 million yen)	[%]
Air pollution control	1,726	61.3
Water pollution control	540	19.2
Noise/ vibration control	298	10.6
Indutrial waste	94	3.3
Facilities	157	5.6
total	2,815	100

Source:MITI

Table 8-3-4 Amount of Pollution Control Equipment Production

million yen

	Total			
		Private Sector	Public Sector	Export
1971	302,259	183,553	102,393	6,313
1972	374,646	218,321	151,538	4,787
1973	488,248	312,138	166,034	10,076
1974	677,307	450,623	216,867	9,817
1975	683,082	435,704	238,303	9,075
1976	693,876	377,991	300,680	15,205
1977	581,127	219,851	348,308	12,968
1978	613,316	171,834	413,351	28,131
1979	644,548	161,124	452,195	31,229
1980	655,109	221,310	393,506	40,293
1981	677,928	243,175	398,915	35,838
1982	610,992	195,472	397,478	18,042
1983	651,436	203,895	424,445	23,096
1984	594,788	211,954	365,222	17,612
1985	652,827	202,863	424,349	25,615
1986	668,603	192,396	418,273	57,934
1987	622,916	173,244	413,913	35,759
1988	644,868	159,168	464,767	20,933

Air pollution control				Water pollution control			
	Private Sector	Public Sector	Export		Private Sector	Public Sector	Export
124,651	118,595	3,506	2,550	142,316	70,626	67,927	3,763
132,690	121,827	7,130	3,733	186,513	86,642	98,888	983
209,272	194,149	9,065	6,058	211,890	102,198	105,689	4,003
334,253	318,471	9,820	5,962	265,328	117,517	143,967	3,844
312,464	298,602	10,806	3,056	296,067	125,990	164,296	5,781
280,981	262,134	13,955	4,892	315,841	101,173	204,362	10,306
144,345	127,268	12,677	4,400	324,953	73,790	244,022	7,141
109,758	83,719	10,518	15,521	379,178	65,926	303,418	9,834
112,271	82,407	18,270	11,594	408,223	65,561	323,477	19,185
160,109	122,732	17,216	20,161	352,132	79,081	253,175	19,876
162,846	130,075	11,441	21,330	369,904	87,398	268,605	13,901
141,916	114,060	19,634	8,222	322,981	68,918	244,612	9,451
146,880	119,848	17,411	9,621	337,872	68,791	256,003	13,078
158,323	128,345	20,569	9,409	315,832	73,340	234,606	7,886
147,681	118,301	13,819	15,561	322,458	58,417	255,286	8,755
151,759	118,733	11,956	21,070	335,839	54,177	257,595	24,067
143,232	103,180	13,280	26,772	334,679	51,292	277,274	6,113
104,049	82,139	10,376	11,534	343,868	54,227	283,426	6,215

Noise/vibration control				Waste disposal			
	Private Sector	Public Sector	Export		Private Sector	Public Sector	Export
805	747	58	0	34,487	3,585	30,902	0
1,010	964	45	1	54,433	8,888	45,475	70
1,062	1,007	40	15	66,024	14,784	51,240	0
1,291	1,239	52	0	76,435	13,396	63,028	11
1,541	1,406	134	1	73,010	9,706	63,067	237
2,162	1,598	564	0	94,892	13,086	81,799	7
5,070	3,636	1,025	409	106,759	15,157	90,584	1,018
3,944	2,567	1,201	176	120,436	19,622	98,214	2,600
3,983	2,580	1,313	90	120,071	10,576	109,135	360
6,484	2,947	3,476	61	136,384	16,550	119,639	195
5,746	1,369	4,262	115	139,432	24,333	114,607	492
6,780	4,400	2,213	167	139,315	8,094	131,019	202
4,439	2,232	2,055	152	162,245	13,024	148,976	245
6,672	3,987	2,617	68	113,961	6,282	107,430	249
3,821	2,583	959	279	178,867	23,562	154,285	1,020
3,977	3,213	563	201	177,028	16,273	148,159	12,596
4,857	4,427	370	60	140,148	14,345	122,989	2,814
3,630	2,449	1,162	19	193,321	20,353	169,803	3,165

