Preface

In recent years, science and technology has accomplished rapid and dynamic development., and the influence which technology has on economy and society is still larger. In the inside of such a situation, in order to grasp exactly the situation of the technology activity over which it goes intricately and variably, it is important to equip the sciecne and technology indicators systematically analyzed based on objective / quantitive data.

In this laboratory, since the systematic science and technology indicators were created for the first time in 1991, it had revised about in every three years and since the report of a version was collected in 2000 this time, it announces officially.

While it expects that this report is utilized not only for people engaged in science and technology activity but for people of broad each class, if the opinion of Gentlemen is got, I will think that it is happy for much more fullness and improvement of a future science and technology indicators.

Finally, gratitude is deeply expressed in creating this report to the persons concerned of every direction which obtained great cooperation.

April 2000

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(This is an English version of the report published in April, 2000.)

TABLE OF CONTENTS

Chapter 8 Public Opinion on Science and Technology

Chapter 9 Regional Science and Technology Activities

Boxed item

Explanatory Notes

1. All descriptions, figures, tables, etc., except for diagrams whose source has been specifically mentioned, are the work of the National Institute of Science and Technology Policy.

2. Information sources for indicators listed below figures and tables in this report are defined as follows;

   Sources: Original source for indicator data or original provider of data. In this report, figures and tables have been prepared on the basis of data from these sources; the expressions "prepared from" or "compiled from" will be used when considerable processing of data has been carried out.

   Duplication: Figures duplicated from other publications.

3. Commentary on the text is marked by (1) within the text, and the commentary itself is given later in an appropriate spot.

4. References are given at the end of the chapter. References are marked by [1] within the text.

5. For yearly data, survey times and periods may differ by country or type of statistics. Distinctions between calendar and fiscal years are not necessarily made in the same manner as in the original source but rather expressed in a way appropriate for showing the characteristics of the date and for international comparisons.

Introduction　About a Science and Technology Indicators

The purpose and structure of science and technology indicators creation

Since the National Institute of Science and Technology Policy(NISTEP) published the "science and technology indicators" report of the 1st edition in 1991, it was scheduled to publish the 4th edition in this time. The "science and technology indicators" has been utilized for people who hold concern in internal and external science and technology as data which grasp science and technology activity of our country quantity-wise and systematically. On the other hand, the science and technology in the world after entering in the 1990s is carrying out intense change which was not expected. when the 1st edition is created. Also in our country, while recognition of the importance of a science and technology indicators increases ignited by formation of the science and technology organic act in 1995, decision of the science and technology master plan in 1996, etc., various requests are brought near. Based on such a request, its best was tried to carry out the latest situation of science and technology activity for whether being dawn in this version.

By the way, only one indicator cannot express the present condition of science and technology activity. It is because not only the science and technology activity which is the object of an indicator goes over it intricately variably,but also the range of the object which has a base supporting it and influence is extensive and also in time, a long viewpoint is required.

namely,　if it is going to express science and technology activity with an indicator, It is necessary　that statistics are collected from the large range and analyze by the time series.　Moreover, it is indispensable also to the comparison with other industrialized nations in the same situation. If that is right, what statistics should be collected and by what statistics should compare? If it says about individual statistics, it is required that a definition is clear, that it is reliable, to be collected serially, for comparison (for example, international comparison) to be possible, etc. However, just this is insufficient.

It is necessary to recognize to consist of what element and it is carrying out what structure in that the present condition of science and technology activity of one country is grasped.

The system of science and technology indicators was developed for such the purpose. Since signs that water flows and falls gradually from a top are resembled, it is called

Cascade Sstructure. This structure can compare worth of an individual indicators now, and choice became possible. Since it has already introduced with the previous version about the details of this system, it omits here.

Composition of this report

In accordance with a science and technology indicators system, we are collecting and checking the composition individual indicators of this report. However, if it gets poisoned by constituting a report, in consideration of the ease of reading etc., it has not necessarily carried out as the system. The report was made the following composition.

Chapter 1 Overview of Science and Technology Activity in Japan

While main things were introduced out of the indicator shown in detail after Chapter 2, some indicators for synthetic grasp were added and science and technology activity of Japan was surveyed.

Chapter 2 Education and Human Resources Development for science and technology

International comparison of the present condition of the mathematics and the science education in a junior high school, ratios of students going on to higher schools such as a high school and a university, the situation of the desire and entrance seen by the faculty of a university, the employment situation by the industry after the graduation from a university, the situation of entrance into a school of higher grade to a graduate school, etc. were described.

Chapter 3 R&D Systems and the Public Sector

R&D activities of the advanced major power centering on Japan were shown using the data of a R&D cost or a R&D human resources. It took up also about the science and technology relation foundation which has achieved the function as a semi- public sector for the function and activity situation of a public sector with R&D activities of the whole country.

Chapter 4 R&D in Universities

The situation was described for the activity as a R&D organization of an university using the indicator about a research and development cost, a R&D human resources, etc and added also international comparison.

Chapter 5 R&D in Industry

About the situation of R&D of an industrial sector, the international comparison which used the data of a research and development cost or a R&D human resources, and the detailed analysis by industry were described.

Chapter 6　R&D Achievements

The result of R&D of Japan was quantitatively shown using the indicator about a science and technology paper, a patent, and technical trade including international comparison.

Chapter 7　Social Contribution of Science and Technology

In order to consider the influence affect economy and society of Japan by science and technology activity, the indicator related, respectively is introduced about technical progress and improvement in productivity, the innovation seen from new product development, and development and its contribution of information communication technology and life science

Chapter 8 Public Opinion on Science and Technology

The result of the opinion poll about technology is analyzed, and national consciousness about science and technology at large, and in each field of declaration, information, and environment.

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Chapter 9 Regional Science and Technology Activities

In order to grasp the many-sided science and technology activity in an area, the indicator about each item of education, research and development, the technology promotion measure of all prefectures, the result of technology activity, technology activity and regional economy, a structural change of regional economy, was introduced.

The feature of this report

(1) The first step policy evaluation type from a present condition report type

In creating the "Science and Technology Indicators" of the 1st edition, the purpose of Science and Technology Indicators was examined and divided roughly and it was thought that there were three models. They are the "present condition report type" which reports the present condition of science and technology activity, the "judged type" which judges situations such as internationalization, and the "policy evaluation type" by which the effect of a policy is evaluated. Although devoted to the present condition report type at the beginning, some judged type indicators (for example, comprehensive science and technology indicator) were developed and added after it. With this version, one step is further advanced to the policy inclination type. It specifically examined what indicators were required for policy decision (large meaning), and each indicator was improved based on it. In this process, the person in charge of indicators development did participating in the workgroup which works on a policy etc., and bore the role of mediation of indicators development and policy decision.

- In order to grasp many subjects for policy decision more correctly, various indicators are required and it is actually used. However, since the room of much more improvement was in the practical use method, it tried to described the point which it should be careful of in case data as in detail as possible, and show the indicators for performing a suitable argument. For example, science and mathematics detached building of youth, shortage of a researcher supporter, appropriateness of the required level of a basic research cost and a public burden rate, burden structure of the R&D capital of a university etc.
- By international comparison, it turned out that the indicators which show the problem and weak point of science and technology of Japan were important, and efforts were paid to fullness of the indicators of international comparison, and the improvement in suitable nature.
- In the NISTP, the trend of the science and technology policy of an overseas major power was investigated, the result was taken in, and the indicators used in each country was enriched.

(2) Addition of a new indicators

The new indicators were added, taking into consideration the science and technology indicators system introduced previously. An aggressive trial is also in inside and we want to decide worth of indicators such them by accumulating research further from now on.

- Chapter 9 Regional Science and technology activities was reformed extensively. The most is based on original investigation of the NISTP. Since there were little existing statistics about science and technology activity of area, we added many indicators by original investigation, and developed the new indicators.
- In Chapter 7 Social Contribution Science and Technology, while the relation of the science and technology and improvement productivity was shown,we tried development of the indicators about the innovation seen from new product development. This indicators are completely not only new, but it is thought possible to compare from now on.

(3) Fullness of the existing indicators

Various knowledge was acquired by accumulation of the R&D about the indicators after the 1st edition. Based on them, the existing indicators were improved and it was substantial.

- It was made as clear about the limit of the statistics about science and technology, important matter, and also shortage of further statistics as possible. Although the recognition to the importance of science and technology statistics is increasing, statistical fullness has not caught up. It expects that this report is useful to these problems.
- The indicators which show development of the globalization which was the remarkable feature of the latest science and technology was enriched. For example, patent international application, international comparison of technical trade, etc.
- About the comprehensive indicators, each data was improved in detail, continuing the method to last time, and improvement in reliability or validity was aimed at.

In addition, it tried to make an interpretation of indicators exact hard. Moreover, It regarded so that it might become a plain description as possible. We think that we want to publicize also generally widely in addition to people engaged in a science and technology policy, and the report of Science and Technology Indicators is carried to the homepage of the NISTP. Moreover, since there are strong needs also internationally, while it translates immediately and it publishes, it is due to carry to the homepage of the NISTEP. Finally, in order to make it the reference at the time of improving Science and Technology Indicators, we want to expect the opinion which does not have the reserve of the broad persons concerned to this report.

Fujio Niwa

Chapter 1 Overview of Science and Technology Activities in Japan

1.1 R&D Expenditures

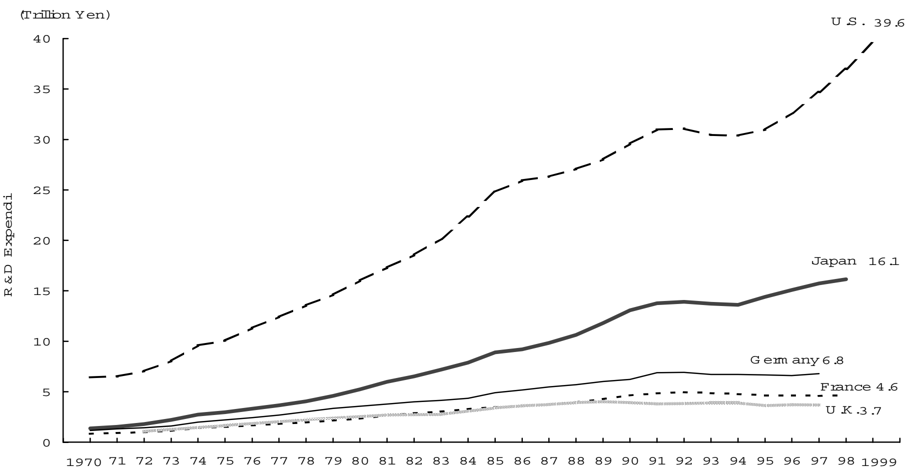
(1) R&D Expenditures for Japan as a Whole

The investment of funds into science and technology has come to take on increased importance in the majority of countries throughout the world as a driving force in stimulating economic growth, securing employment and overcoming social problems. Of this investment, R&D expenditures are an investment to generate new science and technology, and that data is vital in ascertaining trends in the world's science and technology. As a result, R&D expenditures will be the first topic dealt with. It needs to be stressed, however, that R&D expenditures are only one part of investment in science and technology, and are no more than an indicator of one aspect of science and technology initiatives.

◆ In Japan, the U.S., Germany, France and the U.K., in the early 1990s the rate of increase in R&D expenditures stagnated from the 1980s. Upon entering the late 1990s, however, R&D expenditures in Japan and the U.S. have increased markedly once more.

The total amount of R&D expenditures was 16.1399 trillion yen in FY1998, the

Figure 1-1-1 Trends in gross domestic R&D expenditures in selected countries Nominal Value (Nominal value: OCED Purchasing Power Parity Calculations)



Notes: Data for each country include natural science and humanities/social science. (this or subsquents ones section 1-1 and 1-2 same)
Data for Germany is an old federal area till 1990. About other details of each country, it is referring to the note of figure 3-1-1 and appendix table 3-1-1.

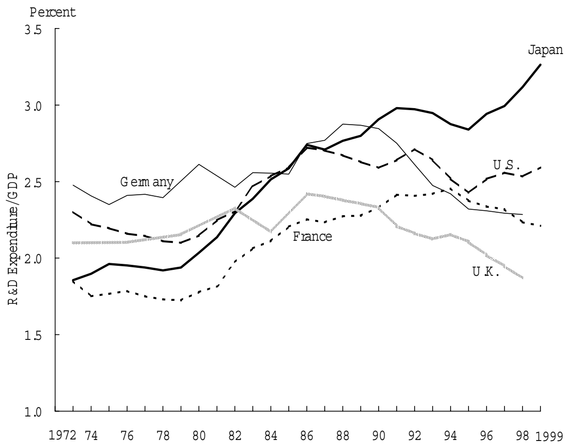
Sources: Japan – The management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
U.S. – NSF, "National Patterns of R&D Resources" (each year edition)
Germany – BMBF, "Bundesbericht Forschung 1996", "Faktenbericht 1998"
France – État de la recherche, et du développement technologique, "Projet de loi de finances", OECD, "Main S&T Indicators 1999/2" (from 1993 value)
U.K. – OECD, "Main S&T Indicators 1999/2", "Basic Science and Technology Statistics 1996"
Purchasing Power Parity – OECD, "Main S&T Indicators 1999/2", "National Accounts, 1999"
(In this chapter, the above sources used the abbreviated name of "The R&D Statistics of each country")

See: figure 3-1-1 and appendix table 3-1-1

fourth consecutive increase continuing on from FY1995 to FY1998. Against the background of the continuing economic recession, this increase can be attributed mainly to the sustained R&D expenditures by industry and the increase in the government's science and technology-related budgets (Figure 1-1-1).

◆ R&D expenditures as a percentage of gross domestic product (GDP) fell in the three European countries from the late 1990s, while these figures increased for Japan and the U.S., indicating a divergence of values between countries. Japan's figures have remained the highest of the five countries since 1989. In the late 1990s, R&D investment was sustained despite the sluggishness of GDP, which meant that the percentage increased. The figure of 3.26% for FY1998 was a new record (Figure 1-1-2).

Figure 1-1-2 Trends in ratio of gross domestic R&D expenditures in selected countries.

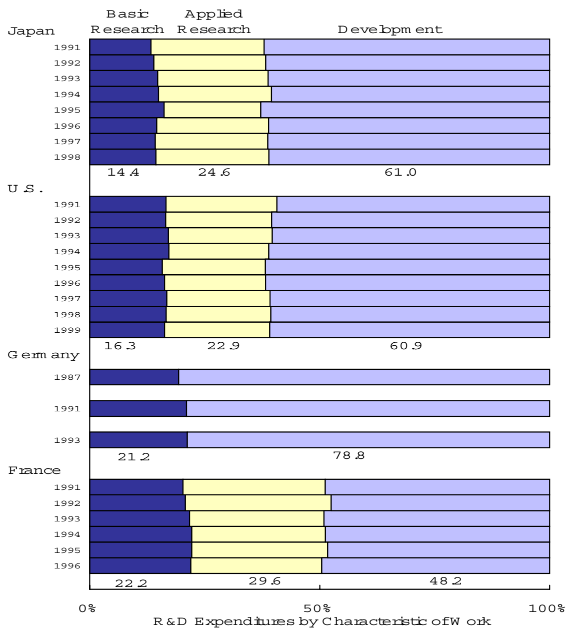


Source: The R&D statistics of each country
See: figure 3-1-2 and appendix table 3-1-2

◆ While Germany, France and the U.K. did not record conspicuous increases in R&D expenditures, quantitative expansion is evident in terms of several output aspects of R&D. In the background to these changes are the advances in R&D made in the 1990s under the framework of the EU (see Chapter 1, Section 5).

◆ Comparing R&D expenditures by nature (breakdown of R&D expenditures by basic research, applied research, and development), apart from Japan's percentage of basic research exceeding that of the U.S. in 1995, this figure has constantly remained at the bottom of the four countries. Additionally, the percentage of R&D expenditures devoted to basic research in the U.S. is lower than that of Germany and France. The fact that the percentage of R&D expenditures accounted for by basic research in Japan and U.S. is affected by the high percentage of R&D expenditures of the industrial sector (Figure 1-1-3).

Figure 1-1-3 Trends in R&D expenditures in selected countries by characteristic of work

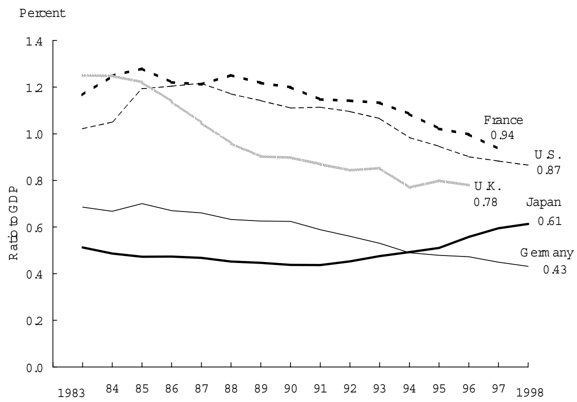


Note: There is no difference between applied research and development research in Germany. (other details see figure 3-2-3)
Source: The R&D statistics of each country
See: figure 3-2-3 and appendix table 3-2-3

(2) Government Investment and Policy

- Comparing science and technology expenditures as a percentage of GDP in the five selected countries, Japan is a low level within the selected countries, but since the late 1980s Japan is the only country to be increasing. The decreases in the U.S., Germany, France, and the U.K. indicate their contractions in defense-related science and technology expenditure and the changes in the role of government in R&D (Figure 1-1-4).

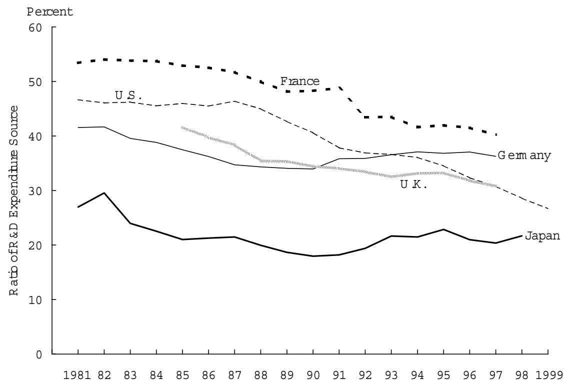
Figure 1-1-4 Trends in ratio of governmental S&T budget to GDP in selected countries



Note: Other details of each country see figure 3-3-3 and appendix table 3-3-3
Source: Science and Technology Agency Data
See: figure 3-3-5 and appendix table 3-3-5

- Changes in the role of government in the R&D system are evident in the fall in the percentage of the government's share of R&D expenditures in the U.S., France, and the U.K. That is to say, since 1981, the percentage of R&D expenditures shouldered by the government in these countries has been falling, and the fall in the U.S. has been particularly marked. However, Japan is consistently at a lower percentage than these countries, with the percentage shouldered by the government in 1998 being 21.7%. While there have been no great changes to the percentage in Japan over the long term, the percentage in the 1990s is somewhat higher than that of the late 1980s (Figure 1-1-5).

Figure 1-1-5 Trends in ratio of R&D expenditures sources by government in selected countries

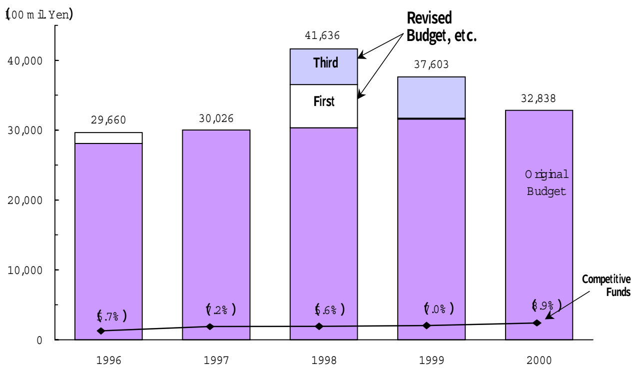


Note: The R&D statistics of each country
Source: figure 3-3-1 and appendix table 3-3-1

- Japan's "Science and Technology Basic Plan" (approved by the Cabinet in July 1996) the need to have a total government science and technology expenditure from FY1996 to FY2000 of approximately 17 trillion yen is clearly stated. Totaling up the government's actual science and technology expenditure over this five-year period, a figure of 17.1763 trillion is reached, indicating that the target is likely to be reached (Figure 1-1-6). Under the Science and Technology Basic Plan, the percentage of the total occupied by competitive funding is gradually increasing.

- In most countries, not only central government, but also local government are important providers of public R&D funds. In FY1997 in Japan, the total amount of science and technology budgets incurred by prefectures and semi-autonomous cities was 862.3 billion yen, equivalent to 28.7% of the central government's science and technology budgets (3.0026 trillion yen in the same year). The large part of science and technology budgets by prefectures and semi-autonomous cities is accounted for by expenditures relating to public experimental and research institutions (46% of the total) and expenditures relating to science higher education institutions (35% of the total). (See Chapter 3, Section 3. For regional science and technology activities see Chapter 9.)

Figure 1-1-6 Trends in the S&T budget in the S&T basic plan in Japan



Note: Competitive capital showed the amount of money (vertical axis) by the polygonal line, and displayed in the parenthesis the rate for which it accounts to the whole. It is the proposal general invitation of a science research cost subsidy (Ministry of Education), technology promotion adjustment expense (Science and Technology Agency), a welfare science research cost subsidy (Ministry of Health and Welfare), earth-environment research synthesis promotion expense (Environment Agency), the new basic research promotion system (each ministry agency) by the special public corporation, and reformist technical development which was made into competitive capital here.

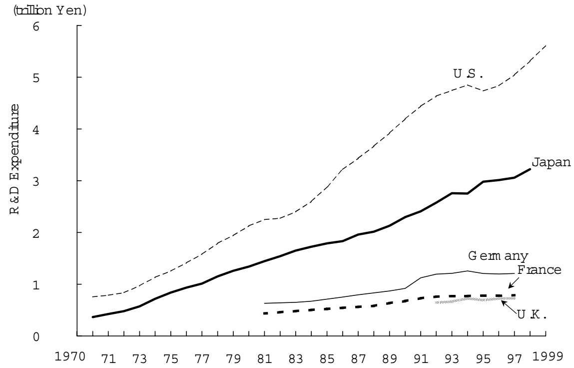
Source: Science and Technology Agency Data

See: figure 3-3-7 and appendix table 3-3-7

(3) University R&D

◆ Each of the selected countries places emphasis on the amount of R&D expenditures used by the university sector. R&D expenditures incurred by Japanese universities and so forth in FY1998 were 3.2229 trillion yen, equivalent to 20% of R&D expenditures incurred throughout Japan (Figure 1-1-7).

Figure 1-1-7 Trends in R&D expenditures in universities/colleges in selected countries

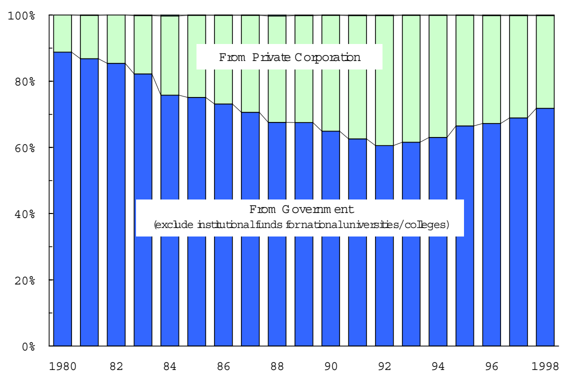


Source: The R&D statistics of each country

See: figure 4-1-1 and appendix table 4-1-1

◆ A noteworthy feature of the R&D expenditures incurred by Japan's university sector compared to those of other countries is that the portion of expenditures shouldered by the universities themselves is high at 90% (FY1998). On the other hand, of the amount of R&D expenditures used, funding received from out-side the universities amounted to 339.1 billion yen (FY1998). The percentage of R&D expenditures received from external sources that is provided by industry is decreasing in recent years (Figure 1-1-8).

Figure 1-1-8 Trends in breakdown of R&D funs paid outside in Japan



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

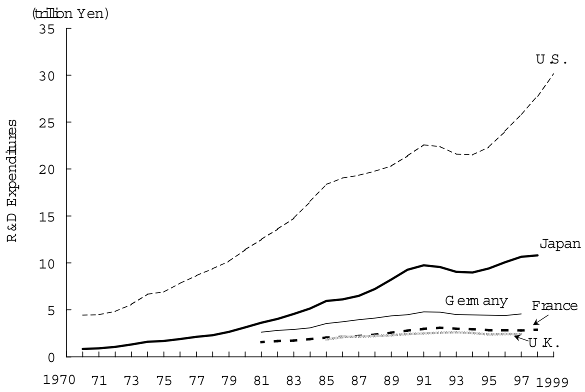
See: figure 4-2-2 and appendix table 4-2-2

(4) Industry

- The industrial sector is the largest sector in terms of both incurring and funding R&D expenditures in the major industrialized countries. In Japan in particular, the weight occupied by the industrial sector is high, as is the case in the U.S. The R&D expenditures of Japan's industrial sector were 10.8001 trillion yen in FY1998, accounting for some 66.9% of the nation's R&D expenditures (see Chapter 3, Section 1).

- R&D expenditures in industry of the five major industrialized countries, including Japan, after increasing in the 1980s, stagnated in the early 1990s. In the subsequent period, Japan's R&D expenditures increased once more from the late 1990s. R&D expenditures in the U.S. have also increased dramatically in the late 1990s (Figure 1-1-9).

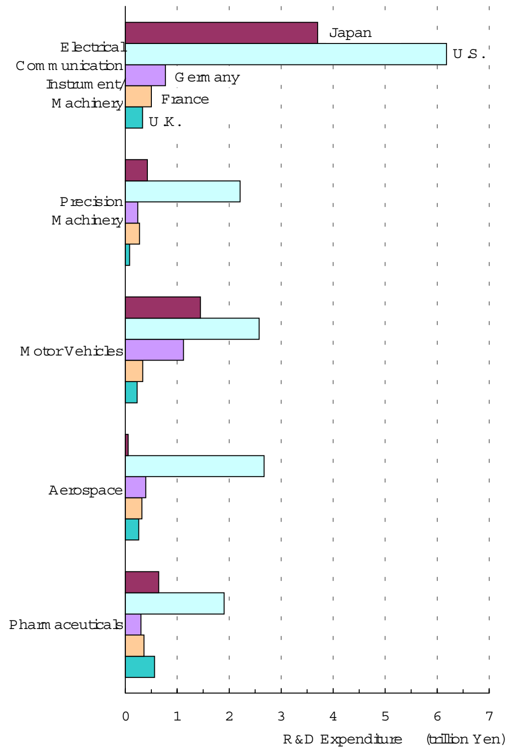
Figure 1-1-9 Trends in industrial R&D expenditure in selected countries



Source: The R&D statistics of each country.
See: figure 5-1-1 and appendix table 5-1-1

- Comparing R&D expenditures in industry of the selected countries for the major industries, in "electrical communication instrument and machinery" industry Japan's R&D expenditures are 60% of those of the U.S. on a purchasing power parity basis, but there is a great difference between Japan and the U.S. in the "precision instrument" industry. In addition, Japan's R&D expenditures in the "aerospace" industry are extremely low within the major industrialized countries. In the "motor vehicles" industry Japan's R&D expenditures are higher than those of Germany, France and the U.K., but are only 56% of those of the U.S. In the "pharmaceuticals" industry the difference between Japan and the U.S. is great, but Japan's expenditures still exceed those of other countries (Figure 1-1-10).

Figure 1-1-10 Major industrial R&D expenditure in selected countries (major industries: purchasing power parity)

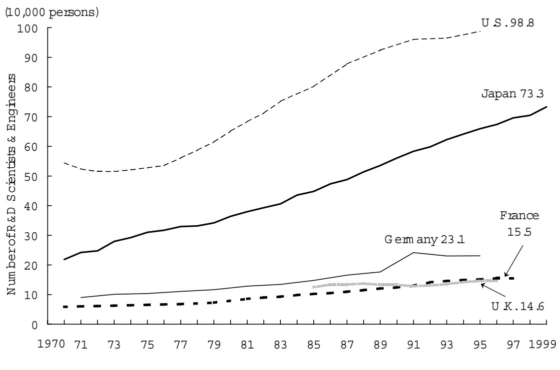


Notes: 1) Other industries are included in "The electrical communication instruments and machinery" of Japan and the U.S. and "the motor vehicles" in the U.S..
2) Since the value by industry was unknown, "aerospace" of Japan added up the research and development cost about the airplane in "machine industries for transportation other than the motor vehicles"
Source: OECD, "Basic Science and Technology Statistics 1998"
See: figure 5-1-3, appendix table 5-1-3

1.2 Science and Technology Human Resources and their Development

◆ Japan had some 733,000 R&D scientists and engineers in 1999, which in terms of population is a high level compared with other countries on the world stage. Over the past 30 years, this number has increased in an almost straight line due mainly to an increase in the number of R&D scientists and engineers in industry. The overall of numbers of R&D scientists and engineers in each of the other industrialized countries is also basically increasing. There are differences by country in the statistical data concerning R&D scientists and engineers, and a variety of different conditions must be taken into account when making comparisons (Figure 1-2-1).

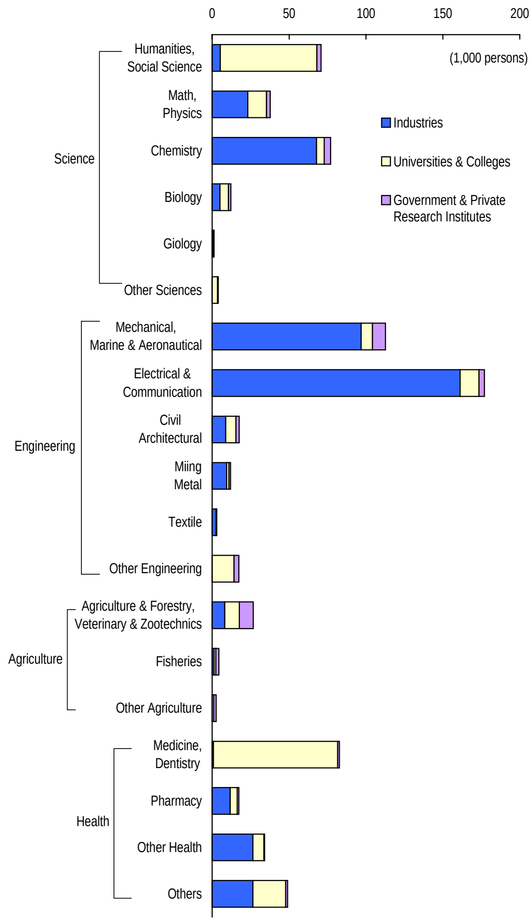
Figure 1-2-1 Trends in number of R&D scientists and engineers in selected countries



Source: The R&D statistics of each country
See: figure 3-1-3 and appendix table 3-1-3

◆ Taking a look at a breakdown of Japan's R&D scientists and engineers (733,000) by specialty and by sector, a large percentage of R&D scientists and engineers are in "electrical and communications" and "machinery, shipbuilding, and aeronautics" and other engineering sectors. The majority of these R&D scientists and engineers belong to the industrial sector. "Medicine and dentistry" follows these sectors, with the majority of R&D scientists and engineers in these areas affiliated with universities and so forth. The majority of R&D scientists and engineers engaged in the "human, cultural and social sciences" are also affiliated with universities (Figure 1-2-2).

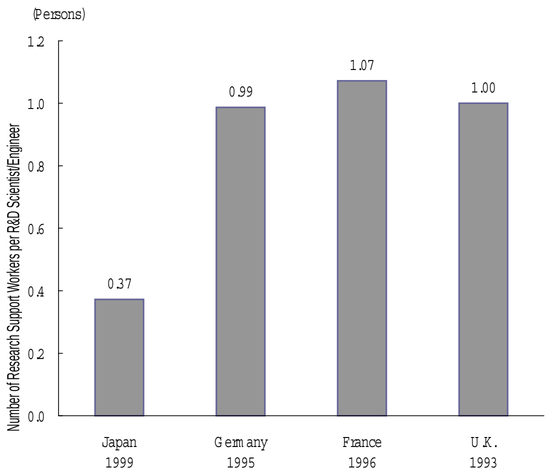
Figure 1-2-2 Number of R&D scientists and engineers by specialty and sector in Japan (1999)



Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: figure 3-2-5 and appendix table 3-2-5

◆ The human resources responsible for R&D activities are not limited to R&D scientists and engineers, however. Technicians and research clerical coordinators also play an important role. Looking at these research support staff per researcher, Japan's figures are low on an international basis. This percentage is also falling as the years go by (Figure 1-2-3).

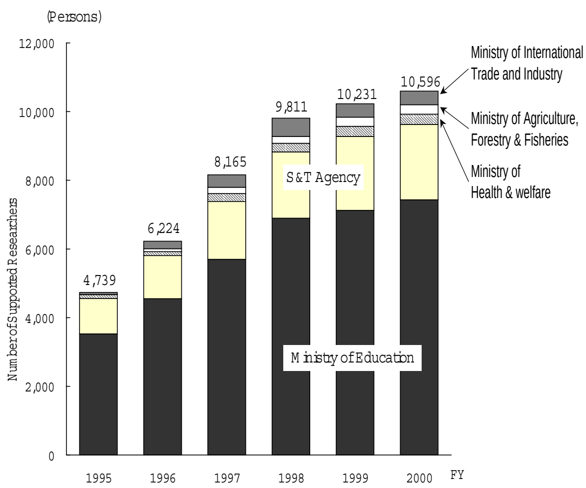
Figure 1-2-3 Number of Research Support workers per R&D scientists and engineers in selected countries



Source: The R&D statistics of each country
See: figure 3-2-6 and appendix table 3-2-6

◆ In Japan, in an effort to promote the development and expansion of young R&D scientists and engineers, the "Plan for 10,000-man Support for Post Doctorates" has been promoted since FY1995. This plan attempts to provide some 10,000 post doctorate students with the opportunity to engage in research activities in national research institutions and universities by FY2000. The plan has promoted an expansion in support for a variety of post doctorates by government ministries and agencies. In fact, FY1999 saw support measures adopted for some 10,231 post doctorates including those in the supplementary budget, increasing dramatically to a figure 2.6 times greater than that of FY1995 (Figure 1-2-4).

Figure 1-2-4 Trends in number of researchers supported by plan for 10 thousand post-doctoral researchers

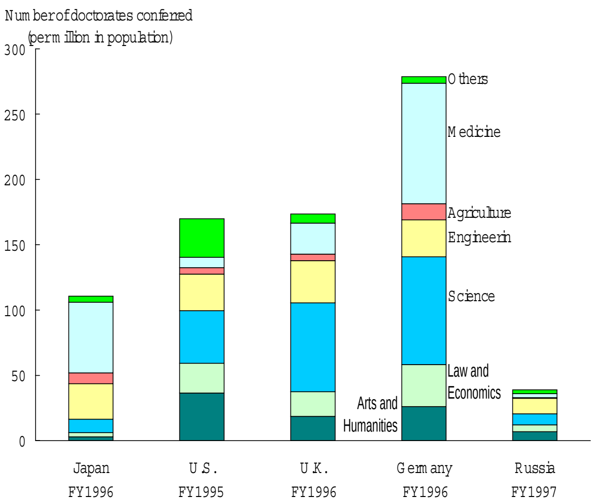


Note: Each fiscal year shows the budget measure number, and a part for a supplementary budget is included.
Source: Science and Technology Agency data
See: figure 3-2-8 and appendix table 3-2-8

Carrying out an international comparison on the development of human resources responsible for advanced science and technology activities including R&D according to the number of people who have obtained doctorates, Germany has the largest number of people with 279 doctorates per 1 million head of population, followed by the U.K. (174), and the U.S. (170). Japan's figure of 111 is only approximately 40% of that of Germany, and just over 60% of that of the U.S. and the U.K. (Figure 1-2-5).
Comparing the breakdown of people with doctorates by major, the U.S. has a high percentage in art and the humanities, UK has a high percentage in science, and Germany has a high percentage in medicine. In Japan, the percentage of doctorates in engineering and medicine in particular are higher than in other countries.

◆ Looking at the development of human resources responsible for science and technology activities from the number of academics entering university faculties, overall the figure of 333,000 in 1970 has increased to 590,000 in 1998, a factor of around 1.8. Within these figures, entries into the social sciences increased by a factor of around 1.7, while entries into engineering increased by 1.6, which were increases of a similar magnitude. On the other hand, entries into science increased by approximately 2.0, humanities by around 2.5, and health by around 4.3, which were relatively larger increases. Overall, however, large changes were not evident in the percentage composition by main faculties (see Chapter 2).

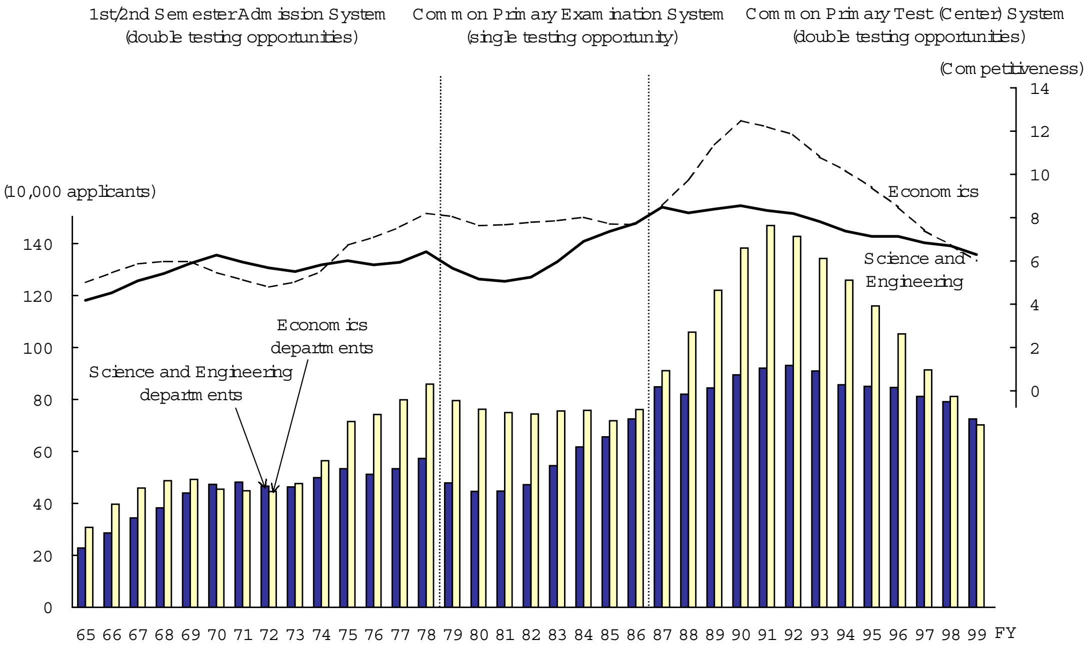
Figure 1-2-5 International comparison of the number of doctorates conferred



Note: Table show international comparison of number of doctorate conferred in each year.
Source: Ministry of Education, "International Comparison of Education Indicators"
See: figure 2-5-3 and appendix table 2-5-2

The number of people hoping to be admitted to university, which acts as key data when discussing human resources development in universities, reflects the impact of the social situation. Comparing the total number of people hoping to be admitted to university (total number of applications submitted to universities by people wanting to enter university) according to science/technology and economics, in the 1970s and from the late 1980s to the early 1990s the number of science and technology applicants fell or increased slightly. In contrast, the number of economics applicants has increased, and there are fears that there will be a movement away from science and technology. The late 1990s saw a marked reduction in economics applicants, but the percentage of science and technology applicants has flattened out (Figure 1-2-6).

Figure 1-2-6 Trends in number of applicants for admission and competitiveness



Source: Ministry of Education, "Report on Basic Survey of Schools"
See: figure 2-3-1 and appendix table 2-3-1

1.3 The Public and Science and Technology

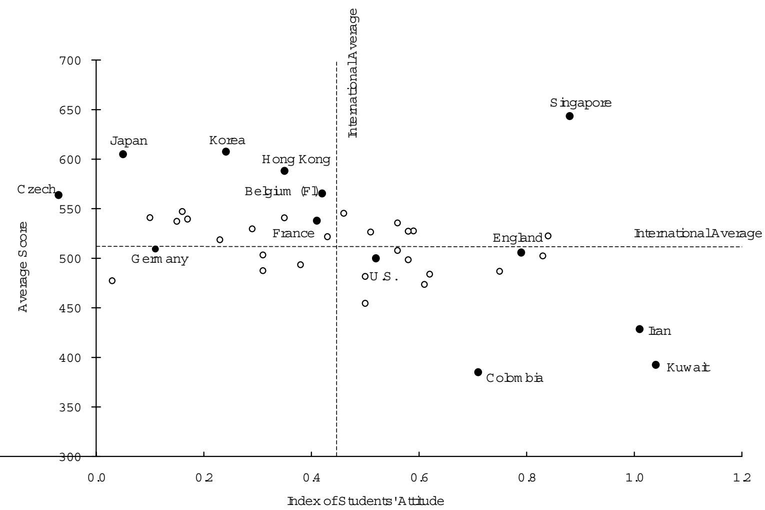
◆ According to results of a survey making an international comparison of the level of education achieved in mathematics and science in elementary and junior high school, Japan boasts extremely high average scores, while on the other hand there is also a strong tendency to dislike mathematics and science.

In the scores for mathematics in 2nd grade of junior high school, Singapore ranked highest with 643 points, followed by Korea, Japan (605 points) and Hong Kong, which all had similar levels.

On the other hand, making an international comparison of the like/dislike of mathematics, a particularly high percentage of Japanese students dislike mathematics. That is to say, looking at the responses about the degree of like/dislike of mathematics (response from four choices), the international average percentage of responses indicating a like a lot for mathematics is 19% , while 49% of students like mathematics (giving a combined total of 68%), indicating that mathematics is liked in the majority of countries. In Japan, however, only 10% of students like a lot mathematics, while 43% of students like mathematics (giving a total of 53%), which is the second lowest result above Czech Republic (Figure 1-3-1).

Furthermore, Japanese students do not find mathematics enjoyable, and they have a low perception that mathematics is important for their daily lives. There is also a low consciousness of people wanting to do work that uses mathematics.

Figure 1-3-1 International comparison of relationship between student attitude toward mathematics and sores



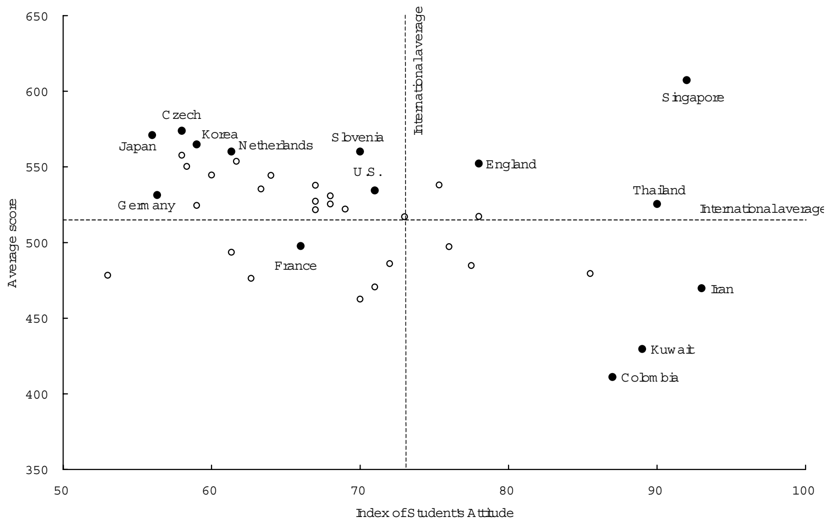
Note: "Like/dislike index" means, it point-ized by the following weight,
"Like a lot" +2, "Like it" +1, "Dislike it" -1, "Dislike a lot" -2
Source: Ministry of Education, National Institute for Educational Research, "International Comparison of Mathematics and Science Education in Junior High Schools", March 1997
See: figure 2-1-1 and appendix table 2-1-1

◆ With regard to science, too, almost the same trend as mathematics is evident. In Japan, while the average score is extremely high, as is the case with mathematics, a large number of students have a strong dislike for the subject.

The score for science in 2nd grade junior high school is highest in Singapore (607 points), followed by Czech Republic, Japan, Korea, Bulgaria, Netherlands (with no statistical difference within this group). Looking at the other selected countries, the U.K., the U.S. and Germany all recorded average scores, with France's score below average.

Asking students about their like/dislike for science, on average some 73% of responses indicated a like a lot or like for the subject, indicating that students in most countries like science. The same figure for Japan was 56%, however, placing Japan at the lowest level (Figure 1-3-2).