Table 8-3-5 Fluegas Desulphurisation Units and Fluegas Denitrification Units

	Desulphurisation		Denitrification	
	Number	Treatment Capacity (million Nm3/h)	Number	Treatment Capacity (million Nm3/h)
1970	102	5.4	—	—
1971	183	9.3	—	—
1972	323	18.0	5	0.1
1973	543	28.8	10	0.4
1974	768	42.7	20	1.2
1975	994	79.5	45	4.3
1976	1,134	103.8	71	8.2
1977	1,192	110.5	93	13.7
1978	1,227	114.8	109	22.2
1979	1,266	117.5	122	28.4
1980	1,329	122.0	140	39.1
1981	1,362	126.5	175	63.6
1982	1,366	127.2	188	71.7
1983	1,405	129.1	231	95.1
1984	1,583	133.4	253	103.5
1985	1,741	154.5	305	109.9
1986	1,758	155.0	323	125.9
1987	1,789	169.2	348	138.1
1988	1,810	176.3	379	142.1
1989	1,846	176.0	434	158.7

Source:Enviroment Agency, "White Paper on Environment"

Table 8-3-6 SOx, NOx Emissions

	Japan [1983]	U.S. [1986]	W.Germany [1986]	U.K. [1987]	France [1987]
SOx [1000t]	1,079	21,200	2,223	3,867	1,517
NOx [1000t]	1,416	19,300	2,924	2,303	1,652
TPER [Mtoe]	350.77	1798.53	270.63	208.67	206.46
SOx/TPER [kg/toe]	3.08	11.79	8.21	18.53	7.35
NOx/TPER [kg/toe]	4.04	10.73	10.80	11.04	8.00

Source:OECD, "OECD ENVIRONMENT DATA, COMPENDIUM 1989"

Table 8-3-7 Annual Average Concentration of SO_2, NO_2

Unit:ppm

	SO_2	NO_2	
	Air pollution monitoring station	Air pollution monitoring station	Automobile exhaust monitoring station
1965	0.057	—	—
1966	0.057	—	—
1967	0.059	—	—
1968	0.055	—	—
1969	0.050	—	—
1970	0.043	0.022	—
1971	0.037	0.021	0.032
1972	0.031	0.020	0.034
1973	0.030	0.025	0.037
1974	0.024	0.027	0.040
1975	0.021	0.026	0.040
1976	0.020	0.027	0.042
1977	0.018	0.026	0.042
1978	0.017	0.028	0.043
1979	0.016	0.028	0.042
1980	0.016	0.027	0.043
1981	0.014	0.026	0.042
1982	0.013	0.025	0.042
1983	0.012	0.025	0.040
1984	0.012	0.025	0.038
1985	0.011	0.024	0.037
1986	0.010	0.026	0.039
1987	0.010	0.028	0.041
1988	0.010	0.028	0.042
1989	0.011	0.028	0.042

Source:Enviroment Agency

Table 8-3-8 C O2 Emission from Fossil Fuel Consumption

Unit:100 million tC

	Japan	U.S.	W.Germany	U.K.	France	Canada	U.S.S.R.	China	OECD	World total
1971	2.2	11.6	2.0	1.8	1.2	1.0	6.1	2.3	23.2	38.3
1973	2.6	12.6	2.2	1.8	1.4	1.0	6.7	2.5	25.5	42.2
1975	2.5	11.9	1.9	1.6	1.2	1.1	7.4	2.9	24.0	42.5
1977	2.6	13.1	2.0	1.7	1.3	1.2	7.9	3.5	26.0	46.5
1979	2.7	13.4	2.2	1.7	1.4	1.2	8.4	3.9	27.0	50.9
1980	2.6	12.9	2.1	1.6	1.3	1.2	8.6	3.9	26.6	49.7
1982	2.4	11.9	1.9	1.5	1.2	1.1	8.8	4.0	24.1	47.9
1983	2.4	11.9	1.9	1.5	1.1	1.1	8.8	4.2	24.0	48.7
1984	2.6	12.4	2.0	1.4	1.1	1.1	8.9	4.6	24.7	52.0
1985	2.6	12.5	1.9	1.5	1.1	1.1	9.1	4.9	24.9	51.2
1986	2.6	12.4	2.0	1.6	1.0	1.1	9.3	5.2	25.0	52.2
1987	2.5	12.9	1.9	1.6	1.1	1.2	9.6	5.4	25.6	53.8
1988	2.8	13.4	1.9	1.6	1.0	1.2	9.8	5.7	26.4	55.6

Sources:OECD, "ENERGY BALANCES OF OECD COUNTRIES 1987-1988"
OECD, "WORLD ENERGY STATISTICS AND BALANCES 1971-1987, 1985-1988"

Table 8-3-9 Primary Energy Supply

Unit:Mtoe

	Japan	U.S.	W.Germany	U.K.	France	Canada	U.S.S.R.	China	OECD
1971	282.37	1630.28	239.69	211.27	159.00	157.98	777.45	241.45	3188.14
1973	331.19	1754.94	265.97	220.58	182.92	179.39	855.92	270.32	3519.75
1975	318.46	1679.43	240.74	201.58	169.87	188.46	950.58	321.39	3377.42
1977	341.27	1836.48	261.38	209.69	180.52	205.17	1029.07	377.40	3659.37
1979	362.38	1896.00	285.95	219.33	198.21	220.59	1108.35	427.85	3849.77
1980	354.95	1826.06	273.99	200.64	198.19	223.27	1140.15	423.54	3733.56
1982	336.96	1706.84	251.82	192.55	187.38	212.55	1184.80	436.54	3521.69
1983	341.29	1711.76	252.15	192.30	190.30	212.15	1199.44	460.10	3538.47
1984	364.00	1781.99	261.85	191.72	195.37	223.90	1237.53	497.85	3678.39
1985	365.25	1791.79	267.92	202.00	201.39	230.69	1281.33	539.89	3739.59
1986	368.80	1792.81	269.85	205.49	203.87	233.16	1314.27	568.40	3769.34
1987	371.11	1859.46	270.86	208.02	209.69	240.25	1357.12	594.57	3880.48
1988	398.76	1928.36	274.11	208.52	208.90	249.50	1405.72	625.13	4002.96

Sources:OECD, "ENERGY BALANCES OF OECD COUNTRIES 1987-1988"
OECD, "WORLD ENERGY STATISTICS AND BALANCES 1971-1987, 1985-1988"

Table 8-4-1 Number of International Telephone calls and Telexes Handled

Unit:10 thousands

	Telephone calls	Telexes
1975	857	1,623
1976	1,022	1,971
1977	1,212	2,344
1978	1,566	2,786
1979	1,959	3,272
1980	2,343	3,798
1981	2,973	4,207
1982	3,808	4,568
1983	4,974	4,962
1984	6,890	5,210
1985	9,563	5,017
1986	13,461	4,379
1987	18,830	3,473
1988	25,286	2,657
1989	32,102	2,061

Source:Ministry of Posts and Telecommunications

Table 8-4-2 Facsimill Production

	Number	Value (million yen)
1975	22,163	11,773
1976	19,380	19,057
1977	29,202	29,671
1978	47,262	42,643
1979	70,071	61,897
1980	100,356	81,070
1981	127,341	105,942
1982	228,933	143,541
1983	303,731	168,762
1984	511,015	247,790
1985	865,575	313,162
1986	1,234,228	302,957
1987	2,411,221	364,844
1988	4,327,834	465,888
1989	4,857,346	502,190

Source:MITI

Table 8-4-3 Overseas Circulation of Japanese Newspapers

	printed in Japan		Satellite edition
	morning edition	evening edition	
1980	37,269	27,858	—
1981	41,149	30,848	—
1982	44,598	33,272	—
1983	46,045	34,616	—
1984	48,418	36,677	—
1985	51,393	37,828	—
1986	49,020	35,747	5,333
1987	51,729	27,036	20,039
1988	55,767	26,417	25,520
1989	59,400	27,221	30,182

Sources:Asahi Shinbun
Nihon Keizai Shinbun
Japanese Newspaper Association

Table 8-4-4 Japanese Residing Overseas

Unit:person

	Total	long-term	permanent
1980	445,372	193,820	251,552
1981	450,873	204,731	246,142
1982	463,680	215,799	247,881
1983	471,873	223,601	248,272
1984	478,168	228,914	249,254
1985	480,739	237,488	243,251
1986	498,196	251,756	246,440
1987	518,318	270,391	247,927
1988	548,404	302,510	245,894
1989	586,972	340,929	246,043

Source:Ministry of Foreign Affairs

Table 8-4-5 International Transmission of Images Via Satellite

	Total	Pre-Scheduled	Non-Scheduled	Asia Vision
1980	1,279	730	549	—
1981	1,348	729	619	—
1982	1,850	990	860	—
1983	2,300	1,250	1,050	—
1984	3,536	1,889	1,647	—
1985	4,996	1,670	1,899	1,427
1986	6,177	2,245	2,516	1,416
1987	9,447	5,188	2,851	1,408
1988	11,787	7,311	3,524	952
1989	13,242	7,583	4,965	694