Figure 1-3-2 International comparison of relationship between students attitude towards science and scores



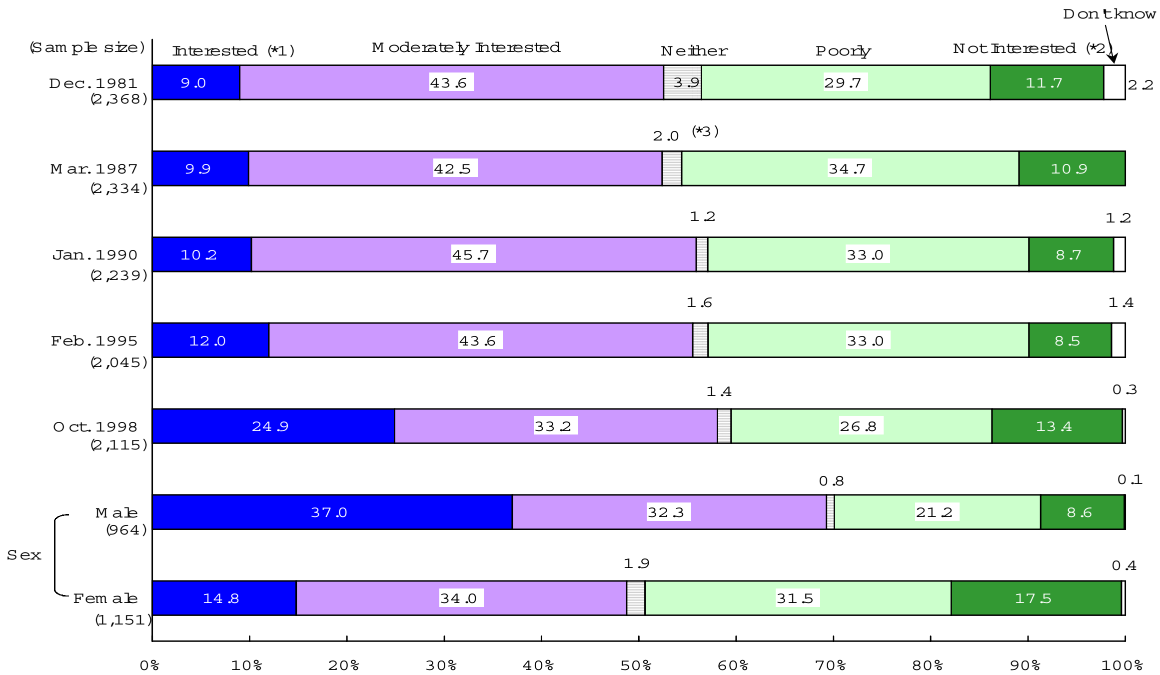
Note: Index means the ratio of students who "like science very much" or "like science"

Source: Ministry of Education, National Institute for Educational Research, "International Comparison of Mathematics and Science Education in Junior High Schools", March 1997

See: figure 2-1-2 and appendix table 2-1-2

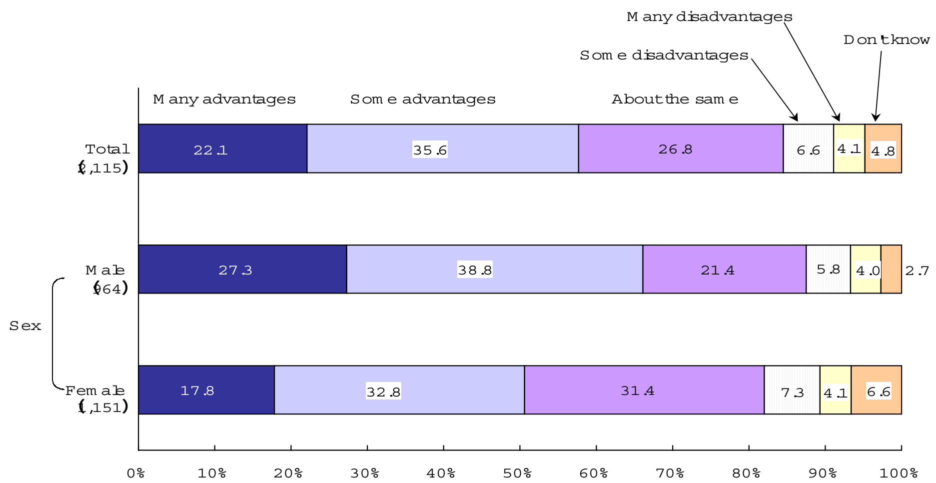
◆ In response to the question whether people are interested in news and topics of conversation about science and technology, a 1998 survey indicated that some 58.1% of people are interested (total of "interested" and "moderately interested"), representing more than half of the population.
Looking at the results by sex, the percentage of males who indicate an interest is higher, while for females the percentage who indicate not interest is higher. Additionally, the percentage of people who indicated an interest is higher for males aged 30 and older, while the percentage of people who indicated not interest is higher for females aged between 18 and 29, in their 30s and over 60 (Figure 1-3-3).

Figure 1-3-3 Interest in information about science and technology



Note: 1) Before [the investigation carried out in February 1995], it was "very interested".
2) In the investigation carried out in March 1987, It was "not interested al all".
3) In the investigation carried out in March 1987, "neither" and "don't know" were "neither/don't know" combined
Source: Prime Minister's Office, Public Relations Office, "Public Opinion Poll on the Future of Science and Technology"
See: figure 8-1-1 and appendix table 8-1-1

Figure 1-3-4 Public assessments of progress of science and technology



Source: Prime Minister's Office, Public Relations Office, "Public Opinion Survey on Future of Science and Technology" (October 1998)
See: figure 8-1-3 and appendix table 8-1-3

◆ With regard to the development of science and technology, in response to the question whether advantages or disadvantages were greater overall, a 1998 survey indicated that 57.7% of respondents thought there were many advantages (total of "many advantages" and "some advantages"), accounting for more than half of respondents. On the other hand, some 10.7% of the population thought there were many disadvantages, with 26.8% of respondents answering that advantages and disadvantages were about the same (Figure 1-3-4).

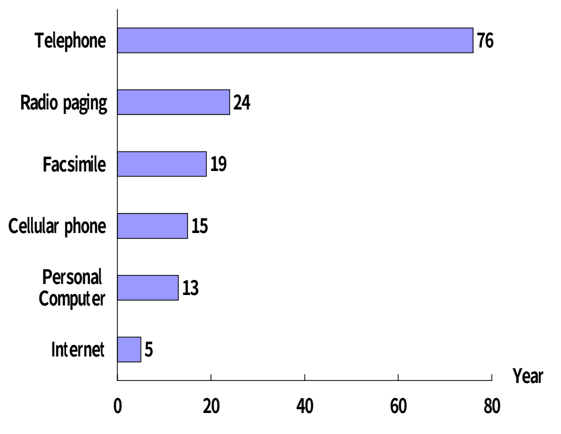
Comparing these results with those of a survey carried out in 1995, the percentage of respondents who thought that the advantages and disadvantages were about equal has fallen, indicating a trend of polarization of thinking.

1.4 Science and Technology and Economy and Society

Science and technology activities have a variety of impacts on the economy and society, and conversely, the progress of science and technology is affected by social and economic conditions. Such a mutual relationship is both complex and wide-ranging, but here we will deal with the recent advances in information technology and the life sciences, and indicators of the impact that technological advances have on economic growth.

◆ The time required for major telecommunications media to achieve market penetration of 10% in Japan was 76 years for the telephone, but this has become shorter with cellular phones and car phones only taking 15 years, and personal computers taking 13 years, while the Internet only took 5 years. There is a clear tendency for the time required for market penetration of new technology to become shorter (Figure 1-4-1).

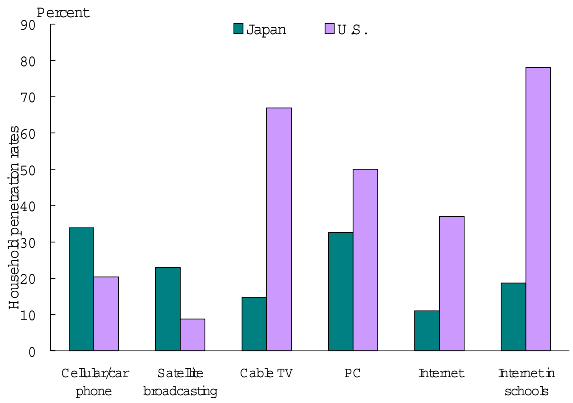
Figure 1-4-1 Time required to reach 10% penetration rate in Japan by media



Source: Ministry of Posts and Telecommunications ed., "White Paper on Telecommunications" (FY 1999 Edition)
See: figure 7-3-6 and appendix table 7-3-6

◆ Comparing the market penetration of telecommunications equipment in Japan with that of the U.S., the household penetration rate of personal computers is 50.0%, compared to 32.6% in Japan. There is also a great divergence between Japan and the U.S. in terms of the Internet household penetration rate and the percentage of schools connected to the Internet. On the other hand, however, Japan boasts higher individual market penetration rates for cellular phones and car phones (Figure 1-4-2).

Figure 1-4-2 Penetration of Info-communications equipment and services in Japan and the U.S.

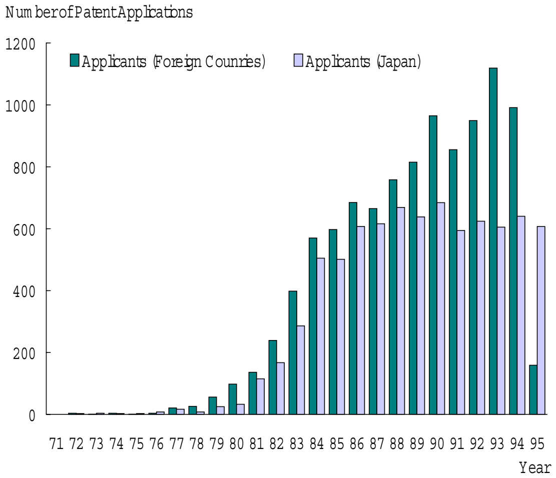


Source: Ministry of Posts and Telecommunications ed., "White Paper on Telecommunications" (FY1999 Edition)
See: figure 7-3-7 and appendix table 7-3-7

The recent advances in the life sciences are indicated by patent data. Taking a look at trends in the number of patent applications concerning genetic engineering in Japan, the 131 applications in 1980 increased dramatically in the following years to 1,724 applications in 1993.
Looking at the source of these applications, the number of applications by foreigners has consistently exceeded the number made by Japanese nationals. Some 60% of these applications originate

in the U.S., which is much higher than Germany (9%) in second place and the other countries (Figure 1-4-3).

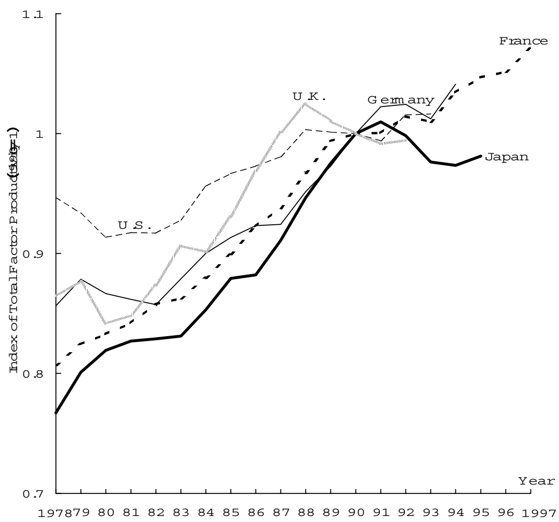
Figure 1-4-3 Number of patent applications in Biogenetics by country
(as of Mar.,1999)



Note: The patent for which it applied by the international application system based on a patent cooperation treaty has delay of time in an official announcement in Japan, and it has decreased seemingly 1995.
Source: Patent Office Homepage
See: figure 7-4-5 and appendix table 7-4-5

◆ In order to gain a clear picture of the impact that science and technology has on economic growth, attempts are being made to measure improvements in productivity (the production output per investment factor in production activities). The typical indicator of such productivity, total factor productivity, is the total added value per unit of the total production investment factors (labor and capital). This indicator indicates the efficiency of production of a nation, so the rate of growth in such productivity is regarded as reflecting technological progress.
Taking a look at trends in the total factor productivity index (value achieved by dividing the total factor productivity of each year by the value for FY 1990) in the five selected countries(1), while there are slight fluctuations, the observation can be made that the index is generally moving upwards. This indicates that during this period all of the five selected countries have experienced sustained technological progress.

Figure 1-4-4 Trends in total factor productivity index in selected countries



Source: OECD International Sectoral Database (FY1998)
See: figure 7-1-3 and appendix table 7-1-3

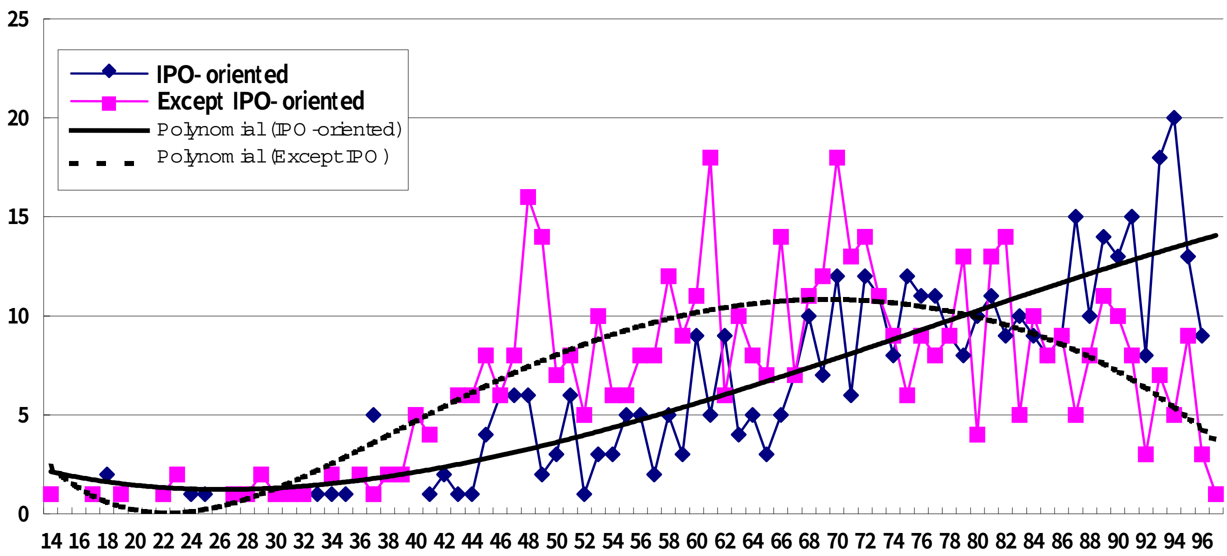
Looking at the changes over time by country, Japan recorded consistent upward movement until 1999, but 1992 figures were lower than 1990 figures, and in subsequent years no real gains were made. The index in the U.K. peaked in 1988, and in the following years it dropped off. In contrast, in the U.S., France and Germany, while slight fluctuations were recorded, they continued to record improvements in 1990 and beyond. France, in particular, improved by 7% in 1997 compared to 1990 figures.
Taking a look at the average annual growth rate in total factor productivity,

(1) "German's total factor productivity index" is the "West German total factor productivity index."

regarded as reflecting technological progress, over the whole period (1978 to 1997), France recorded the highest growth rate at 1.47%, followed by Japan with 1.29%, then Germany (1.15%), the U.K. (1.00%) and the U.S. (0.62%). Looking at the average growth rates by dividing the observation period into the 1980s and the 1990s, in the 1980s Japan had the highest growth rate (2.00%), followed by France (1.89%) and the U.K. (1.46%). In the 1990s, however, average growth rates slowed in all countries, and the stagnation was particularly marked in Japan and the U.K..

◆ In today's situation where the creation of new industry is an important issue faced by Japan, it is extremely important to gain a clear picture of the state of venture companies. Taking a look at the results of a questionnaire survey about Japan's venture companies carried out by the National Institute of Science and Technology Policy, many venture companies that took part in the survey were established in 1970 or later, but there were also a large number which were established before that, giving a wide-ranging distribution. As a recent trend, however, there has been a marked increase in the number of new companies where management is striving towards a listing on the stock exchange, and the creation of R&D-oriented companies (companies where R&D accounts for at least 10% of sales) is also progressing gradually. While Japan's venture companies are often referred to as being in a slump, in this way there are some aspects for which expectations can be held (Figure 1-4-5) (Reference [9]).

Figure 1-4-5 Distribution of the year of establishment of the venture companies



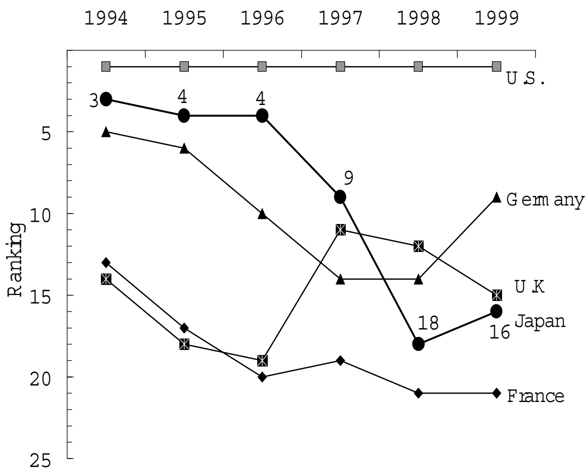
Note: "IPO-oriented" means companies whose management replied that they were "striving towards Initial Public Offering (IPO)"
Source: Science and Technology Agency, National Institute of Science and Technology Policy, "Research into Japan's Venture Companies and Founders" (NISTEP Report No.61)
(March 1999)

1.5 Performance of Science and Technology

Recently fears have been spreading about a drop in Japan's international competitiveness. Although there have been several efforts to evaluate the competitiveness of the countries of the world, few attempts have been made to make a comprehensive assessment of science and technology. In the section below, we will therefore introduce the indicators appearing in this report that concern the performance of science and technology, in order to contribute to the review of the competitiveness of Japan's science and technology.

◆ A representative attempt to assess the competitiveness of countries throughout the world is the "World Competitiveness Report" published annually by IMD (Institute for Management Development), a Swiss business school and survey organization. According to this report, Japan's international competitiveness was ranked 3rd in the world in the 1994 edition, after which it has fallen to a rank of 16th in the world in the 1999 edition. This survey is an attempt to make a comparison of conditions for companies and organizations to engage in activities. Although it may not necessarily be described as an indicator of the competitiveness of a country on the whole, its assessment is that Japan's competitiveness fell in the late 1990s (Figure 1-5-1).

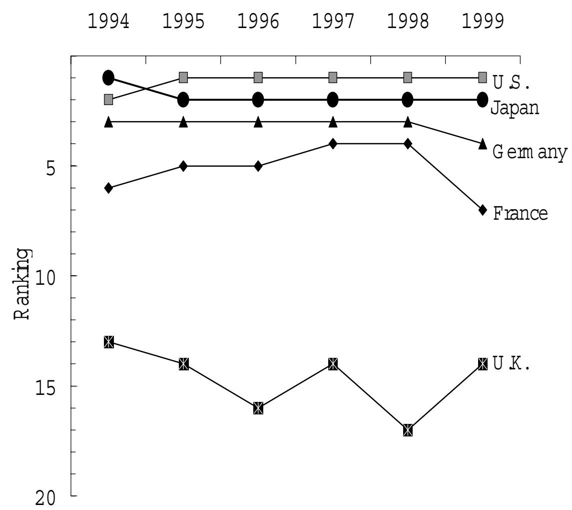
Figure 1-5-1 Trends in competitiveness according to "The world competitiveness yearbook" in selected country



Source: IMD, "The World Competitiveness Yearbook" (each year Edition)
See: appendix table 1-1

The report states that with regard to science and technology alone, Japan's competitiveness has continued to be rated highly, and in 1999 the country is ranked 2nd in the world after the U.S.. However, such a high assessment can be attributed largely to the high level of investment in science and technology. Such an assessment is an assessment of potential competitiveness, and in order to assess Japan's competitiveness a separate assessment is required concerning performance, the other aspect of competitiveness (Figure 1-5-2).

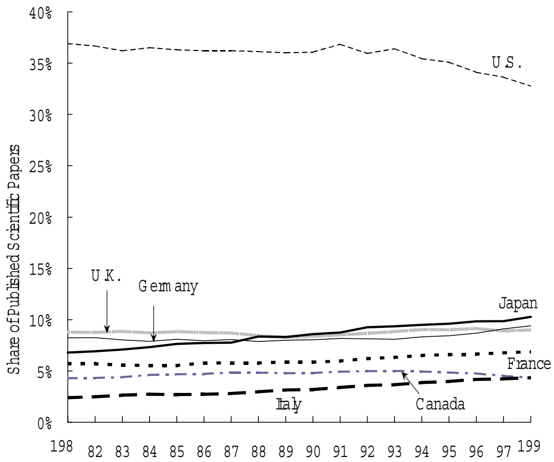
Figure 1-5-2 Trends in number and share of Published scientific papers



Source: IMD, "The World Competitiveness Yearbook" (each year edition)
See: appendix table 1-1

◆ There are several indicators of performance in R&D, and one of these is the number of scientific papers published in the fields of science and engineering. Taking a look by country at the number of scientific papers recorded in the SCI (Science Citation Index), a database for science and technology literature which is often used in such analyses, Japan's share is 2nd in the world after the U.S.. The share accounted for by the U.S. is overwhelmingly high, but due to the increase in scientific papers from other countries and regions, its share is falling in recent years (Figure 1-5-3).

Figure 1-5-3 Trends in number and share of Published science papers

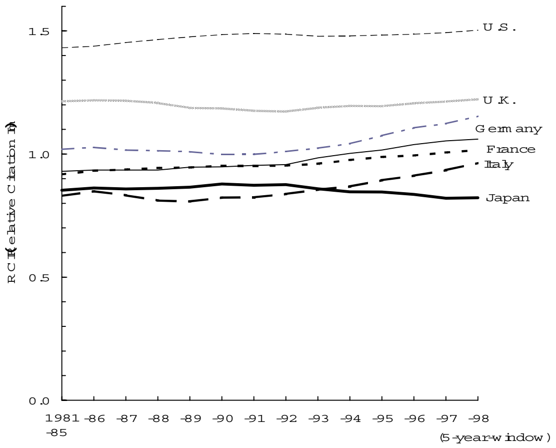


Note: The paper of a humanities/social field was removed.
Duplication appropriation of international collaboration paper is carried out in each author's affiliation country.
Source: Based on Institute for Scientific Information, and "National Science Indicators on Diskette and 1981-1998 (Deluxe version)", the National Institute of Science and Technology Policy totaled.
See: figure 6-1-3 and appendix table 6-1-3

◆ It is important that the assessment of scientific papers in science and technology takes into account qualitative aspects rather than solely counting on quantitative aspects. The frequency with which scientific papers are cited, which is regarded as acting as an indicator of their degree of impact, is a useful indicator to review quantitative aspects.

Taking a look at the degree of impact of the scientific papers from each country according to the citation frequency (the number of times a country's scientific papers are cited per scientific papers divided by the world average), an index of the citation frequency of these recorded with the SCI, the value for Japan's scientific papers is positioned lowly among major industrialized countries, and this ranking has been falling since the early 1990s. The drop in citation frequency can also be attributed to the increase in the number of scientific papers. In other words, it does not indicate a drop in power of influence, but the U.K., Germany and France, countries which have increased share of the number of scientific papers, have also recorded increases in the citation frequency. In addition, the U.S., which has suffered reduced share in the number of scientific papers, has not recorded a drop in the citation frequency. Based on these trends evident in other countries, there are fears of a drop in the relative power of Japan's influence (Figure 1-5-4).