Unit:hours

	Total	Pre-Scheduled	Non-Scheduled	Asia Vision
1980	383	161	222	—
1981	503	175	328	—
1982	708	262	446	—
1983	874	359	516	—
1984	1,368	522	846	—
1985	1,585	512	885	187
1986	2,514	986	1,344	184
1987	4,849	2,911	1,757	181
1988	7,435	4,094	3,162	179
1989	7,635	4,612	2,861	162

Source:NHK

Table 8-4-6 Number of Households Receiving Satellite Broadcasts

Unit:Households

	Total	Personal	Community
1984	38,100	5,100	33,000
1985	61,400	7,000	54,400
1986	117,500	7,500	110,000
1987	421,600	112,100	309,500
1988	1,248,500	570,500	678,000
1989	2,009,500	1,070,500	939,000
1990	2,744,000	1,726,000	1,018,000

Source:Ministry of Posts and Telecommunications

Table 8-4-7 Number of NHK Television Broadcast Subsctibers

	Total	non-Satellite		Satellite broadcast
		monochrome	color	
1984	31,061,592	2,155,820	28,905,772	—
1985	31,509,288	2,055,142	29,454,146	—
1986	31,954,635	1,954,888	29,999,747	—
1987	32,396,565	1,704,912	30,691,653	—
1988	32,839,193	1,549,755	31,289,438	—
1989	33,188;737	1,446,803	30,534,930	1,207,004

Source:NHK

Table 9-1-1 Interest in Science and Technology

	Very interested	Interested	Not interested, not sure
1976/10	15.0	47.0	38.0
1981/12	9.0	43.0	48.0
1986/3	10.0	37.5	52.5
1988/3	9.9	42.5	47.6
1990/1	10.2	45.7	44.1
Male	16.5	53.0	30.3
Female	4.7	39.4	55.9

Source:Prime Minster's Office,
"Opinion Survey on Science, Technology and Nuclear Energy" 1976.
"Opinion Survey on Science & Technology" 1981.
"Opinion Survey on Interest in Science & Technology" 1986.
"Opinion Survey on Science, Technology and Society" 1987, 1990.

Table 9-1-2 Sources of Information on Science and Technology

Percentage(Multiple answers)

	Respondents	T.V.,radio news papers magazines	Conversation with family & friends	S&T magazines and journals	Museums & events	Others	No sources	Total
Both	2,239	90.0	23.8	10.9	6.7	0.5	8.1	140.0
Male	1,041	90.8	19.2	17.2	7.2	0.7	6.9	142.0
Female	1,198	89.2	27.9	5.3	6.2	0.4	9.2	138.2

Source:Prime Minister's Office, "Opinion Survey on Science, Technology and Society" 1990

Table 9-1-3 Recognition of Science and Technology Terms

(1) Japan (Respondents : 2,344* and 2,239 persons)

Percentage

	Understand the meaning	Understand the meaning somewhat	have heard the term	do not understand
DNA*	8.0	6.6	18.6	66.8
DNA	9.7	8.2	21.3	60.8
GNP	26.6	18.6	28.2	26.5
Acid rain	30.7	26.6	24.0	18.7
Nuclear fusion	21.2	23.4	32.8	22.6
Immunity	43.0	31.1	17.0	8.9
Computer Software*	21.1	19.3	30.9	28.7
Data base*	12.7	11.7	28.8	46.7
Data base	14.0	13.1	28.0	44.8
VAN	8.7	6.0	16.4	68.8
Ozone	35.5	28.2	23.7	12.7
AI	5.6	4.0	10.8	79.7

Note:* are the results of 1987 survey

Source:Prime Minister's Office, "Opinion Survey on Science, Technology and Society" 1987, 1990.

(2) U.S. (Respondents : 2,005 person)

Percentage

	know well	know	don't know
DNA	14.0	24.7	61.3
GNP	23.3	20.3	56.4
Computer Software	20.3	31.8	47.8

Source:National Science Foundation, "Science and Engineering Indicators," 1989

Table 9-1-4 Recognition of Scientific Hypotheses

Percentage

	True		Not sure/ Don't know	Untrue	
	Definitely true	Probably True		Definitely untrue	Probably untrue
man evolved from animals(*)	21.6	53.2	13.1	10.2	1.9
man evolved from more primitive animals	25.8	53.4	11.8	8.5	1.5
continents are moving little by little in a timespan of thousands of years(*)	24.1	54.1	16.7	4.7	0.5
continents are moving little by little in a timespan of thousands of years(*)	28.0	53.6	14.6	3.4	0.3
the universe began a massive explosion	16.9	36.7	33.8	9.9	2.7
laser beams can be obtained by concentrat-ing sound waves	8.6	32.2	45.4	10.7	3.2
electron are smaller than atoms	10.0	27.1	48.3	11.6	3.0
antibiotics kill smaller than atoms	17.0	53.2	21.4	6.5	1.8
the earth's core is extremely hot	30.7	47.4	17.8	3.4	0.7