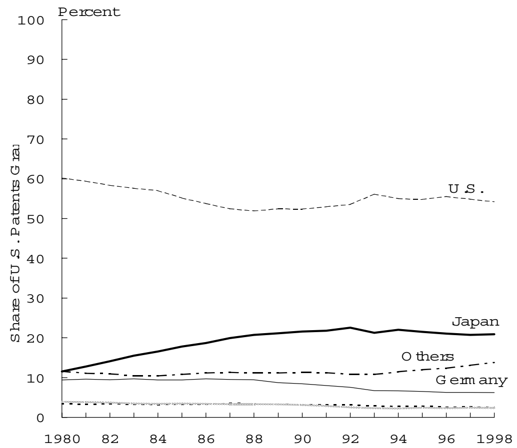
Figure 1-5-4 Trends in RCI of scientific papers in selected countries



Note: The Relative Citation Index (RCI) is found by calculating the number of citations per paper for each country, and dividing this number by the international average.
Source: Based on Institute for Scientific Information, "National Science Indicators on Diskette, 1981-1998 (Deluxe version)", the National Institute of Science and Technology Policy calculated.
See: figure 6-1-5 and appendix table 6-1-5

◆ With regard to the performance of R&D, patent data also acts an important indicator. Although patent systems differ from country to country, making an international comparison difficult, taking a look at the number of patents obtained in the U.S. by the nationality of claimants, Japan's share has accounted for 20% of the total number since the late 1980s, evidence that Japan is bringing into full play a great performance in terms of quantity. In the 1990s, however, increases in the number of patents granted to other countries and regions has meant that while the number of patents granted to Japanese claimants continues to increase, the share is tending to fall away somewhat (Figure 1-5-5).

Figure 1-5-5 Trends in number of U.S. patents granted by selected countries

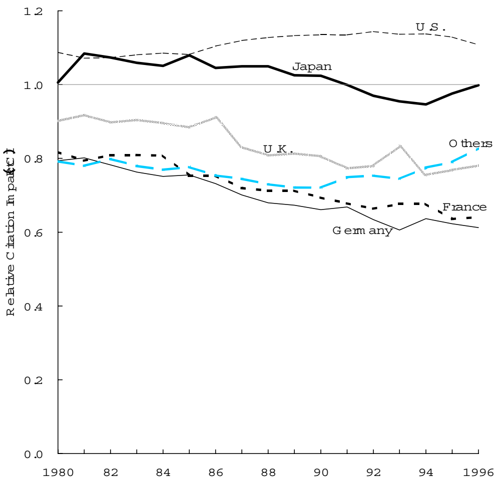


Note: The National Institute and Technology Policy calculated on the basis of CHI Research Inc., "National Technological indicators 1998"
See: figure 6-2-7 and appendix table 6-2-7

◆ With regard to patents, too, review by citation frequency is also useful. In order to indicate the nature of inventions as objectively as possible, patent examiners from the U.S. Patent Office make citations of leading patents and a variety of literature. Of these citations, it is possible to tabulate the number of times patents are cited in subsequent patents, and calculate the citation frequency in the same way as scientific papers.
Taking a look at the citation frequency by nationality of the inventor, Japan's figures exceeded 1 in the 1980s, a similar level as the U.S., but this figure fell

to below 1 from 1991.
In 1995 and 1996 a slight increase was evident, but patent citation data does not stabilize until a certain number of years have passed, so it is unclear whether it is a certain tendency or not. On the other hand, the values for the U.S. were higher in the 1990s than in the 1980s, and values are stable (Figure 1-5-6).

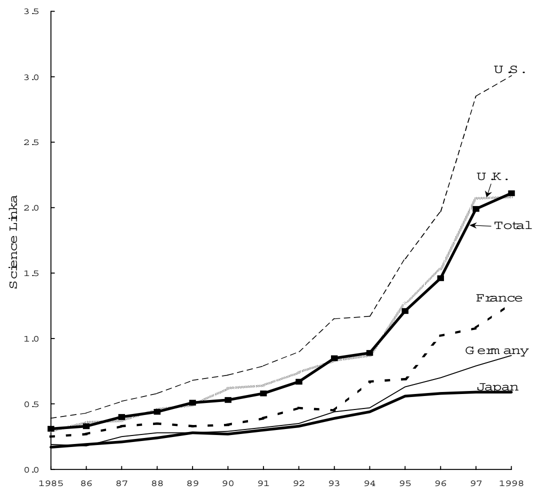
Figure 1-5-6 Trends in relative citation impact of U.S. patents



Note: The Relative Citation Index (RCI) is found by calculating the number of citations per patent for each country, and dividing this number by the international average.
Source: same as figure 1-5-3
See: figure 6-2-8 and appendix table 6-2-8

- The "Science Linkage," an indicator that shows the strength of the relationship between patents and science scientific papers, is the number of times scientific papers are cited per patent in examination reports of the U.S. Patent Office. Looking at trends in "Science Linkage" values for US patents by nationality of patent claimants, the overall values are increasing, and the relationship between patents and scientific papers is becoming stronger. Looking at the figures by country, values are the highest for the U.S., and the increase is quite significant. On the other hand, the value for Japan is the lowest of the five countries shown in the graph, and the gap with other countries has widened in the late 1990s (Figure 1-5-7).

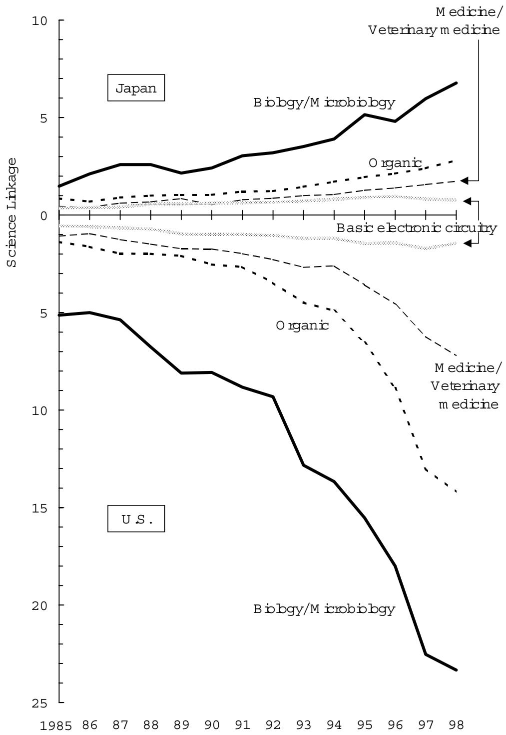
Figure 1-5-7 Trends in the science linkage of U.S. patent in selected countries



Source: same as figure 1-5-3
See: figure 6-2-10 and appendix table 6-2-10

With regard to the four sectors with high science linkages, looking at trends in figures for Japan and the U.S., it is clear that over the past 10 years, figures have increased for the U.S. in the fields of "biology and microbiology," "organic chemistry," and "medicine and veterinary medicine." On the other hand, while figures for these fields are increasing for Japan, those figures are much smaller than those recorded by the U.S. The field of "basic electrical circuitry" recorded a slower increase than values in the other three fields, but this field has an important place within all fields, and is increasing gradually Figure 1-5-8).

Figure 1-5-8 Trends in science linkage by major field in Japan and U.S.



Source: same as figure 1-5-3
See: figure 6-2-12 and appendix table 6-2-12

1.6 Integrated Indicators – The Integration of Science and Technology Indicators

In order to quantitatively assess the science and technology activities which have complex and diverse aspects, a large number of the indicators that appear in this report are required. However, while this large number of indicators are suited to gaining an understanding of individual situations, it is difficult to gain a clear picture of the whole. Therefore, as will be discussed below, by summarizing the information possessed by the large number of science and technology indicators using a statistical method called principal component analysis, it is possible to gain a comprehensive understanding of the science and technology activities of Japan and other major industrialized countries.

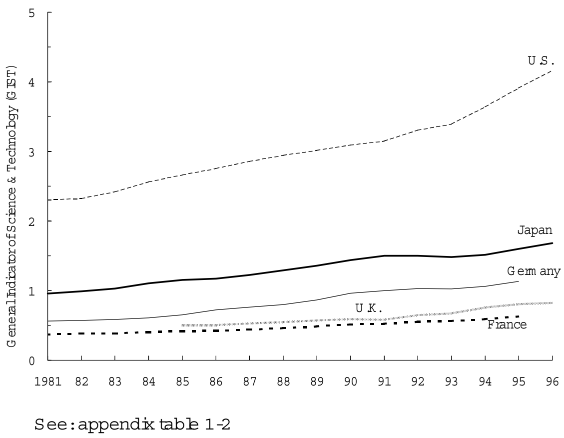
Principal component analysis is one type of multivariable analysis, analysis which analyses multiple variables (multiple types of quantitative data). The summarized indicators (integrated indicators) which result from principal component analysis are displayed as a small number of numbers, making it easy to understand the whole. In addition, if necessary it is possible to return to individual indicators, and in that regard they are capable of fulfilling a supplementary role to individual indicators.

(See column "Integration of Indicators by Multivariable Analysis")

Integrated Science and Technology Indicators

◆ The "General Indicator of Science and Technology (GSIT)" was developed to give a comprehensive indication of the science and technology activities of each country by bringing together information with a variety of indicators. This indicator was synthesized by performing principal component analysis on 12 major science and technology indicators, and indicates the sum total of science and technology activities of each country with a single number. It is useful in making comparisons between countries, comparisons with other variables and looking at changes over time. The figures for the General Indicator of Science and Technology for the five selected countries almost perfectly reflects the size of countries represented by population and GDP, with the value for the U.S. being highest, and basically increasing. The U.S. is followed by Japan at approximately half the amount, then Germany, then France and the U.K., which had similar values. Japan's figure, after increasing steadily from the late 1980s, leveled off in the early 1990s, but started to increase once again from the late 1990s (Figure 1-6-1).

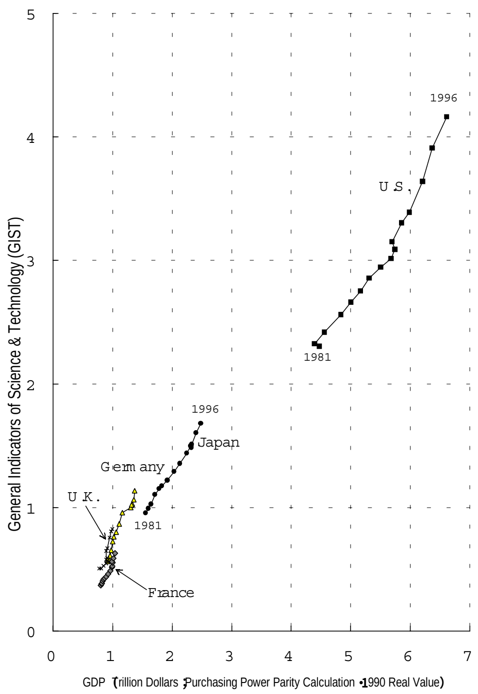
Figure 1-6-1 Trends in the general Indicator of science and technology for the five selected countries



See: appendix table 1-2

◆ Comparing the GIST with GDP of various countries, the resultant graph is distributed linearly on the whole, and there seems to be a correlation between the two volumes. In addition, looking at the trends for each country, these are generally increasing upward to the right, indicating that both science and technology activities and GDP are increasing (Figure 1-6-2).

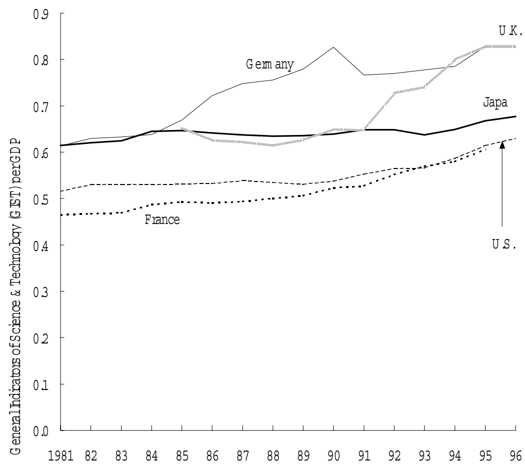
Figure 1-6-2 Trends in Integrated Science and Technology Indicators and GDP



Source: figure 1-2 and appendix table 1-2

◆ In order to make a comparison of science and technology activities taking into account differences in the size of countries, taking a look at the value of GIST per unit of GDP, Japan is positioned in the middle of the five selected countries, and is moving sideways. In the 1990s values for the U.K. have increased dramatically, with the U.S. and France both showing increases (Figure 1-6-3).

Figure 1-6-3 Trends in the value of general Indicator of Science and Technology per unit of GDP in the five selected countries



See: figure 1-2 and appendix table 1-3

Integration of Indicators by Multivariate Analysis

Multivariate analysis is the collective name for a variety of methods to analyze a large number of variables (many types of quantitative data). Of this variety of methods, this report uses principal component analysis for the integration of science and technology indicators. Principal component analysis is used in the following case: when a particular subject is represented by a number of variables, principal component analysis summarizes their comprehensive characteristics into a small number of new variables.

In addition, although this is not discussed in the main text, structural analysis of science and technology activities is also carried out using factor analysis, thereby confirming the appropriateness of variables selected. Factor analysis is a method which attempts to explain information with a large number of variables using a small number of potential factors (factors which themselves cannot be directly observed, but which are regarded as being in common between different types of data that have been observed). The details of this method of analysis are described in detail in Reference [1]).

Data Used

The countries subjected to analysis are the five countries of Japan, the U.S., France, Germany and the U.K. With regard to the period surveyed, data is taken from the 16 years from 1981 to 1996, from which statistics with a high degree of reliability can be obtained.

The variables used, i.e. the individual indicators, are representative indicators that indicate the state of science and technology activities in a particular country. The following 12 indicators were used.

[1] Number of Bachelors of Science (number of persons who have obtained a bachelor degree in the science faculty of a university)

[2] Number of Bachelors of Engineering (number of persons who have obtained a bachelor degree in the engineering faculty of a university)

[3] Number of R&D scientists and engineers (see Chapter 3, Section 1)

[4] R&D expenditures (see Chapter 3, Section 1)

[5] Value of technology imports (See Chapter 6, Section 3)

[6] Number of scientific papers (number of scientific papers recorded with the SCI. See Chapter 6, Section 1)

[7] Frequency of scientific paper citations (citation frequency of scientific papers recorded in SCI. See Chapter 6, Section 1)

[8] Number of domestic patent applications (number of patent applications in one's own country. See Chapter 6, Section 2)

[9] Number of overseas patent applications (number of patent applications to other countries. Chapter 6, Section 2)

[10] Value of technology exports (Chapter 6, Section 3)

[11] Added value of industrial products (added value of secondary industry)

[12] Value of production of high-tech products (added value of high-tech industry)

(See Table 1-4 for details of data)

The conditions and survey methods for these data vary from country to country, and while there may be slight problems with the reliability of data, changes over time have a strong impact on analysis results, so these differences are expected to cause few problems with the reliability of analysis results.

General Indicator of Science and Technology (Results of Principal Component Analysis)

The first main component obtained from principal component analysis had a fixed value of 8.48, a ratio of 70.7%, and an explaining ability of around 70%. This first principal component has been adopted as an indicator that shows the overall state of science and technology activities in each country, and it has been named the General Indicator of Science and Technology (GIST).

Variables are affected by the size of the country in question, so the General Indicator of Science and Technology generated from these variables are also affected by the size of the country. This GIST is well suited in respect of the fact that as an indicator that shows the science and technology activities of a country as one number, it is possible to examine the trends in that indicator without being affected by other variables. In addition, if trying to make a comparison without the impact of country size, it is possible to make a comparison by standardizing the general indicator by GDP or population, as shown in Figure 1-6-3.

Taking a look at the changes over time in the GIST (Figure 1-6-1), all countries are increasing over the long term. A number of temporary reductions are evident, however. The reduction in the figures of the GIST are a phenomena that should be noted, so we will take a look at the factors at work. The drop in Japan's figures in 1993 can be largely attributed to the reduction in "R&D expenditures," "added value of industrial products," and "added value of high-tech products." Japan also experienced drops in the "number of scientific papers," "number of domestic patent applications," "number of overseas patent applications," and "the value of technology imports." This indicates that in this year, Japan experienced an overall reduction in science and technology capacity.

Germany also experienced a drop in its figure for the GIST in 1993, and the U.K. experienced a drop in its GIST in 1991. In the background to Germany's drop was the drop in "R&D expenditures," "number of R&D scientists and engineers," "number of scientific papers," "value of technology exports," "added value of industrial products," and "added value of high-tech products" in 1993. The drop in GIST in the U.K. can be attributed to the fall in "R&D expenditures," "number of R&D scientists and engineers," "value of technology imports," "value of production of industrial products," and "value of production of high-tech products."

In this way, it is possible to clarify characteristic fluctuations that spread across multiple variables. Not only that, but fluctuations in individual indicators and overall changes are quantitatively related to one another through principal component analysis, which makes the complementary relationship between general indicators and individual indicators more useful.

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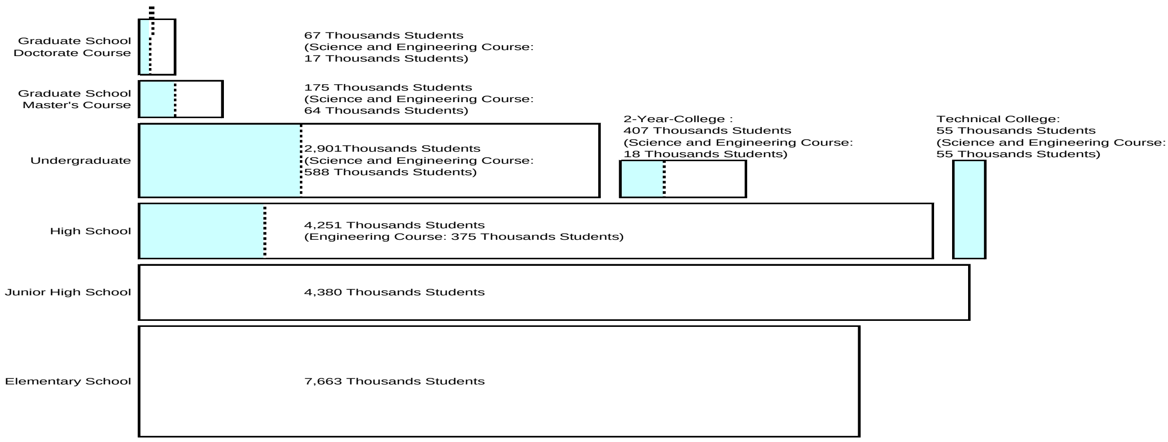
Chapter 1　Hiroyuki Tomizawa

Chapter 2 Education and Human Resources Development for Science and Technology

The development of human resources for science and technology is one of the most important foundations to promote science and technology. Concerning the development of science and technology human resources in school education, this chapter presents an international comparison of the state of mathematics and science education in junior high school, rates of advancement to high schools and universities, the state of applications and admission to university according to department, and employment trends after university graduation by industry.

Figure 2-1-0 shows an overall image of the number of students in school education. According to this graph, the number of elementary school students is 7.663 million, and the number of junior high school students is 4.381 million. These two categories make up compulsory education in Japan. The figure for high school students is 4.251 million, indicating that the rate of advancement to high schools is close to 100%. The percentage of high schools students enrolled in industrial courses is 8.8%. The rate of advancement from high school to university or junior college is 42.5%. The number of students enrolled in university departments is 2.901 million, while the same figure for junior colleges is 407,000, with percentages of students enrolled in science and technology disciplines being 19.2% and 4.4% respectively. Some 175,000 students are enrolled in master's courses, while 67,000 are enrolled in doctorate courses, with 36.6% and 25.4% of students enrolled in science and technology courses under the respective course frameworks.

Figure 2-1-0 Overall image of the number of students in school education (1998)



Notes: 1) Illustrate notionally the item izes (net credit portion) of number, such as a student, a pupil, etc. who is on the register in each educational facilities, and the science and engineering system of those.

2) The "Science and Engineering System" of a university and a graduate school is the sum total of a physical science system and an engineering system department.

3) The "Science and Engineering System" of a junior college is an industrial subject of study.

4) As for the height of stick graph, area expresses the number with which each educational facilities are on the register in the pursuit-of-knowledge period of educational facilities, such as a student and a pupil.

Source: Ministry of Education, "Report on Basic Survey of Schools"

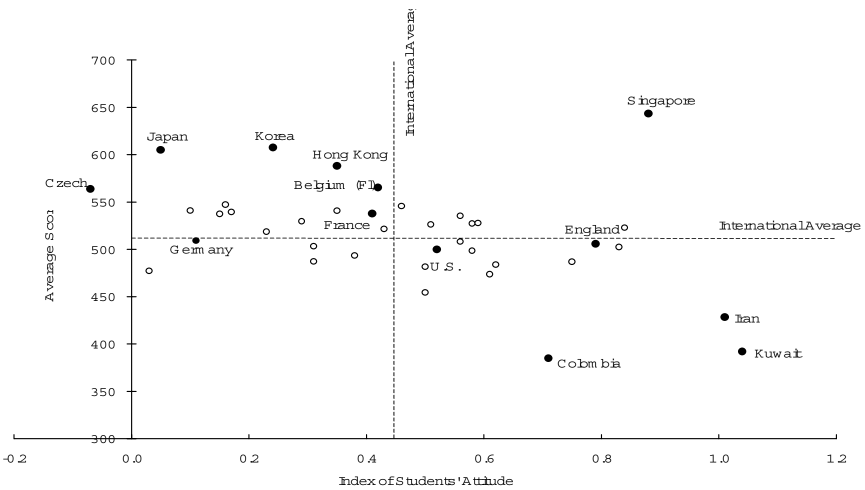
2.1 International Comparison of Mathematics and Science Education in Junior High School

The aim of the Third International Mathematics and Science Study (TIMSS) is to make an international comparison of the level of educational achievement in mathematics and science at elementary and junior high school level. The International Association for the Evaluation of Educational Achievement has implemented this study at the end of each academic year since 1994. Some 46 countries/regions participated in this survey (however, the international comparative analysis applied to 41 countries/regions).

The Ministry of Education's National Institute for Educational Research conducted the survey in Japan, and the results were made public in January 1996. The previous two studies refer to the First International Mathematics Study (1964), the First International Science Study (1970), the Second International Mathematics Study (1981) and the Second International Science Study (1983).

The international average score in the mathematics in second year high-school was 513 points, with Japan scoring 605 points. Looking at these results in order of country/region from highest to lowest scoring, Singapore scored the highest (643 points) (statistically higher than all other countries), followed by a group of countries that included Korea, Japan and Hong Kong. The differences in results in this group of three countries were not statistically significant. This group was followed by Belgium (Flemish) and Czech Republic. Looking at the remainder of the countries, France was positioned higher than the international average, Germany was average, while the England and the U.S. were positioned below the international average.

Figure 2-1-1 International comparison of relationship between student attitude towards mathematics and scores



Note: "Like/dislike index" means, it point-ized by the following weight.
"Like a lot" 2, "Like it" 1, "Dislike" -1, "Dislike a lot" -2

Source: Ministry of Education, National Institute for Educational Research, "International Comparison of Mathematics and Science Education in Junior High Schools", March 1997

See: appendix table 2-1-1

In Japan's results, some 30% of students were placed in the top 10% of the distribution of scores from all participating countries.

Furthermore, looking at the results according to content areas, Japan's percentage of correct responses was high in all six areas: "fractions and number sense" (2^{nd} out of 41 countries in percentage of correct responses), "geometry" (1^{st}), "algebra" (2^{nd}), "expression/analysis of data, and probability" (3^{rd}), etc.

Focusing on the differentials in scores between males and females, in terms of international averages (2^{nd} grade junior high school students), the score for males at 519 was slightly higher than that of females at 512, but in the majority of countries/regions no significant difference was evident between males and females. However, Japan, together with Iran and Korea, had results which were statistically higher for males than females in both 1^{st} and 2^{nd} grade of junior high school.

As the above observations show, while Japan boasts a high level of achievement in mathematics at junior high school, the situation is totally different when the perception of mathematics is looked at. That is to say, looking at responses to the question: "To what extent do you like mathematics?" in terms of international averages, some 19% of students responded they "like a lot" the subject, 49% of students "like" it (giving a combined total of 68%), indicating that most countries have a favorable opinion of mathematics. In Japan, however, only 10% of students like a lot the subject, while 43% like it, giving a total of 53%, ranking Japan second-lowest above Czech Republic.

Figure 2-1-1 shows in graphic form the average scores in mathematics referred to above and the "like/dislike index." Looking at the graph, it is clear that while Japan has extremely high average scores, there are an extremely large number of students who dislike the subject.

Furthermore, the survey results indicate that Japanese students don't find mathematics enjoyable and have a low perception of it being useful in their daily lives, and a low desire to engage in work that involves using mathematics.

Almost identical tendencies can be observed with regard to science.

The international average of scores in science in 2^{nd} grade junior high school was 516 points, while Japan's average was 571 points. Looking at the countries from highest to lowest average score, Singapore had the highest score with 607 points, followed by a group of countries that included Czech Republic, Japan, Korea, Slovenia, and Netherlands (with no statistical difference within this group). Looking at the remaining selected countries, scores for the England, the U.S. and Germany were average, while France's score was positioned below the international average.

In Japan, some 18% of students were placed in the top 10% of the distribution of scores of all participating nations.

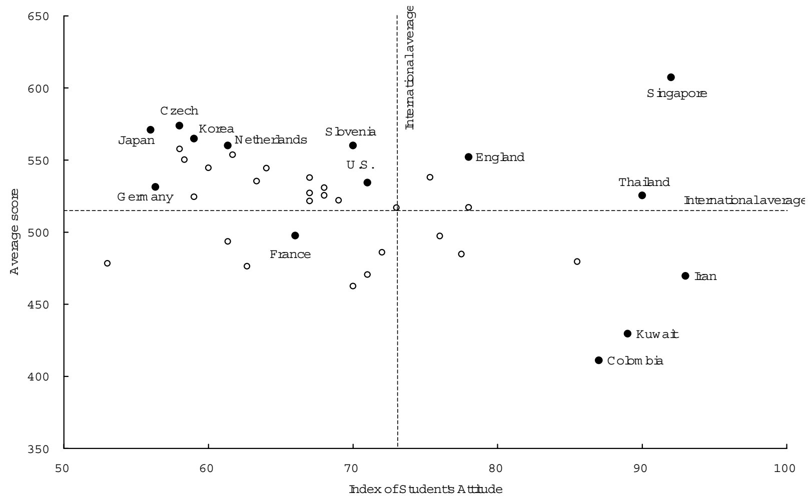
Focusing on the differences in scores according to sex, the international average for males (2^{nd} grade junior high school) of 525 was higher than the average for females of 509, and in contrast to mathematics, a significant difference in results was observed between females and males in 28 countries/regions. In Japan, males' results are statistically higher than females'.

As observed above, in the same way as mathematics, the level of achievement in science of Japan's junior high school students is high, but the same tendency as mathematics was evident in the awareness of science.

That is to say, asking students about their like/dislike of science, in the international average, some 73% of responses were accounted for by "like a lot" and "like," indicating that the subject is generally thought of favorably in most countries. In Japan, however, the same figure was 56%, leaving Japan at the lowest level in terms of these figures. In addition, Japan also has the characteristic of having the largest difference between males and females in terms of their degree of like for the subject (males are shifting towards a like for geometry, while females like this subject the least).

Figure 2-1-2 shows the average score of science mentioned above and the "like index" according to country/region. According to this graph, in the same way as mathematics, while the average is extremely high, there is also an extremely large number of students who hate the subject.

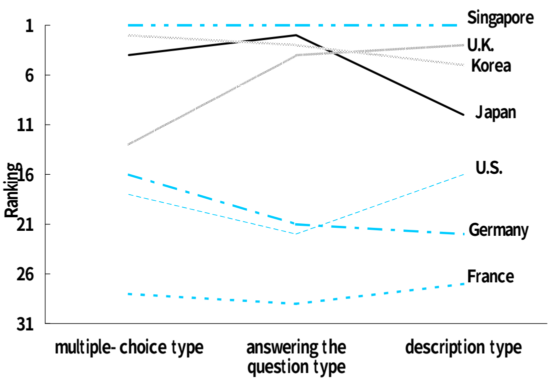
Figure 2-1-2 International comparison of relationship between students attitude towards science and scores



Note : Index means the ratio of students who "like science very much" or "like science".
Source: Ministry of Education, National Institute for Educational Research, "International Comparison of Mathematics and Science Education in Junior High Schools", March 1997
See: appendix table 2-1-2

In addition, science results in Japan are at a top level in terms of content areas such as "physics" (2nd out of 41 countries in the order of percentage of correct responses) and "science" (4th out of 41 countries). Looking at the results according to the type of problem, while Japanese students scored quite highly in the average percentage of correct responses to multiple-choice questions and short-answer questions (4th and 2nd respectively), Japan's position fell to 10th for long-answer questions, which was still above the international average (Figure 2-1-3).

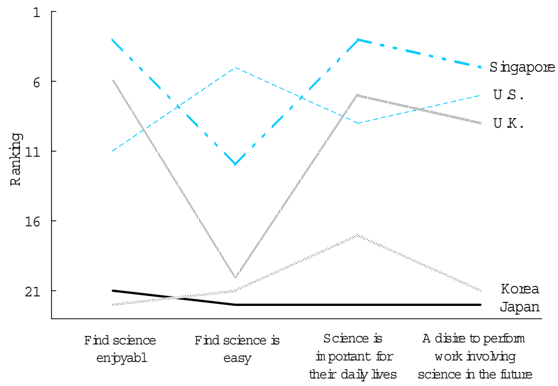
Figure 2-1-3 The ranking of the average validity according to the question type (2nd year junior high school)



Note: Ranking of 41 countries
Source: Ministry of Education National Institute for Educational Research, "International Comparison of Mathematics and Science Education in Junior High Schools", April 1997
See: appendix table 2-1-3

Figure 2-1-4 shows the perception of science among Japanese students. According to this graph, some 53% of students in Japan "find science enjoyable" (compared to an international average of 73%), a figure which left Japan second-lowest above Korea. Some 15% of students "find science easy" (compared to an international average of 43%), 48% of students think, "science is important for their daily lives" (compared to 79%), and 20% of students expressed "a desire to perform work involving science in the future" (compared to 47%). These figures left Japan at the lowest level of the 22 countries between which a comparison could be made.

Figure 2-1-4 The Ranking of the attitude towards science
(Ratio of the student who like science)
(2nd year junior high-school)



Note: Ranking of 22 countries
Source: Ministry of Education, National Institute for Educational Research, "International Comparison of Mathematics and Science Education in Junior High Schools", April 1997
See: appendix table 2-1-4

As mentioned above, although the results of Japan's junior high school students in mathematics and science are at an internationally top level, in terms of interest in the subjects (degree of like/dislike), they are conversely at the lowest level.

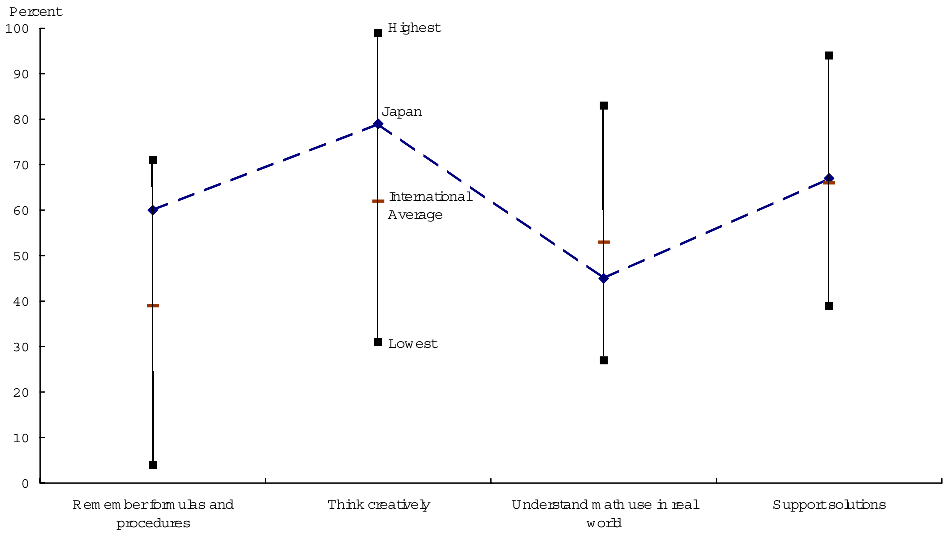
With regard to the background and factors behind these figures, while there are a variety of different circumstances at work, for example, according to the answers to the question "requirements to make students able to do mathematics" posed to teachers in the same survey, 60% said "to remember formulas and procedures" (compared to an international average of 39%), while 79% said "to be able to think creatively" (international average 62%), figures which were higher than the international average. In contrast, 45% of teachers said "to understand the way in which mathematics is used in the real world", which was below the international average of 53% (Figure 2-1-5).

In addition, "frequency with which daily life situations are used in problem solving as part of science classes" was 22% (international average 42%), leaving Japan at the lowest level of all the countries.

In order to foster science and technology human resources, in addition to maintaining the currently high level of results, initiatives to improve the interest in mathematics and science are vital.

In December 1999, the results (bulletin) of the additional survey (2nd stage survey) in Japan as part of The Third International Mathematics and Science Study presented above were made public. According to these results, although the level of achievement in science and mathematics of 2nd year junior high school students is at a similar level to that achieved in the same survey implemented four years ago, with regard to the degree of like/dislike for mathematics and science, the percentage of students who have a favorable attitude towards the subjects has fallen even further. For example, as presented in Section 2.1.1, the percentage of students who "like a lot" and "like" mathematics according to this survey was 53%, second-lowest after Czech Republic, which has dropped even further to 47%, a drop of 6 percentage points.

Figure 2-1-5 Student skills required success in mathematics (2nd year junior high school)



Note: A teacher is questioned about the required matter for a student coming do as for mathematics, and the reply is expressed with the rate of the corresponding number of students

Source: Ministry of Education, National Institute for Educational Research, "International Comparison of Mathematics and Science Education in Junior High Schools", April 1997

See: appendix table 2-1-5

2.2 High Schools

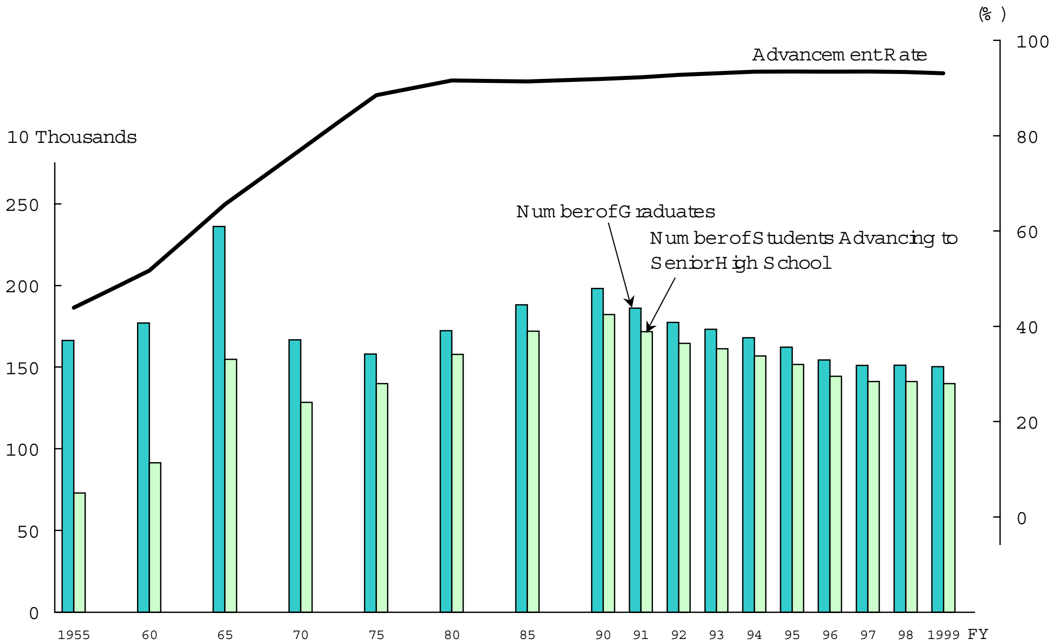
2.2.1 Trends in Number of Admissions and Enrolments

(1) Trends in Percentage of Advancement to High School and Number of Admissions

Some 1.503 million people graduated from junior high school in Japan in March 1999, and 93% of these, 1.399 million went on to study at full-time high school. If night high school and college of technology are included this figure increases to 1.455 million, equivalent to 97% of junior high school graduates. This indicates that in Japan, after compulsory education has been completed, almost all students are going on to further study in high schools and so forth.

Figure 2-2-1 shows trends in the percentage of students going on to study at full-time high schools. According to this graph, while only around 50% of students went on to high school before 1960, after 1980 this figure came to exceed 90%, after which a high level has been maintained. However, the absolute numbers of people going on to study at high schools in FY1999 has fallen to 77% of 1990 levels, reflecting the fall in the population of young people.

Figure 2-2-1 Students advancing to senior high school



Note: Students graduate their schools in March (end of year before).
Source: Ministry of education, "Report on Basic Survey of Schools"
See: appendix table 2-2-1

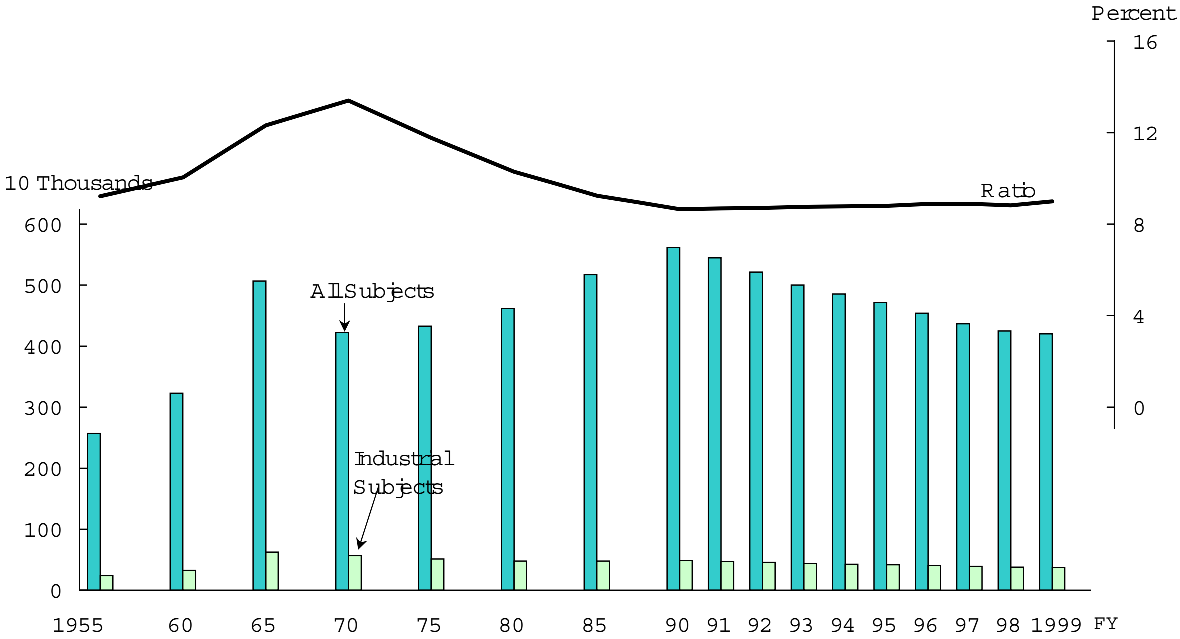
(2) Trends in Numbers of Industrial Students

The number of students enrolled at high schools (all subjects) in FY1955, which was 2.572 million people, increased to 4.223 million and 1970 and 5.617 million in 1990 due to the increase in the percentage of people going on to further study. In contrast, the number of industrial students increased from 237,000 in 1955 to 566,000 in 1970, but fell back to reach 486,000 in 1990 (Figure 2-2-2). As a result, the ratio of industrial students as a percentage of students enrolled in all subjects which rose to exceed 10% from the 1960s to the 1970s moved into decline, and in the 1980s went under the 10% barrier.

This increase in the number of students enrolled in general subjects can be attributed to the desire among students and their parents for them to go on to further study at university, and the increase in the capacity of universities to take more students.

From the early 1990s, reflecting the decreasing in younger age groups of the population, the absolute number of high school students (all subjects) has been decreasing, and the percentage of students enrolled in industrial subjects has been moving around just under 9%.

Figure 2-2-2 Ratio of senior high school students in industrial subjects

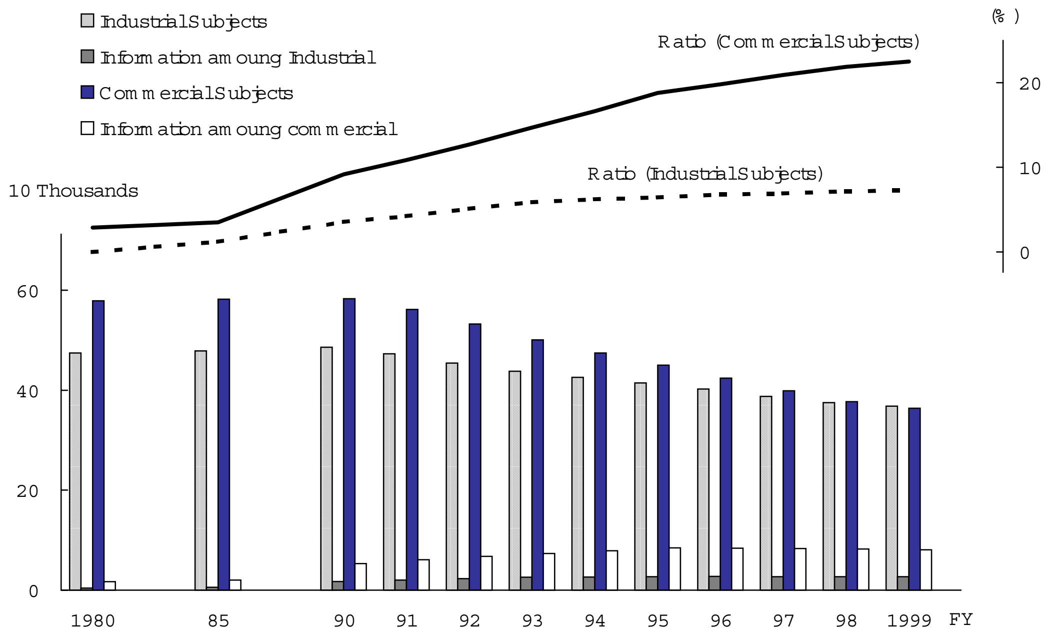


Source: Ministry of Education, "Report on Basic Survey of Schools"
See: appendix table 2-2-2

(3) Trends in Numbers of Students Enrolled in Information Science Subjects

Figure 2-2-3 looks at the state of development of information science human resources at the high school stage of education. From FY1980 to FY1999 the number of students enrolled in industrial subjects and commercial subjects fell by approximately 30% overall, and the number of students enrolled in information science subjects (information-processing subjects in commercial high schools and information technology subjects in industrial high schools) increased during the same period rose from 21,000 to 109,000, a dramatic increase of approximately 5.3%. As a result, the number of students enrolled in information science subjects as a percentage of students enrolled in industrial subjects and commercial subjects increased dramatically from the early 1990s. That is to say, the number of such students enrolled in industrial subjects increased from 1% in FY1980 to 7% in FY1999, and the number enrolled in commercial subjects increased from 3% to 23%, suggesting that the development of information science human resources has been promoted.

Figure 2-2-3 Trends in numbers of students in information science subjects among industrial and commercial subjects



Source: Ministry of Education, "Report on Basic Survey of Schools"
See: appendix table 2-2-3

2.2.2 Routes of High School Graduates

(1) Trends in Percentage of Students Going on to Further Study

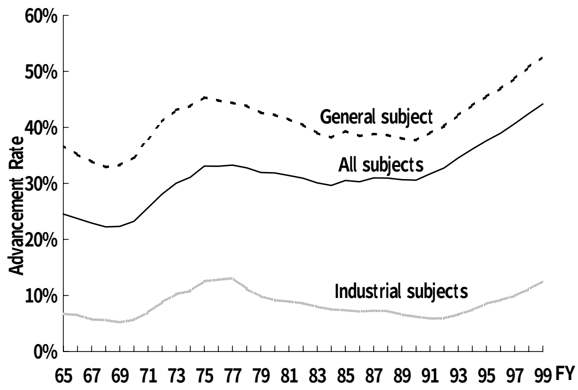
Some 1.363 million students graduated from high schools (all subjects) in March 1999, of which 602,000 went on to further study at universities (universities and junior colleges), accounting for 44% of the total. The total number of students who went on to further study, including those who went on to study at higher vocational schools, is 966,000, accounting for 71% of all graduates.

Looking at trends in the percentage of students going on to study at universities, while the number was only between 20% and 30% in the 1960s, in the 1970s this figure rose to above 30%, and in the 1990s has risen to between 40% and 50% (Figure 2-2-4).

Dividing these figures up into ordinary subjects and industrial subjects, enrolments in ordinary subjects have continued to move in roughly the same pattern, and in particular in 1998 and onwards, the percentage of students going on to study at university exceeded 50%.

In industrial subjects, the percentage of students going on to study at university is relatively low, in the 1970s reaching a peak in excess of 10%. In subsequent years this figure stayed below 10%, but in recent years it has been increasing, exceeding 10% once more in FY 1998 and reaching 12.5% in FY 1999.

Figure 2-2-4 Trends in percentage of students of going on further study



Note: The number for "Enrolled in university" means graduates enrolled universities, colleges or other similar institutes
Source: Ministry of Education, "Report on Basic Survey of Schools"
See: appendix table 2-2-4, 2-2-5, 2-2-6

(2) Employment in Major Industries

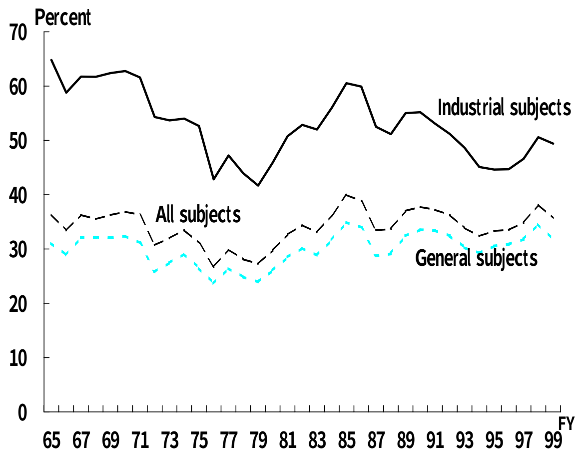
Meanwhile, the number of graduates from high school (all subjects) in March 1999 who found employment was 276,000, or 20% of the total. Looking at the industries that employed these students, the manufacturing industry accounted for 35% and the service industry accounted for 23%.