Not:* are the results of March 1987.
Source:Prime Minister's Office, "Opinion Survey on Science, Technology and Society" 1990

Table 9-1-5 Opinion on Achievements in Science and Technology

Percentage

	Responden (Number)	Positive greater	About equal	Negative greater	Don't know /Not sure
1985/12	2,005	68.3	4.4	19.2	8.1
1987/3	2,334	54.3	28.7	8.3	8.7
1990/1	2,239	52.7	30.5	7.3	9.6

Note:1985 result was from the survey coducted in the U.S.
(Source:National Science Foundation "Science and Engineering Indicators," 1989)
Source:Prime Minister's Office, "Opinion Survey on Science, Technology and Society" 1990

Table 9-1-6 Feelings about the Relationship between Scientific and Technology Progress and Spiritual Richness

(1) "Life is becoming move convenient with the steady advance of science and technology, but along with this, we are gradually losing the richness in our lives"

Percentage

Year	lose richness	indefinable	not lose richness	Others	no answer	Total
1953	30	17	35	1	17	100(2,254)
1958	33	17	34	0	16	100(920)
1963	38	22	28	1	12	100(2,698)
1968	40	16	35	1	8	100(3,033)
1973	50	21	22	1	6	100(3,055)
1978	43	21	30	1	5	100(2,032)
1983	48	20	28	1	4	100(4,429)
1988	47	24	26	1	3	100(1,858)

(2) "We shall not lose the richness in our lives, regardless of how mechanised society becomes"

Year	lose richness	indefinable	not lose richness	Others	no answer	Total
1953	17	8	58	1	16	100(2,254)
1958	21	10	53	1	16	100(920)
1963	18	19	49	1	13	100(2,698)
1968	22	13	56	1	9	100(3,033)
1973	31	20	42	1	7	100(3,055)
1978	25	15	53	1	6	100(2,032)
1983	31	17	46	1	5	100(4,429)
1988	33	22	42	1	3	100(1,858)

Source:Institute of Statistical Mathematics, "A Study of the Japanese National Character -The Eighth Nation Wide survey-" (Research Report General Series No.69), 1989

Table 9-1-7 Opinions for Impacts of Science and Technology

"Work will become more interesting as science and technology advances"

Percentage

	Ture		Not sure/ Don't know	Untrue	
	Definitely true	Probably true		Definitely untrue	Probably untrue
1986/3	8.4	38.2	16.8	32.3	4.3
1990/2	9.5	32.4	22.0	30.6	5.4

Our lives will become more comfortable as science and technology advances"

	Ture		Not sure/ Don't know	Untrue	
	Definitely true	Probably true		Definitely untrue	Probably untrue
1990/2	14.0	40.4	13.5	25.8	6.3

"Employment will fall due to the spread of robbots and computers"

	Ture		Not sure/ Don't know	Untrue	
	Definitely true	Probably true		Definitely untrue	Probably untrue
1990/2	11.7	43.7	12.5	27.5	4.6

"Virtually all socio-economic problems we are facing today can be resolved by scientific and technological progress"

	Ture		Not sure/ Don't know	Untrue	
	Definitely true	Probably true		Definitely untrue	Probably untrue
1986/3	2.5	17.1	16.7	50.6	13.2
1990/2	3.9	20.1	17.2	44.4	14.3

Source:Prime Minister's Office, "Opinion Survey on Science, Technology and Society" 1990

Table 9-1-8 Unease Regarding Science and Technology

"feel concerned about the growing danger of abuse or mistaken use of science and technology"

	feel uneasy		others/ not sure	don't feel uneasy	
	feel uneasy seriously	feel uneasy somewhat		don't feel uneasy so much	don't feel at all
1986/3	32.0	50.8	6.4	10.0	0.8
1990/2	23.1	54.3	6.9	13.9	1.8

"feel concerned that although our lives are becoming more convenient, it is at a cost of a lower capacity for action and living"

	feel uneasy		others/ not sure	don't feel uneasy	
	feel uneasy seriously	feel uneasy somewhat		don't feel uneasy so much	don't feel at all
1986/3	17.5	52.0	5.8	21.5	3.2
1990/2	15.5	55.3	5.9	19.8	3.3

"feel concerned that science and technology will become even more minutely categorised, and that non-specialists will no longer be able to understand"

	feel uneasy		others/ not sure	don't feel uneasy	
	feel uneasy seriously	feel uneasy somewhat		don't feel uneasy so much	don't feel at all
1986/3	18.0	47.7	10.5	21.1	2.7
1990/2	15.1	49.6	9.7	21.9	3.5

"feel concerned that scientific and technological progress is moving too fast to keep up"

	feel uneasy		others/ not sure	don't feel uneasy	
	feel uneasy seriously	feel uneasy somewhat		don't feel uneasy so much	don't feel at all
1986/3	12.9	47.8	5.8	28.2	5.3
1990/2	12.0	46.4	5.8	28.9	6.8

Note:Number of respondents are 2,334 for 1986 survey, and 2,239 for 1990 survey.
Source:Prime Minister's Office, "Opinion Survey on Science, Technology and Society" 1990

Table 9-1-9 Categories of Science and Technology to be Developed

Percentage(Multiple answers)

Categories of science and technology	Total	Male	Female
Development of products to assist aged and handicapped persons	46.3	40.2	51.6
Development of alternative (non-fossile) energy sources	38.8	47.8	30.9
Development of earthquake and disaster prevention technology	35.1	34.7	35.4
Development of artificial organs	32.5	32.5	32.5
Development of anti-pollution technologies	31.6	32.7	30.6
Development of forest resource protection & dessert arridation technology	29.1	31.3	27.2
Development of phsycology and medicine for mental health treatment	19.2	18.2	20.2
Development of technology to raise agricultutal productivity especially in factories	13.7	13.5	13.9
Development of home information systems which allow purchases from a home T.V. monitor	10.4	9.9	10.8
Development of new forms of high speed transportation such as a linear motor car	9.6	13.7	5.9
Outer space development such as space station construction	4.8	6.1	3.6
Others	0.1	0.1	0.2
None in particular	2.4	1.5	3.2
Don't know	4.2	2.4	5.8
Number of respondents	2,239	1,041	1,198

Source:Prime Minister's Office, "Opinion Survey on Science, Technology and Society" 1990

Table 9-2-1 The Information Society

"Do you think modern society is an information society ?"

Percentage

	Yes		No	Not sure
	Yes	Yes, to a degree		
1981/2	39.2	34.5	8.0	18.3
20 to 29	50.6	34.0	8.1	7.3
30 to 39	44.8	36.3	7.6	11.3
40 to 49	36.4	39.0	8.9	15.7
50 to 59	35.4	31.6	8.6	24.4
60 to 69	26.2	28.9	7.1	37.8
70 and older	16.2	25.3	6.1	52.4
1985/7	42.0	34.7	10.8	12.5
20 to 29	55.7	33.5	7.8	3.0
30 to 39	48.5	38.9	7.0	5.6
40 to 49	45.1	36.7	10.2	8.0
50 to 59	37.6	35.5	13.9	13.0
60 to 69	27.7	27.4	17.5	27.4
70 and older	23.0	29.1	8.5	39.4

Source:Prime Minister's Office, "Opinion Survey on Protection of Privacy" 1981, and "Opinion Survey on Protection of Private Information" 1985

Table 9-2-2 Images of an Information Society

Percentage(Multiple answer)

Images	1981/2	1985/7
"there is too much information"	48.4	47.0
"it is convenient"	38.2	35.4
"has little bearing on me"	9.2	18.3
"feel cramped by the controlled society"	9.6	12.8
"it is affluent"	12.8	10.1
"feel nothing in paticular"	9.1	8.4
Others	1.5	0.8
"not sure"	2.3	6.9

Note:Respondents who answered "Not sure" to the question of "Do you think modern society is an information society ?" are excluded.
Source:Prime Minister's Office, "Opinion Survey on Protection of Privacy" 1981, and "Opinion Survey on Protection of Private Information" 1985

Table 9-2-3 Opinion for defusion of Computers

Percentage

	Yes	Yes, to a degree	No	Not sure
"the world has been convenient owing to computers"	61.2 57.5	27.4 27.6	4.0 9.5	6.4 5.3
"Computers do not always work for the benefit of the individual"	35.7 32.8	29.4 29.1	18.3 26.4	16.7 11.8
"any conflict of interest that arises through the computers is caused by the person using it"	44.2 48.7	26.0 24.6	10.7 10.7	19.0 16.0
"the spread of computers increases the risk of people's private lives being violated"	20.2 29.4	22.3 21.9	36.7 32.2	20.8 16.6
"Somehow, just cannot get used to computers"	30.2 30.8	26.1 25.3	33.6 38.2	10.2 5.8

Note:Numbers in the upper row are the result from 1981 survey, while in the lower row are the result from 1985 survey.
Source:Prime Minister's Office, "Opinion Survey on Science, Technology and Society" 1990

Table 9-2-4 Opinion for Invasion of Privacy

"Do you think invasions of privacy have incleased ?"