Looking at trends in the percentage of students employed by the manufacturing industry in the late 1960s this figure remained between 30% and 40%, but at the start of the 1970s the impact of the two oil shocks meant this figure dropped to between 20% and 30% (Figure 2-2-5). In subsequent years, this figure rose to around 40% at one time, but in the early 1990s, after the so-called bubble economy which occurred in the late 1980s, this figure dropped to between 30% and 35%, indicating a "move away from the manufacturing industry." This figure has increased again recently, however.

Looking at students enrolled in industrial subjects, the percentage of graduates finding employment with the manufacturing industry was at a higher level across the whole period than students enrolled in all subjects, but is showing tendencies to move in the same direction. In the late 1960s this figure was in excess of 60%, but upon entering the 1970s this figure dropped greatly to between 40% and 50%. In subsequent years, the figure reached a temporary peak of around 60% in the early 1980s, but dropped to between 40% and 50% in the late 1980s and in following years. While this figure is showing signs of increasing again in recent years, in March 1999 the figure was 49%, a lower level than in the late 1960s, in contrast to all subjects.

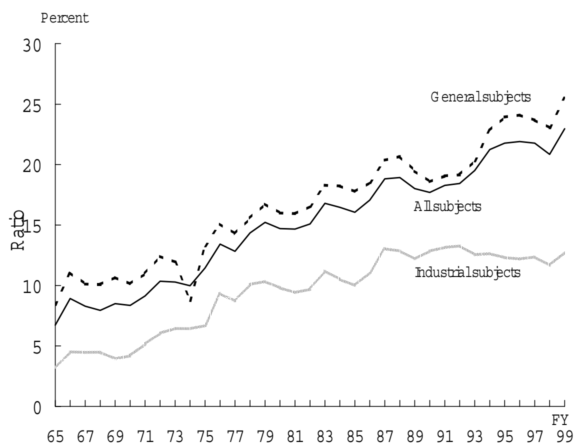
Figure 2-2-6 shows trends in the percentage of graduates employed by the service industry. According to this graph, while being affected by the fluctuations in the economy, the percentage of graduates finding employment in the service industry has continued to increase almost consistently. This same tendency is almost the same for graduates from industrial subjects, which had figures of less than 5% for the late 1960s and has recently come to exceed 10%.

Figure 2-2-5 Trends in the percentage of graduates finding employment with the manufacturing industry



Source: Ministry of Education, "Report on Basic Survey of Schools"
See: same as appendix table 2-2-4

Figure 2-2-6 Trends in the percentage of graduates employed by service industry



Source: Ministry of Education, "Report on Basic Survey of Schools"
See: same as appendix table 2-2-4

2.3 University Departments

2.3.1 Trends in Applicant Numbers

Applicants for admission to university generally submit applications to multiple university departments. Each person can make more than one application, and the total number of these applications is the total number of applications for admission.

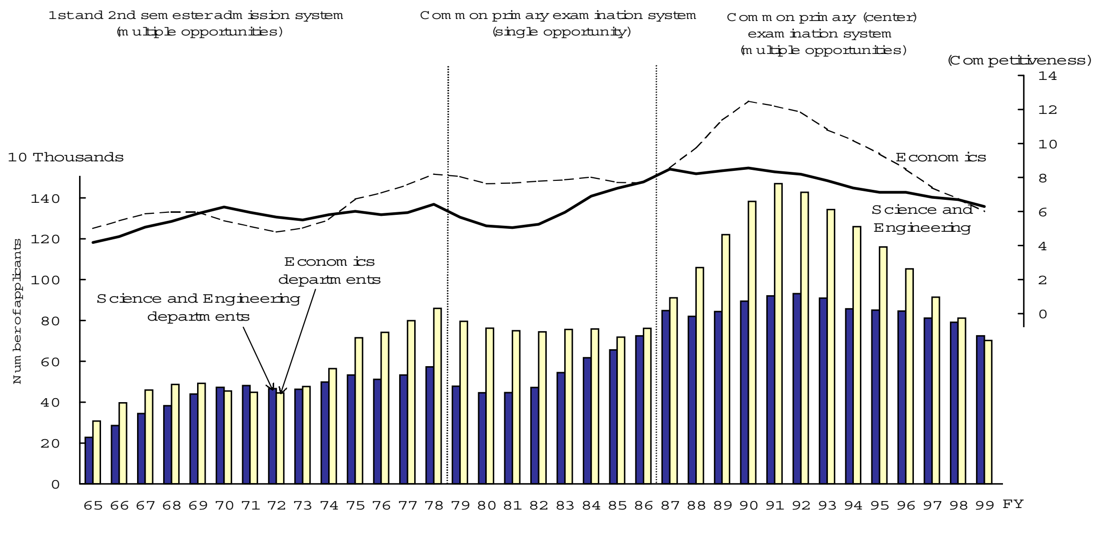
In FY 1965 the total number of applications for university admission (all departments) was 1.203 million, and this number increased consistently through the 1970s against a background of heightening desire for further study, reaching 3.127 million students in FY 1978.

In FY 1979 the system of admission to national universities changed from the "1st and 2nd semester admission system" which had existed up until then, to a "common primary examination system," and in response to the change from multiple opportunities to a single opportunity to sit the examination for admission to national universities, the total number of applicants for admission dropped to between 2.5 and 3 million. In the subsequent years, in response to the change from a single to multiple opportunities to sit for national university entrance examinations with the introduction of the "common primary (center) examination system" from FY 1987, the number of applications increased rapidly, up to 5.063 million in FY 1992.

Despite this, in recent times these figures are decreasing due to the decline in the population aged 18 or younger, which will be mentioned in the next section. The number of applications reached 3.59 million in FY 1999.

Figure 2-3-1 looks at trends in the total number of applications for admission, for science and engineering subjects and economics subjects. According to this table, science and engineering applicants decreased in number in the 1970s, while no great drop in numbers was evident for economics subjects. From FY 1987 to the early 1990s there was a great rise in the number of economics applicants, but this number has in contrast fell more recently.

Figure 2-3-1 Trends in number of applicants for admission and competitiveness



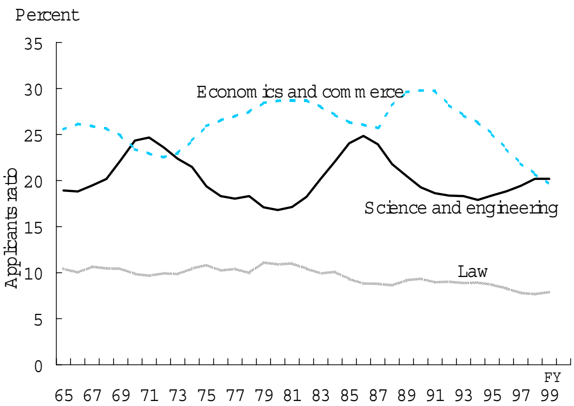
Source: Ministry of Education, "Report on Basic Survey of Schools" See: appendix table 2-3-1

Compared to economics subjects, science and engineering have seen little fluctuation. In FY1999 the number of science and engineering applicants and economics applicants were around the same level at approximately 700,000 each.

Figure 2-3-2 looks at trends in the percentage of total applicants accounted for by department. According to this graph, in the 1970s and the late 1980s, there was a so-called "move away from science and engineering" phenomenon in which the percentage of the total number of applicants accounted for by science and engineering subjects fell, and the percentage accounted for by economics subjects increased. In the early 1980s and more recently, the reverse phenomenon is in evidence.

As mentioned earlier, the total number of applicants for university admission has been affected by changes in the admissions system, but particularly when viewed by department, the economic situation at the time seems to have had a great impact.

Figure 2-3-2 Trends in the ratio of applicant for admission



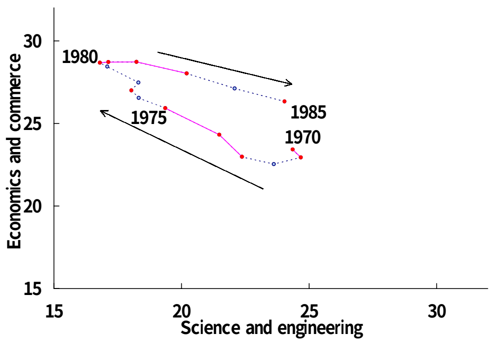
Source: Ministry of Education, "Report on Basic Survey of Schools"
See: appendix table 2-3-2

Figure 2-3-3 shows the percentage of the total number of applicants for admission accounted for by science and technology subjects and by economics subjects, related to the economic situation of the time. Graph (A) shows figures from the 1970s to the early 1980s, and according to this graph, a great shift from science and engineering subjects to economics subjects is evident, caused by the two oil shocks which occurred in the 1970s. Conversely, in the 1980s, as the economic situation became more favorable, we saw a recovery in the science and engineering subjects. However, the booming so-called bubble period in the late 1980s saw a dramatic shift towards economics subjects once more, and in FY1991 when the "bubble burst," and in subsequent years, we saw a recovery of science and engineering subjects, indicating the reverse movement from that which occurred in the early 1980s.

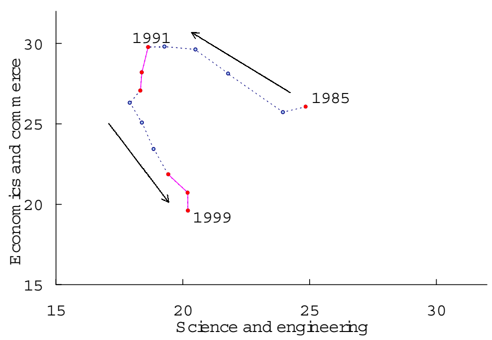
As seen earlier, the "move away from science and engineering subjects" in the 1970s was caused by a reduction in the number of applicants for science and engineering subjects that reflected the deterioration in business conditions in the manufacturing industry in economic recession. In contrast, the move away from science and engineering in the boom times of the economic bubble in the late 1980s was caused by different factors, i.e. a dramatic increase in the number of applicants for economics subjects under the impact of changes to the admissions system for national universities. In recent times, we have seen a sudden drop in the number of applicants for economics subjects, with the result that the percentage of applicants for science and engineering increased, to the point where the percentage of applicants is approximately the same for both subject areas. In this way, care needs to be taken to gain a detailed picture of and to examine the factors behind and content of the phenomenon described as a "move away from science and engineering."

Figure 2-3-3 Percentage of applicants related to the economic situation

(A) 1975-1985



(B) 1986-1999



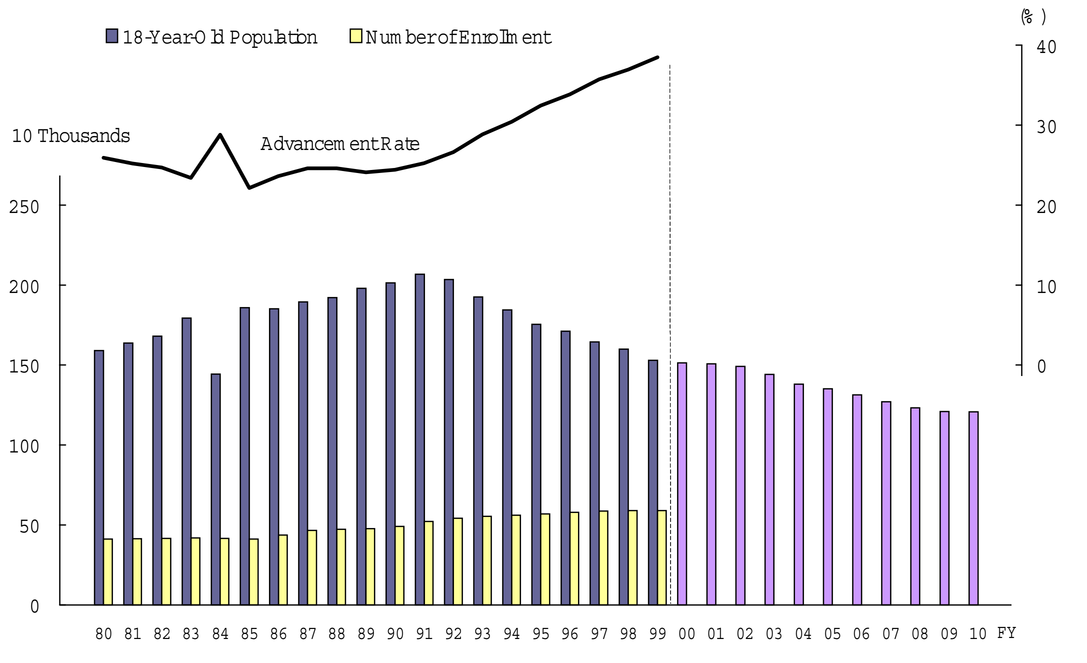
Note: The dashed line portion of a figure corresponds to the prosperity time, and the solid line portion corresponds to the economical retreat time.
Source: Based on Ministry of Education, "Report on Basic Survey of Schools" and Economic Planning Agency data.
See: appendix table 2-3-3

2.3.2 Trends in the 18-year-old Population and Enrollees

According to estimates made by the Ministry of Education's National Institute of Population and Social Security Research, Japan's population of 125.57 million people in 1995 will rise to reach a peak of 127.78 million in 2007, after which it will enter a long-term decline. This is because since the mid-1970s the birth rate has been much lower than that required to maintain the population at a given size (total fertility rate of around 2.08). The 18-year-old population has already reached its peak of 2.068 million in 1991, and is now falling. This population is regarded as continuing to fall in the future – for example falling to 1.208 million by 2010, some 58% of the figure at its peak (Figure 2-3-4).

Against this background, the number of people admitted to university departments has, under a heightening desire for further education and increased capacity of institutions, increased from 412,000 in FY1980 to 590,000 in FY1999, an increase of a factor of 1.4. As a result, the percentage of people going on to higher education (the percentage of the 18-year-old population who are admitted to universities) rose from 26% to 39% over the same period, an increase of 13 percentage points.

Figure 2-3-4 Trends in 18-years-old population and students advancing to undergraduate courses



Notes: 1) 18 years-old population is based on middle estimation
2) A ratio of students going on to higher schools is the rate of the number of university new students to 18 years-old populations.

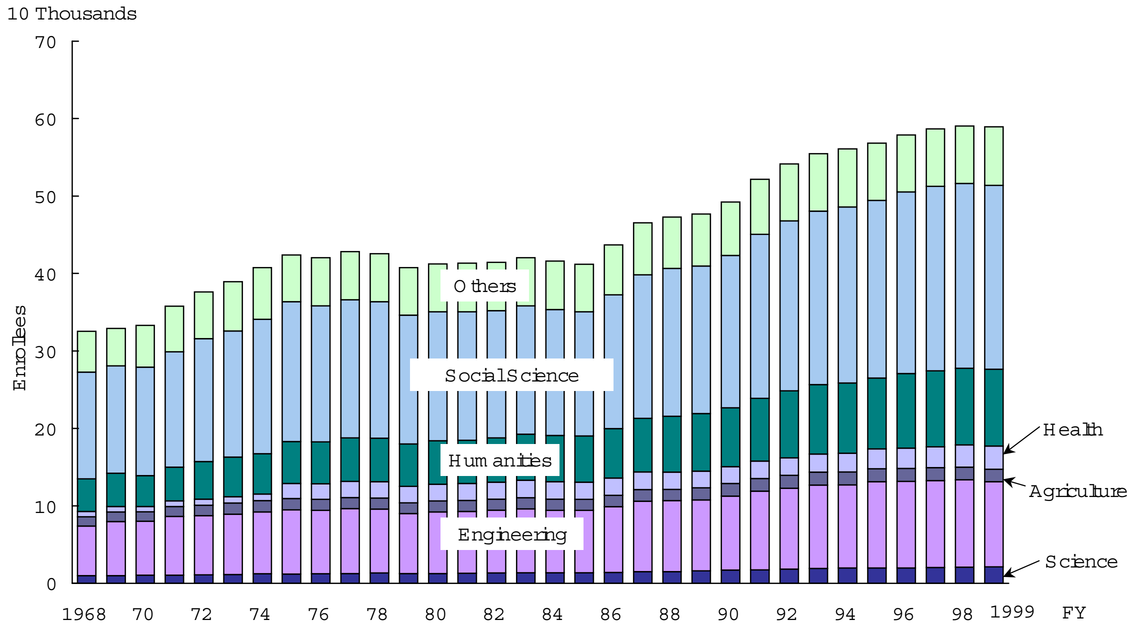
Source: The Institute of Population and Social Security, "Future Population Estimates for Japan" (Jan. 1997 estimation). Ministry of Education, "Report on Basic Survey of Schools"

See: appendix table 2-3-4

Figure 2-3-5 takes a longer-term view of these trends in people admitted to university, as well as looking at them according to department. According to this graph, in FY 1999 the department with the largest number of university entrants was social sciences, with 237,000 people, making up 40% of the total, followed by engineering with 110,000 (19%), and the arts with 99,000 (17%). Some 21,000 students enrolled for the first time in the sciences, accounting for 3.6% of the total.

Next, looking at trends in the number of people admitted to university, overall the figure of 333,000 in FY 1970 rose to 590,000 in FY 1999, an increase of a factor of approximately 1.8. Breaking these figures down into departments, social sciences increased by a factor of 1.7, engineering by 1.6, figures which are similar increases, but sciences increased by a factor of approximately 2.0, the arts by approximately 2.5, and health by approximately 4.3. While these increases are relatively large, no major changes were evident in the percentages of the total occupied by the main departments.

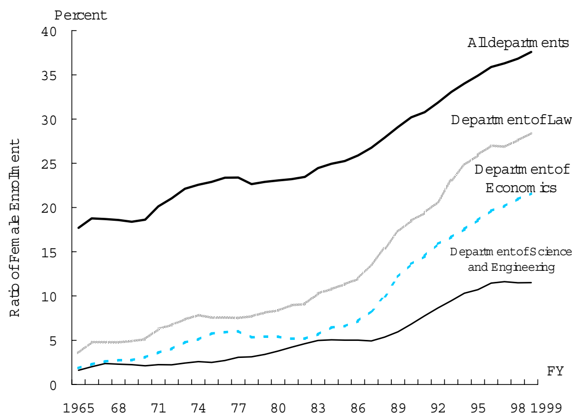
Figure 2-3-5 Enrollment in undergraduate courses by departments



Source: Ministry of Education, "Report on Basic Survey of Schools"
See: appendix table 2-3-5

When looking at trends in the number of people admitted to university, a feature is the increase in the number of female students. In FY1970 there were only 62,000 females admitted to university. This figure increased by a factor of approximately 3.6 to 221,000 by 1999. As a result, the percentage of all students admitted to university who were female has risen from 19% to 38% over the same period (Figure 2-3-6).

Figure 2-3-6 Female enrollment in undergraduate courses by departments



Source: Ministry of Education, "Report on Basic Survey of Schools"
See: appendix table 2-3-6

Looking at this situation by department, the number of female students admitted to science and engineering departments has risen from 1,599 in FY1970 to 13,206 in FY1999, a dramatic increase of approximately 8.3. As a result, the percentage of female students admitted to science and engineering departments rose from 2.1% to 11.5% over the same period, but is still at a lower level than other departments. In addition, up until the early 1990s the percentage of female students was increasing, but recently it seems to have hit the ceiling somewhat.

2.3.3 Career Paths of Science and Engineering Graduates

Some 530,000 people graduated from universities (all departments) in March 1999, but looking at the breakdown, some 50,000 (10%) went on to post-graduate school and so forth, some 320,000 (60%) found employment, some 106,000 (20%) were unemployed (people who were neither working nor engaged in further study - helping at home, for example), and the remainder whose details were unclear was 52,000 (10%).

Looking at the science and engineering departments, some 19,000 people graduated from science departments, of which 7,000 (36%) went on to further study, 9,000 (47%) found employment, the remainder of 3,000 (15%) whom were unemployed. In addition, some 102,000 students graduated from engineering departments, of which 27,000 (26%) went on to further study, 63,000 (61%) found employment, and 13,000 (13%) were unemployed. All of these figures had higher percentages of people going on to further study compared to the average across all departments, and the percentage of unemployed graduates was lower. One figure behind this is the differences in gender makeup of students in these departments.

The following section gives an overview of the state of career paths for graduates from science and engineering departments.

(1) Trends in Academic Advancement and Finding Employment

Figure 2-3-7 looks at the career paths (percentages of total) of science departments and engineering departments.

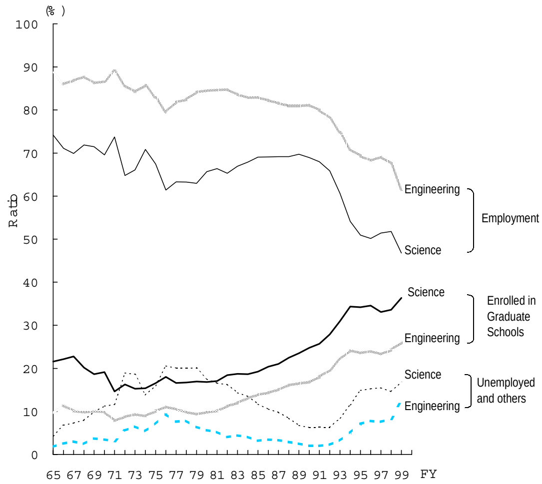
Over the whole period, in science departments the percentage of graduates going on to further study was relatively high, and in engineering departments the percentage of graduates finding employment was relatively high, and the changes show roughly the same shapes.

Looking at the percentage of graduates who found employment, this figure fell during the 1970s with the impact of the oil shocks. This fluctuation corresponds to the increased percentage of unemployed graduates in the same period. In subsequent years, the percentage moved sideways (slight increase in science and a slight decrease in engineering), but upon entering the 1990s, the percentage of graduates who found employment took a great step backwards. During this period, we saw a dramatic increase in the percentage of unemployed, a figure which had been decreasing since the 1980s.

The percentages of graduates who find employment and who are unemployed fluctuate in response to the impact of the economic situation, as mentioned earlier. On the other hand, however, the percentage of graduates going on to further study has almost consistently increased since the 1970s. This figure has leveled off more recently, however.

Figure 2-3-7 Employment academic paths of science and engineering graduates

(percentage of total)



Source: Ministry of Education, "Report on Basic Survey of Schools"
See: appendix table 2-3-6

(2) Percentage of Graduates Finding Employment by Industry

Some 72,000 students graduated from science and engineering departments and found employment. Looking at the main industries employing these graduates, 35.8% of graduates went to the manufacturing industry, 29.9% went to the service industry, 15.4% went to the construction industry, and 8.0% went to the wholesale and retail industry. In addition, some 1.6% of graduates were employed by the finance and insurance industry.

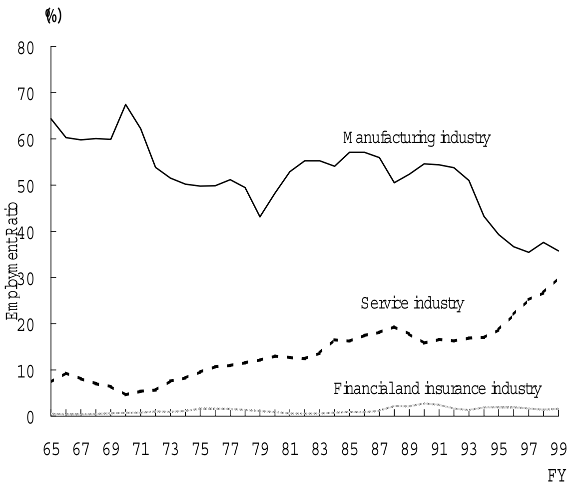
Figure 2-3-8 shows trends in the percentage of graduates employed by the respective industries. The percentage of graduates employed by the manufacturing industry, which was 67.5% in 1970, dropped to 43.2% at one time in 1979, after which it ranged between 50% and 60% in the 1980s. Upon entering the 1990s, however, it dropped right back again, to reach in 35.4% in 1997. The figure did increase slightly to 35.8% in

1999, however.

Meanwhile, the percentage of graduates employed by the service industry has consistently increased over this period, with a particularly marked increase being observed in 1993 and later years.

The percentage of graduates employed by the finance and insurance industry, which was 2.8% in 1990, has dropped off to 1.6% in 1999.

Figure 2-3-8 Trends in the ratio of graduates employed by the respective industries



Source: Ministry of Education, "Report on Basic Survey of Schools"
See: appendix table 2-3-8

2.4 Graduate School

2.4.1 Trends in Numbers of Graduate Students

(1) Master's Courses

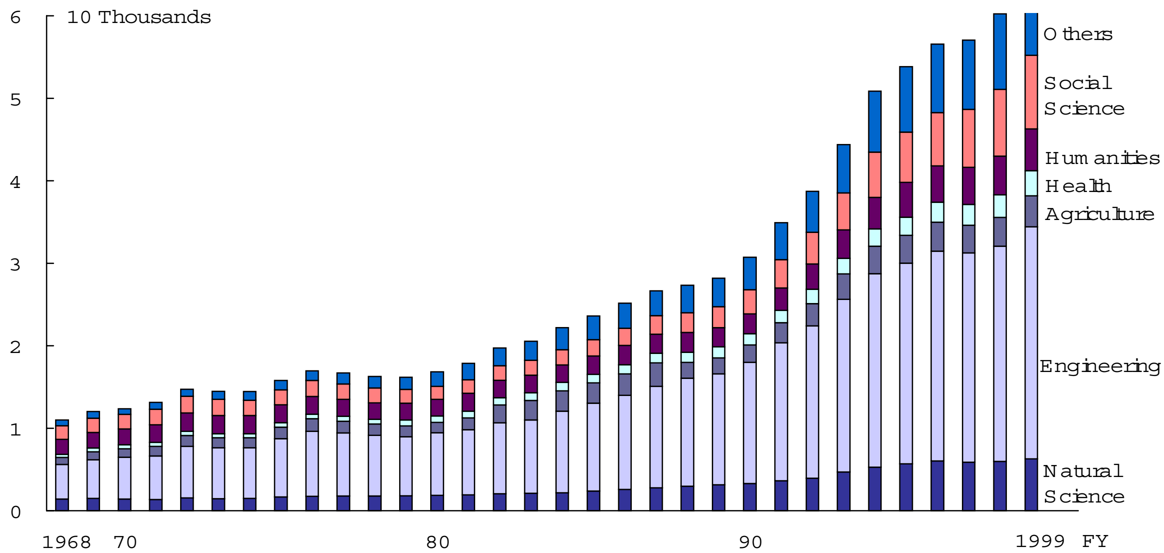
In 1999, some 65,000 people were admitted to master's courses throughout the country. Looking at the breakdown of this figure according to major, engineering was the highest of these with 28,000 (43%), followed by social sciences with 9,000 (14%), and science with 6,000 (10%).

Figure 2-4-1 shows the trends in the number of people admitted to master's courses in graduate school. The number of students admitted to courses was 17,000 in 1980, which rose to 24,000 in 1985 and then again to 31,000 in 1990, which were both significant increases. This tendency to increase strengthened even further from the 1990s, but is slowing somewhat in more recent times.

Looking at the increase from the 1990s, the overall number of students admitted to master's courses increased by a factor of 2.1 from 1990-1999. Breaking down these figures according to major, social sciences increased by a factor of 3.1, showing the greatest growth, with engineering and science both increasing by 1.9, somewhat lower than the overall rate of growth.

However, looking at the rate of contribution to the growth of this period, engineering, with a high number of students admitted, is the highest, and science with 9%, together accounting for 48% of the growth overall. In this way, of the dramatic increase in the number of students admitted to master's courses in the 1990s, approximately half can be attributed to the increase in science and engineering courses.

Figure 2-4-1 Trends in number of students admitted to master's courses



Source: Ministry of Education, "Report on Basic Survey of Schools"
See: appendix table 2-4-1

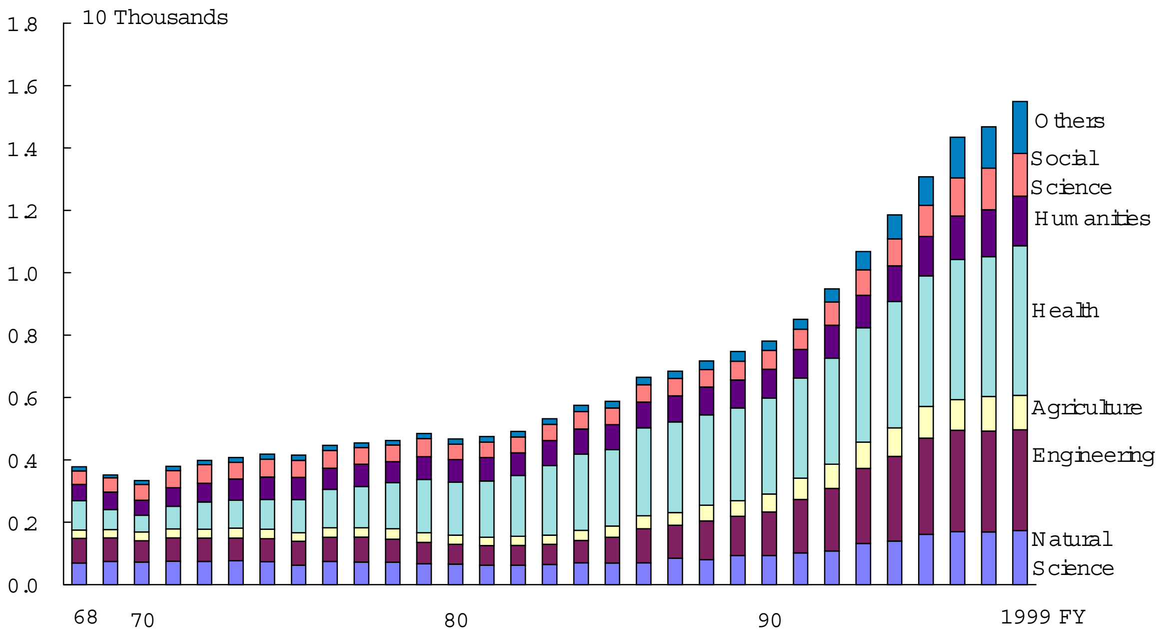
(2) Doctorate Courses

Next, taking a look at the number of students admitted to doctorate courses at universities, in 1999 the total was 16,000. Breaking down this figure this figure by major in order of size, health accounted for 5,000 (32%), engineering for 3,000 (20%), and science for 2,000 (11%), etc.

Figure 2-4-2 shows the trends in the number of people admitted to doctorate courses. In 1980 the figure was 5,000, which rose to 6,000 in 1985, and 8,000 in 1990, a great increase in the same way as that experienced by master's courses. This increase strengthened even further upon entering the 1990s, and although the growth has slowed slightly in recent years, it is moving in roughly the same way as the number of people admitted to master's courses.

The number of students admitted in 1999 was some 2.1 greater than the number in 1990, which again is showing similar growth to that experienced by the number of people admitted to master's courses. Breaking down the figures according to major, growth in engineering was the greatest at a factor of 2.4, accounting for 23% of the growth rate (science grew by a factor of 1.9 and contributed 10% to the growth). In this way, looking at the doctorate courses in the 1990s, just under 40% can be attributed to an increase in the number of students admitted to science and engineering courses.

Figure 2-4-2 Trends in the number of students admitted to doctorate course

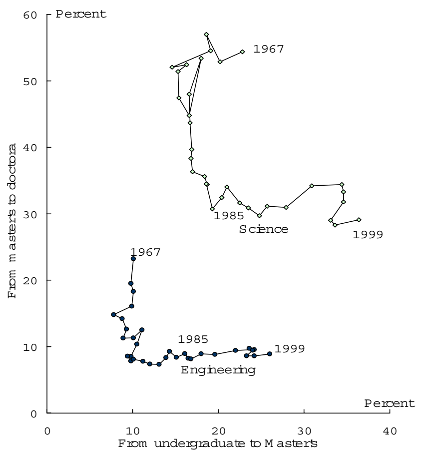


Source: Ministry of Education, "Report on Basic Survey of Schools"
See: appendix table 2-4-2

2.4.2 Developments in Academic Advancement to Graduate School

As demonstrated above, it is clear that the number of people admitted to graduate courses in science and engineering at university in recent years is growing rapidly. Trends in the percentage of students going on to such study are shown in Figure 2-4-3.

Figure 2-4-3 Trends in the percentage of students admitted to graduate courses



Source: Ministry of Education, "Report on Basic Survey of Schools"
See: appendix table 2-4-3

Firstly, looking at the figures for science courses, from the 1970s to the mid-1980s, the percentage of students going on to master's courses was relatively constant at around 15% to 20%. The percentage of students then going on from master's courses to doctorate courses dropped from a level exceeding 50% to approximately 30%. In the subsequent years, up until around 1994 the percentage of master's students going on to doctorate courses ranged from between 30% and 35%, and the percentage of graduates going on to master's courses increased from approximately 20% to around 35%. In this way, with 1985 as a turning point, the figures depict a large L-shape. In very recent times, the percentage of students advancing to doctorate courses has dropped somewhat. On factor in the background to this fall is the increased need by companies for master's graduates as adaptable fighting potential in the development of new products.

For engineering students, the rates of advancement to higher levels of education are relatively lower than for science students, but they show basically the same movement. The turning point in the L-shape is earlier than that for science students, occurring at the start of the 1980s.

2.4.3 Employment of Graduates of Graduate School in Major Industries

(1) Master's Courses

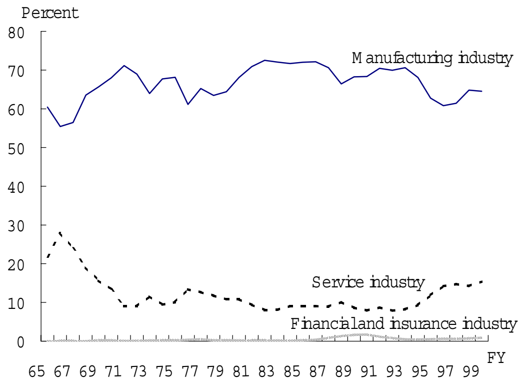
In March 1998 some 29,000 students graduated from master's courses at graduate school. Breaking down these figures, 4,000 went on to further study (12%), 24,000 found employment (80%), and 2,000 (8%) were unemployed.

Further, looking at the percentage of graduates employed in different industries, the manufacturing industry accounts for the majority at 64.5%, followed by IT and other service industries with 15.4% and construction with 5.9%.

Figure 2-4-4 shows trends in the percentage of graduates employed by industry. According to this graph, the percentage of students employed by the manufacturing industry increased from between 65% and 70% to between 70% and 80% up until 1994, but in 1995 and subsequent years it dropped to between 60% and 65%. As if making up for the ground lost by the manufacturing industry, the percentage of graduates employed by the service industry has increased in recent years. In 1999, the percentage of graduates employed by the manufacturing industry started to increase.

In addition, the percentage of graduates employed by the finance and insurance industry was 1.7% in 1989, but this fell to 0.9% in 1999.

Figure 2-4-4 Trends in percentage of graduates employed in different industry



Source: Ministry of Education, "Report on Basic Survey of Schools"
See: appendix table 2-4-4

(2) Doctorate Courses

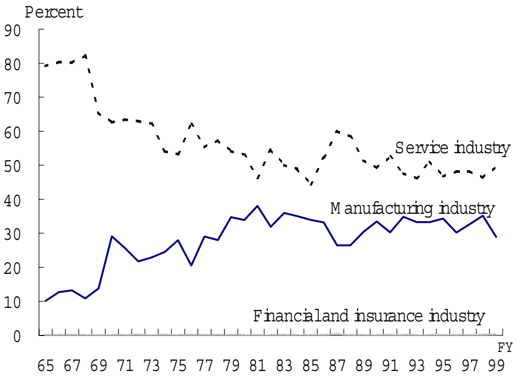
In March 1998 some 4,068 people graduated from doctorate courses in science and engineering. Breaking that figure down, 6 graduates went on to further study (0.1%), 2,440 found employment (60%), and 1,622 were unemployed (40%).

The breakdown of employment by industry is totally different to that for master's courses, with the highest-rating sector being education and other service industries with 49.6%, followed by the manufacturing industries with 29.0% and public service with 9.1%.

Figure 2-4-5 looks at the trends in the percentage of employment to the manufacturing and service industry. According to this graph, the manufacturing industry employed 26.4% of graduates in 1987, and this figure has tended to increase over the subsequent years.

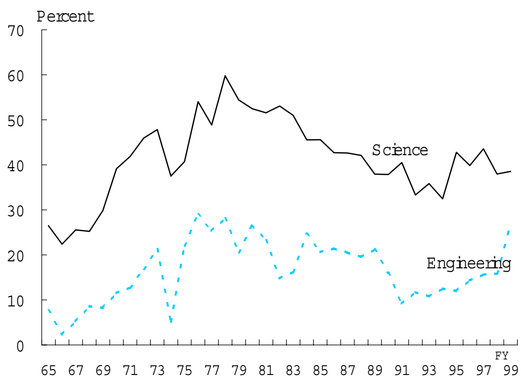
Looking at the percentage of graduates of doctorate courses who were unemployed, in the late 1970s the figure for science graduates was approximately 60%, and approximately 30% for engineering graduates, a temporarily high level for both courses, but in the subsequent years these figures have generally been in decline (Figure 2-4-6). With the deterioration in the economic situation in the late 1990s, however, this figure has been rising again.

Figure 2-4-5 Trends in percentage of graduates employment to the manufacturing and service industry.



Source: Ministry of Education, "Report on Basic Survey of Schools"
See: appendix table 2-4-5

Figure 2-4-6 Trends in the percentage of unemployed doctorate course graduates



Source: Ministry of Education, "Report on Basic Survey of Schools"
See: appendix table 2-4-5

2.5 Number of Persons Obtaining Degrees

2.5.1 Trends in the Number of Doctorates Conferred

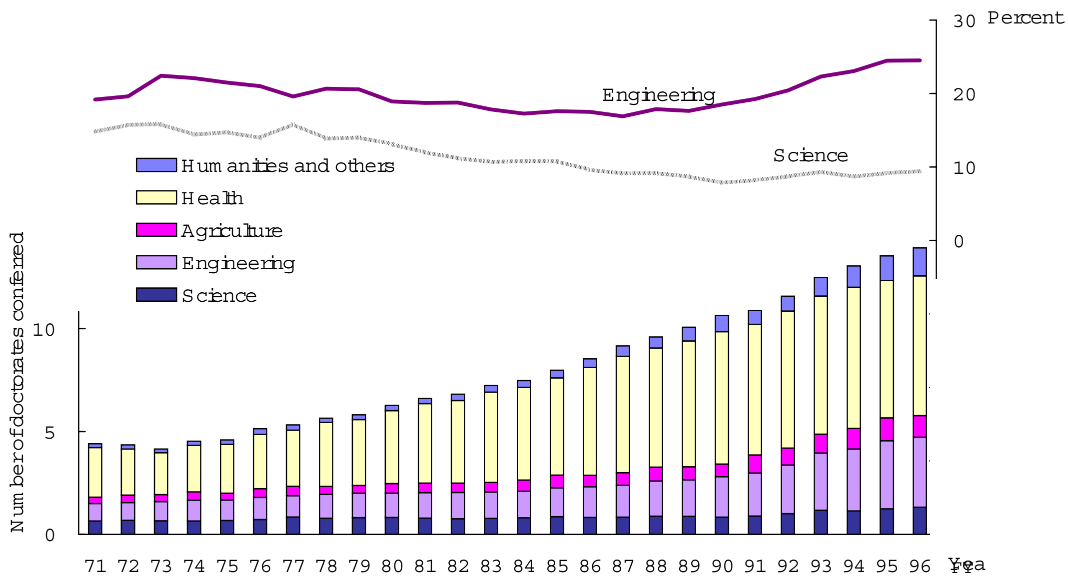
The number of doctorates conferred is regarded as an important indicator in assessing the quality of science and technology human resources.

Figure 2-5-1 shows the trends in the number of degrees conferred according to major. The number of degrees conferred referred to here is the number of degrees conferred (so-called new doctorates) conferred in a particular year in accordance with degree rules. In the early 1970s the number of degrees conferred, which had stopped at between 4,000 and 5,000, consistently increased from the late 1970s, to the point where it exceeded 8,000 degrees in 1986. In the following years the increasing tendency strengthened, reaching 13,921 degrees in 1996.

Looking at the breakdown of the degrees conferred in FY 1996 according to the major majors, there were 6,800 degrees in health (medicine, dentistry, pharmacology and health studies), accounting for 48.8% of the total. Some 1,315 degrees (9.4%) were conferred in science, while 3,411 degrees (24.5%) were conferred in engineering.

Looking at the percentage of the total accounted for science and engineering, since FY 1970 these percentages seem to be decreasing somewhat. However, engineering turned around to an increase from around FY 1988 and science started increasing from FY 1991.

Figure 2-5-1 Trends in the number of doctorates conferred



Notes: 1) Health include medicine, dentistry, pharmacy and health
2): Others education include art and domestic science

Source: Figures for years up to 1986 are cited from "Compilation of Higher Education Statistical Data" published by the Research Center to University Education, Hiroshima University. Figures for year after 1986 are based on data from Ministry Education.

See: appendix table 2-5-1

Figure 2-5-2 shows a breakdown of the number of course doctorates and the number of dissertation doctorates for the number of degrees conferred in science and in engineering, as well trends in those figures. The number of degrees conferred in science was moving sideways in the 1980s, but from FY1991 and onwards it started increasing. Looking at the breakdown of course doctorates and dissertation doctorates, over almost the whole period, the number of course doctorates exceeded the number of dissertation doctorates. In recent times in particular, the increase in the number of degrees can be attributed almost completely to the increase in the number of course doctorates. Such doctorates account for approximately 75.7% of the total.

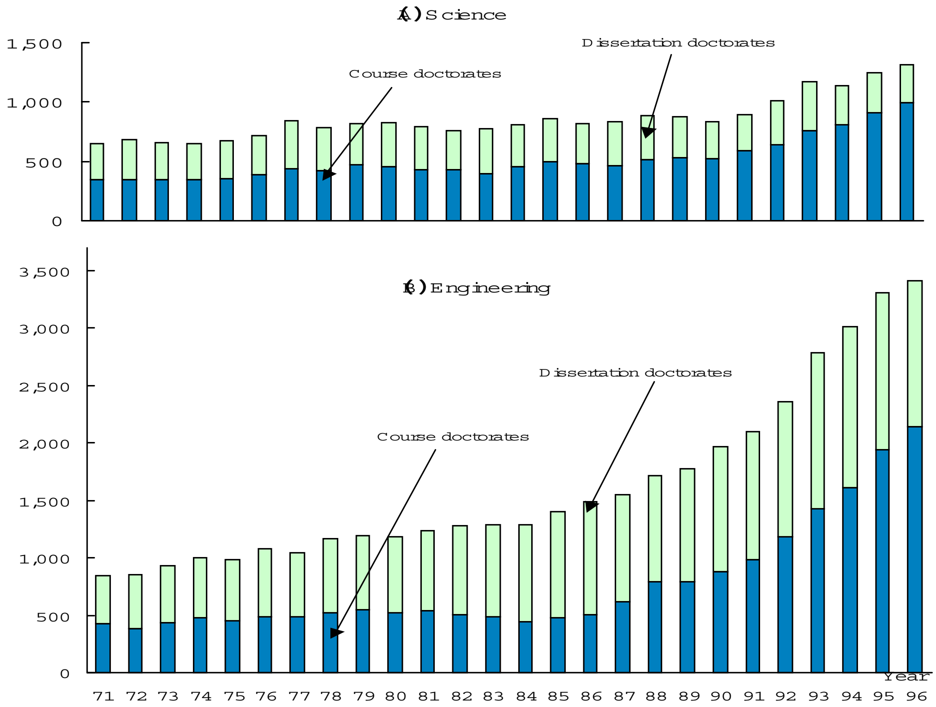
In contrast, the number of degrees conferred in engineering has increased almost consistently over the whole period. From the late 1980s in particular, this increasing tendency has become much stronger. Looking at the breakdown, in contrast to science, the number of dissertation doctorates exceeded the number of course doctorates over virtually the whole period. More recently, however, the increase in the number of course doctorates has been particularly marked, as is the case with science, increasing to the extent that they increased the number of dissertation doctorates in FY1992. In 1996 some 62.8% of the total number of degrees conferred were course doctorates. In the background to these trends are the recent increases in the number of students going on to study at graduate school seen in Section 2.4.2.

2.5.2 International Comparison of the Number of Degrees Conferred

Figure 2-5-3 shows an attempt at an international comparison of the number of doctorates conferred per 1 million head of population in FY1996. Care needs to be taken over the fact that there are differences in the nature of degrees from country to country, but according to these figures, Germany is the country with the largest number of people with doctorates, with 279 per 1 million head of population. Germany is followed by the U.K. with 174 people, the U.S. with 170 and Japan with 111, roughly one-quarter of Germany's number, and just over 60% of the levels in the U.S. and the U.K..