Percentage

	Yes	No	Not sure
1981/2	31.2	48.9	19.9
20 to 29	32.5	54.2	13.4
30 to 39	34.0	50.2	15.8
40 to 49	33.8	48.4	17.8
50 to 59	27.3	48.3	24.4
60 to 69	24.4	47.7	27.8
70 and older	27.3	27.3	45.5
1985/7	48.2	33.8	18.1
20 to 29	57.8	31.1	11.1
30 to 39	54.3	31.8	13.9
40 to 49	51.0	36.5	12.4
50 to 59	46.5	34.1	19.4
60 to 69	36.9	37.6	25.5
70 and older	26.1	27.9	46.1

Source:Prime Minister's Office, "Opinion Survey on Science, Technology and Society" 1990

Table 9-2-5 Opinion for Energy Conservation

Percentage

	1978/ 2	1980/ 2	1980/11	1981/11
We should not increase our energy consumption even if it means some sacrifice in our standard of living.	8.8	13.3	13.5	8.3
We must accept an increase in energy consumption necessary to improve our standard of living, although we should try to check the consumption as much as possible.	-	-	-	39.5
We should save energy, and at the same time, it is necessary to develop new energy source to make up for shortage.	54.2	55.8	54.9	32.5
We should develop new sources of energy whenever necessary.	19.2	16.1	18.1	8
Others	0.3	0.5	0.6	0.1
Don't know	17.4	14.2	12.9	11.6

Note:The second answer was not included in the respondent's choice of the survey in 1978 and 1980.
Source:Prime Minister's Office, "Opinion Survey on Energy and Resouce Use" 1978, 1980, and "Opinion Survey on Energy Use" 1980, 1981.

Table 9-2-6 Opinion for Nuclear Power Generation

Percentage

Year/Month	Yes	No	No ans. etc.
1978/12	55	23	22
1979/6	50	29	21
1979/12	62	21	17
1980/12	56	25	19
1981/12	55	29	16
1984/12	47	32	21
1986年/8	34	41	25
1988年/9	29	46	25
1990年/9	27	53	20

Source:Asahi Shimbun

Reference:Opinion for the future of Nuclear Power Generation

Asahi Shimbun (1988/9)	Should increase	maintain the status quo	should decrease	should be 1	not sure
Percentage	9	55	17	10	9
Prime Minister's (1990/9)	to be increased	not to be increased any more	to be decrease	should be shut down	not sure
Percentage	48.5	30.2	8.9	2.6	9.8

Source:Asahi Shimbun
Prime Minister's Office, "Opinion Survey on Nuclear Power" 1990

Table 9-2-7 Future Main Source of Electric Power

"What do you think will be the main source of electric power ten years from now

Percentage

Main source	1975/10	1976/10	1978/ 2	1980/ 2	1980/11	1981/11
Nuclear power	48.4	49.1	38.1	32.5	46.6	49.8
Solar light (heart)	8.4	16.9	26.3	27.7	18.2	10.8
Hydropower	4.9	5.5	5.2	7.1	6.0	4.6
Thermal generation	7.9	4.4	4.5	12.1	12.5	14.5
Geothermal	1.1	1.8	1.9	1.4	0.9	0.2
Others	0.1	0.1	0.3	0.2	0.2	0.1
Not sure	29.1	22.2	23.8	18.9	15.6	20.0

Main source	1984/ 3	1987/ 8	1990/ 9
Nuclear power	50.9	60.6	50.5
Solar light (heart)	18.3	10.7	12.6
Hydropower	6.4	4.0	5.4
Thermal generation	9.9	9.3	15.2
Geothermal	0.8	0.5	0.7
Others	0.1	0.1	0.2
Not sure	13.5	14.8	15.4

Note:This category was given as "solar heat" generation in the surveys done in November 1981 and prior.

In the surveys in 1988 and prior, didn't ask "tey years from now" but "in future"

"In these surveys, thermal generation devided crude oil, natural gas and coal thermal generation.

Source:Prime Minister's Office, "Opinion Survey on Nuclear Power" 1975, and "Opinion Survey on Science/Technology and Nuclear Power" 1976, and "Opinion Survey on Energy and Resouce Use" 1978, 1980, and "Opinion Survey on Energy Use" 1980, 1981 and "Opinion Survey on Nuclear Power" 1984, 1987, 1990.

Table 9-2-8 Perception on Current Achivement in Life Sciences

(Multiple answers)

Achievement	%
Artificial conception of human babies	75.2
Artificial heart	73.0
Fuel obtained from garbage/waste (energy)	43.1
Treatment of cancer and hereditary diseases	40.1
Plant producing rast number of fruits	36.0
Computer having the capability to learn and reason like human brain	31.5
Bacteria capable of cleaning up polluted sea	31.0
Tomatoes and potatoes growing or sauce plant	27.7
Drugs(insuline growth hormone) produced by colitis germs	24.7
Drugs to retard aging	12.9
No experience so far	7.3
Not sure	5.9

Source:Prime Minister's Office, "Opinion Survey concerning Life Science" 1985

Table 9-2-9 Expectation to Life Sciences

(Multiple answers)

Items	%
Treatment of cancer and hereditary diseases	45.3
Prevention of public nuisance/pollution	13.0
Improvement of living standard	11.2
Development of new industry	4.9
Increase of agricultural output	4.2
Development of new products	4.1
No expectation	4.2
Not sure	13.1

Source:Prime Minister's Office, "Opinion Survey concerning Life Science" 1985

Table 9-2-10 Opinion for Medical Care for Prolonging Human Life

Percentage

	All the available resources in medicine and science should be utilized	Let the life to run its own course without unnatural interference	Not sure
Total (7,439)	32.1	59.6	8.3
Male (3,307)	36.0	56.8	7.2
Female (4,132)	28.9	61.8	9.3
20 to 29 (944)	40.1	53.5	6.4
30 to 39 (1,837)	37.5	54.4	8.1
40 to 49 (1,732)	31.6	60.1	8.3
50 to 59 (1,518)	28.3	62.5	9.2
60 and older(1,408)	24.3	66.5	9.2

Source:Prime Minister's Office, "Opinion Survey concerning Life Science" 1985

Table 9-2-11 Opinion for Brain Death (Should the "Brain Death" be considered as the "Death" ?)

Percentage

	Agree	Rather agree	Not sure	Rather disagree	Disagree	No answer
1982/10	15.2	13.4	23.4	14.7	24.8	8.5
1984/2	21.5	11.7	22.2	12.8	24.0	7.8
1984/11	23.5	14.3	16.8	13.1	25.7	6.7
1985/11	27.8	14.3	19.9	11.5	20.3	6.1
1986/11	28.0	14.0	23.4	9.4	18.2	7.0
1987/11	29.9	16.3	21.9	11.6	16.7	3.7
1988/11	30.6	15.3	23.9	9.8	15.8	4.6
1989/12	28.9	20.6	27.2	9.3	9.3	4.8
1990/11	31.4	19.2	21.7	10.3	13.2	4.2

Source:The Yomiuri Newspaper National Opinion Surveys

Table 9-2-12 Opinion for How Life Science Research is being Conducted

How life science research is being conducted	%
Approve research and utilization in our society, although it is necessary to have understanding of the public.	42.6
Understanding of the public is necessary at the stage of research.	21.7
Research and utilization of life science should be free.	9.5
Research may be done, but it should not be utilized in the society.	3.5
Both research and social use of life science should be prohibited.	1.2
Not sure	21.4

Source:Prime Minister's Office, "Opinion Survey concerning Life Science" 1985

Table 9-2-13 Opinion for Relationship between the Nature and Human Life

Percentagre

		We should stop interfering with the nature and let the nature and the life in geneal stay as they are.	We should respect the nature and the life, while taking advantage from them.	Men should control the nature.	Not sure
1985/12	(7,439)	29.4	50.8	8.0	11.8
1988/1	(2,362)	35.7	45.4	10.9	8.0
Male	(1,092)	32.0	50.5	11.9	5.5
Female	(1,270)	38.9	40.9	10.0	10.2

Source:Prime Minister's Office, "Opinion Survey concerning Life Science" 1985, and "Public Opinion Survey on Environmental Issues" 1988.

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