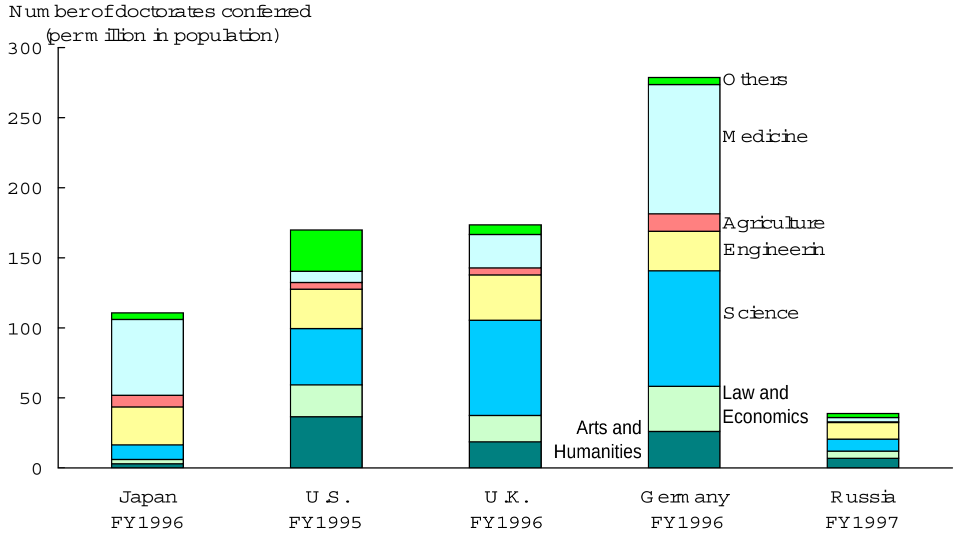
Looking at the percentage of the total accounted for by major according to country, US tends to have a large number in arts, the U.K. has a large percentage in science, and Germany has a large percentage in medicine. Japan has the characteristic that the percentages of degrees in engineering and medicine are high compared to other countries

Figure 2-5-2 Trends in the number of doctorates cofered (course and dissertation)



Source: Figures for years up to 1986 are cited from "Compilation of Higher Education Statistical Data" published by the Research Center to University Education, Hiroshima University. Figures for year after 1986 are based on data from Ministry Education.
See: appendix table 2-5-2-

Figure 2-5-3 International comparison of the number of doctorates conferred



Note: Table show international comparison of number of doctorate conferred in each year
Source: Ministry of Education, "International Comparison of Education Indicators"
See: appendix table 2-5-3

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Chapter 2　Tetsuya Nakata

Chapter 3 R&D Systems and the Public Sector

From Chapter 3 to Chapter 5, we will survey the R&D activities of Japan and other major industrialized countries, using mainly data related to R&D expenditures and human resources. Although this data is limited to R&D inputs, enabling us to gain an understanding of only one aspect of R&D activities, the relatively detailed statistics that can be captured make the information provided an important indication of the internal organization of R&D systems and activities.

This chapter will examine the R&D of a whole country as a single system, using indicators to gain a clear picture of the overall appearance of the system. We will also be paying close attention to the public sector, with an analysis of its R&D activities, in addition to the funds it provides to other sectors, and the functions responsible for overall adjustments. We will also discuss the technology-related foundations that play a similar role to the government's support function.

3.1 International Comparison of R&D Systems

3.1.1 Long-term Trends in R&D

To begin with, we will discuss the total R&D expenditures for each country in order to gain an overview of the scale of R&D and general trends in selected countries, including Japan. Although every effort was made through the OECD and so on to ensure uniformity in the survey methods for R&D expenditures, there are some differences in the details and the survey methods from country to country. As a result, a rigorous comparison is difficult under the present circumstances. Moreover, since it is necessary to convert currencies to compare the R&D expenditures for each country, it is impossible to avoid the influence of factors unrelated to R&D. The R&D expenditures for each country shown in this chapter are converted into yen using the OECD's GDP purchasing power parity.

Figure 3-1-1 shows the total R&D expenditures for each country. Because the total R&D expenditures are largely determined by the size of the economy of each country, the U.S. overwhelms the other countries, followed by Japan, Germany, and then France and the U.K., which are roughly on a par with each other.

Japan's R&D expenditures reached 16.1399 trillion yen in 1998[(1)], a 2.5% increase over the previous year (15.7415 trillion yen). After consistent growth in Japan's R&D expenditures up until the beginning of the 1990s, a decline was recorded in 1993 and 1994. From 1995, however, the trend shifted to growth once again, with consecutive increases recorded over 4 years until 1998. Despite a sluggish economy, these increases occurred due to the government's large contribution towards technology-related expenditures, in addition to the continuation of the industrial sector's R&D expenditures. A more detailed analysis of this background will be discussed later.

Although it is not possible to assess yearly trends from the graphs alone, due to the influence of currency conversion, it is clear that from the outset of the 1990s, there was a stagnation or a decrease in R&D expenditures in all countries except Japan. The exception is the U.S., where there was a remarkable increase in R&D expenditures during the late 1990s.

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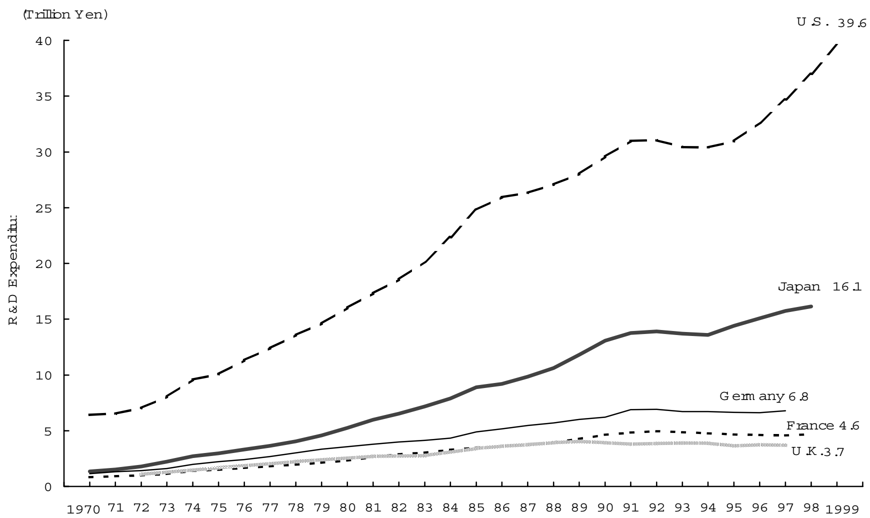
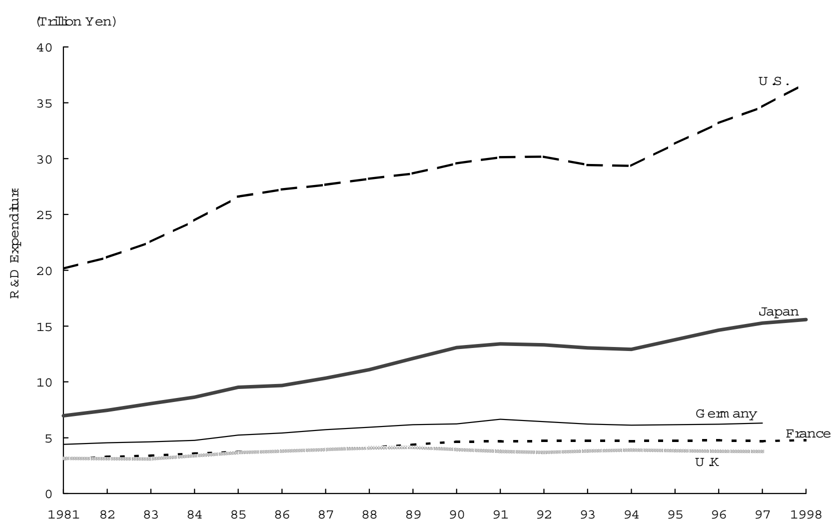
(1) When totaling the R&D expenditures within the limits of the fiscal year, there are differences between countries. Consequently, in this chapter we usually use "annual" for the sake of international comparisons. With regards to individual data, "fiscal year" is used when it is more convenient to do so.

Figure 3-1-1 Trends in gross domestic R&D expenditures in selected countries

(A) Nominal value (OECD Purchasing Power Parity Calculations)



(B) Real value (Based on 1990 Data: OECD Purchasing Power Parity Calculations)



Note: (A)(B) Same Data – Data for each country include natural science and humanities/social science.

As for Japan, software industry newly became the investigation object from the FY1996 Data for Germany is an old federal area till 1990 and it is Germany in 1991 and afterwards.

A) -The amount of money in 1998, 1999 of the U.S. is reserve value. The amount of money in 1998 of France is provisional value.

B) -Calculation of real value used GDP deflator by OECD.

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

US. – NSF, "National Patterns of R&D Resources 1999 Data Update"

Germany – BMBF, "Bundesbericht Forschung 1996", "Faktenbericht 1998"

France – : État de la recherche, et du développement technologique, "Projet de loi de finances", OECD, "Main S&T Indicators 1999/2" (from 1993 value)

U.K. – OECD, "Main S&T Indicators 1999/2", "Basic Science and Technology Statistics 1996"

The Purchasing Power Parity – OECD, "Main S&T Indicators 1999", "National Accounts, 1999"

GDP Deflator – OECD, "National Accounts"

See: appendix table 3-1-1

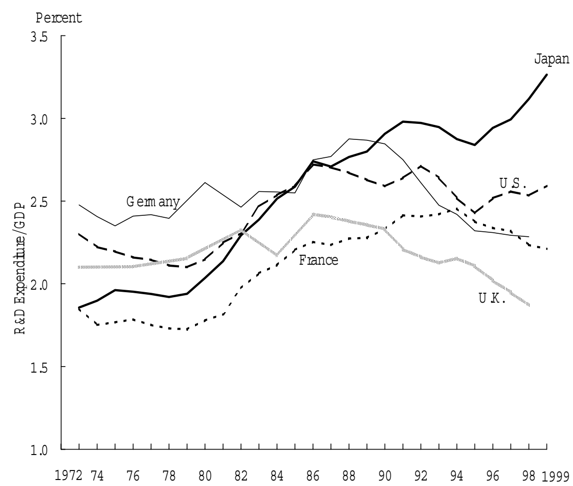
Following is a comparison of R&D expenditures with consideration to the size of the economy of each country. Figure 3-1-2 shows "a comparison of changes in R&D expenditures relative to GDP." This indicator shows the degree of focus received by R&D in each country, and since it does not require currency conversion, it is often used for international comparisons. The values themselves are also discussed as policy objectives.

From a long-term perspective, the R&D expenditures of each country increased as a percentage of GDP growth from the 1970s to the 1980s. During most of the 1980s, the R&D expenditures of all 5 countries exceeded 2% of GDP. However, from the late 1980s to the early 1990s, the growth rate slowed down or even fell. During the late 1990s, the rates between the countries diverged, with continual declines for the three European countries, but with Japan and the U.S. experiencing increases once again.

Japan reached the highest level of the 5 countries in 1989 due to increases after the 1970s, and has maintained that status ever since. Despite a decline during the 4-year period from 1991 to 1994, the rate began to climb again from 1995. The rate for FY1998 was 3.26%, which is a 0.14% increase over the previous year. The increase in 1998 was partly influenced by a reduction in the GDP compared to the previous year, and despite moderate increases in the GDP from 1995 to 1997, the greater influence was the increase in the R&D expenditures itself, relative to GDP.

The rate for the U.S. fell significantly from 1992 to 1994, but climbed again after that to 2.59% in 1998 - a relatively high level compared to the past. After ranking top of the five countries in 1987, Germany's rate fell to 2.28% in 1997. However, it is necessary to bear in mind that around 1991, the scope of data changed for Germany with the integration of data for East Germany in 1991. France shows a moderate but almost consistently rising trend from the late 1970s to the early 1990s, peaking in 1993 and then falling to 2.26% in 1997. The U.K. reached a peak of 2.42% in 1985, and the rate has declined since with the exception of 1993. The increases in the GDP for Germany and the U.K. from 1990 onwards are also factors behind the declining rates for these countries.

Figure 3-1-2 Trends in ratio of gross domestic R&D expenditures to GDP in selected countries



Note: same as figure 3-1-1

Source: R&D expenditures - same as figure 3-1-1

GDP - The Science and Technology Agency, "The Science and Technology White Paper". Economic Planning Agency, "The Economic Survey of Japan", "Annual Report on National Economy".

OECD, "Main S&T Indicators 1999/2", "National Accounts"

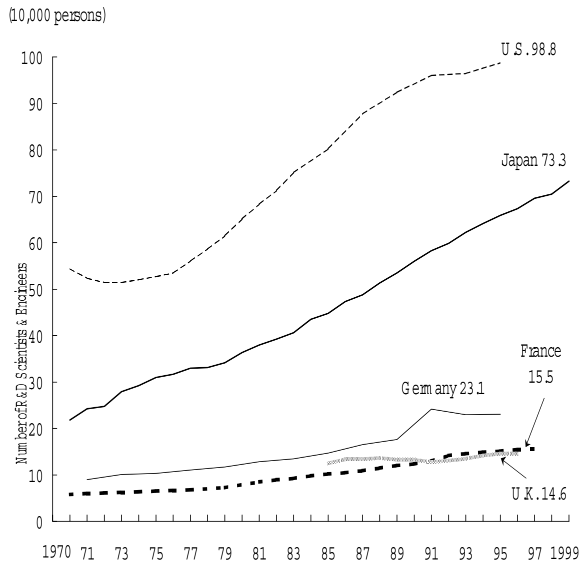
See: appendix table 3-1-2

Next, we discuss the number of researchers for each country. The difficulty with the current statistical data concerning the number of researchers is the lack of uniformity in the definition[2] and method for measuring the numbers of researchers between countries. Nonetheless, by examining the data for changes in the number of researchers for the main countries in Figure 3-1-3, we can see that the number of researchers in the U.S. exceeds the other countries by a wide margin during the period shown. The country with the next larg-est number of researchers is Japan, with 733,000 in 1999.

The number of researchers in Japan has been increasing at an almost constant rate throughout the period displayed. As described below, this increase is largely due to an increase in the number of researchers in the industrial sector.

The number of researchers in the U.S. increased greatly from the late 1970s. After the reunification of east and west, Germany experienced a slight decrease in 1993, which was largely influenced by the number of researchers in the industrial sector. Despite a decrease in the number of researchers in the U.K. from 1989 to 1991, there was an upward trend in subsequent years. The number in France has consistently risen. In all of the countries, the number of researchers in the industrial sector accounts for 60% to 80% of each system, and fluctuations in these numbers largely dominate the changes in the number of researchers.

Figure 3-1-3 Trends in number of R&D Scientists and engineering in selected countries



Note: Data are the total of natural science and humanities/social science. Japan R&D scientists and engineers are not FTE. Data for Japan include software industry since 1997. Data for Germany up to 1990 are old federal area and since 1991 as of Germany

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

U.S.-NSF, "National Patterns of R&D Resources 1998".

Germany-BMBF, "Bundesbericht Forschung 1996", "Faktenbericht 1998",

France – OECD, "Main S&T Indicators 1999/2" ("Basic Science and Technology Statistics" up to 1991)

U.K.-OECD, "Main S&T Indicators 1999/2" ("Forward look" up to 1992)

See: appendix table 3-1-3

[2] The definition of "researcher" is described below. The term "researcher" in this book corresponds to the term "R&D scientists and engineers" used in the OECD's Frascati Manual. This definition covers "specialists engaged in new information, products, manufacturing methods, processes, and system planning and creation, together with the management duties attached to these."

For Japan, the items referred to as "full-time researchers" in the Management and Coordination Agency's statistics [5], are referred to as "researchers" in this book. In the Management and Coordination Agency's statistics, "full-time researchers" are defined as "university (excluding junior college) graduates (or those possessing specialized knowledge at the same level or higher) with over 2 years of research experience, and carrying out a specific research theme" within each facility and those mainly carrying out research.

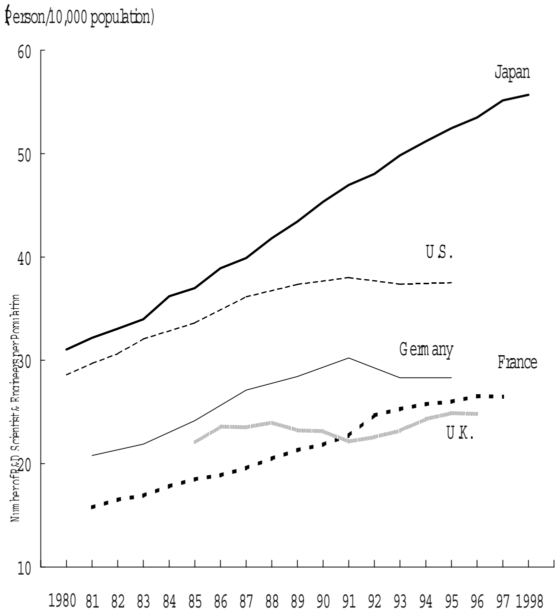
In the Management and Coordination Agency's statistics, "research" is classified as basic research, applied research and development research, with the "full-time researchers" carrying out these activities being roughly equivalent to the OECD's "R&D scientists and engineers."

Moreover, the method used for measuring the number of researchers in Japan differs from the Full Time Equivalent (FTE) method used in most countries, which creates many problems for making comparisons with other countries. Under the Full Time Equivalent method of counting researchers, the details of researchers activities are taken into consideration, excluding time which is assigned to activities outside of research[3]. As a result, there appears to be an overestimation of the number of researchers in the current statistics for Japan relative to other countries. In addition, since the personnel expenditures of researchers is included in R&D expenditures, it would appear that the statistics for Japan are over-reported. Full Time Equivalent estimates, which are based on a variety of results, are shown in several places in this book. However, the data shown here is based on statistics used up until now. This is because it is data that has become widely circulated, and to gain a clear picture of long-term trends, under the current circum-stances this data is more suitable.

Next, we will attempt an international comparison that takes the scale of each country into account according to the number of researchers relative to the population or the working population. Figures 3-1-4 and 3-1-5 show the number of researchers per 10,000 people and per 10,000 workers respectively. In both cases, Japan's values are high compared to the other selected countries. The widening gap becomes particularly noticeable starting in the 1990s, when the numbers for the U.S. and Germany continually declined, while Japan's rose.

[3] For example, if a 60% of a researcher's activities in a one-year period are spent on R&D, he is counted as 0.6 of a researcher (or more accurately, 0.6 per year).

Figure 3-1-4 Trends in number of R&D Scientists and Engineering per population in selected countries



Note: Same as figure 3-1-3

Source: Number of R&D Scientists and Engineer/Same as figure 3-1-3

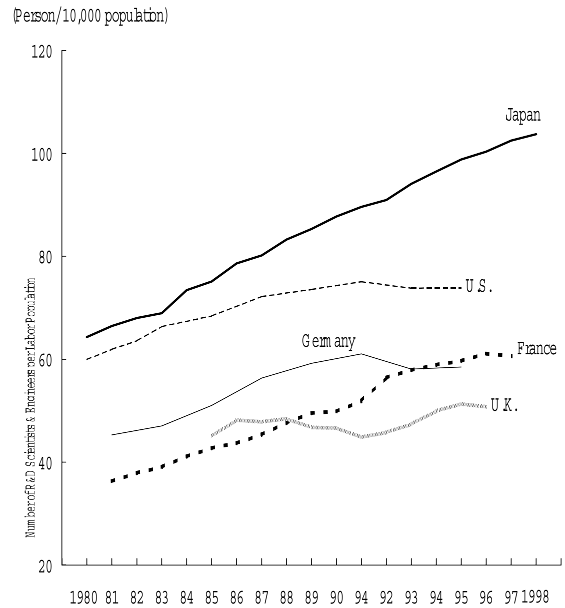
Population/Japan – Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development" "Population Estimates Yearbook Home Page as of October 1, 1998".

U.S. – NSF, "National Patterns of R&D Resources 1998".

Germany, France & U.K. – OECD, "Main S&T Indicators"

See: appendix table 3-1-4

Figure 3-1-5 Trends in number of R&D Scientists and Engineer per labor population in selected countries



Note: Same as Figure 3-1-3

Source: Number of R&D Scientists and Engineer/Same as Figure 3-3-1.

Labor population/Japan – Management and Coordination Agency, Statistics Bureau, "Annual Report on the Labour Force Survey".

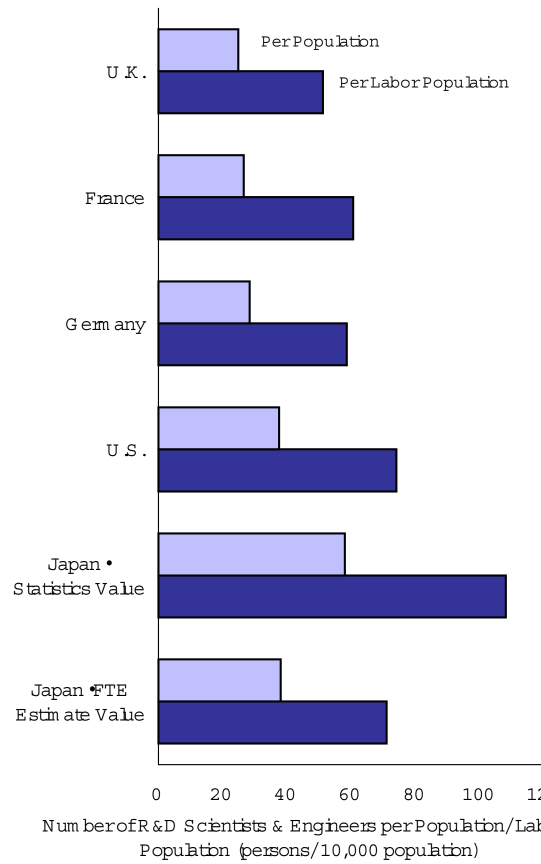
U.S., Germany, France and U.K. - OECD, "Main S&T Indicators

See: appendix table 3-1-5

However, as stated earlier, because the number of researchers in Japan is not based on Full Time Equivalent, these values have been over-estimated in comparison to other countries. Consequently, we have estimated the Full Time Equivalent values for the number of researchers in Japan, which are shown in Figure 3-1-6 along with the other countries. These values are not actual Full Time Equivalent values, but are estimates based on data from various surveys. Also, because the most recent data has been used for all countries, the survey years differ from country to country. However, since the fluctuations over time in these values are not large, it is possible to compare them.

Although there is a significant reduction in the number of researchers per population and per working population from the original estimate for Japan, it still exceeds the levels for Germany, France, the U.K. and so on. For example, in the U.S., only researchers who have obtained doctorates in the U.S. are counted as university researchers, which, conversely to Japan, could be considered to be an under-reporting of the real situation. As a result, although it is possible that the number of researchers per head of population or working population exceeds that of Japan, a suitable method of estimation has not been found in the present circumstances. Since the university sector is particularly important in the estimated Full Time Equivalent (estimated) values for the number of researchers in Japan, this will be discussed in more detail in Chapter 4 (Figures 4-1-3 and 4-1-5).

Figure 3-1-6 Number of R&D Scientists and Engineering by sector in selected countries (per 10,000 population and per 1,000 labor population)



Note: 1) Japan is in 1999, U.K. and France are in 1996, Germany and U.S. are in 1995.
2) FTE estimation value of Japan is based on the following estimation based on the various results of an investigation about activity of a researcher. In the university section, the full time conversion equivalent value of the number of teachers was estimated at 89,000 persons based on the data of the various organs concerned etc. The graduate school doctoral course registered person, the member of the medical staff, etc. multiplied statistics value by one half with reference to the method of many foreign countries. In the industrial section, statistics value was multiplied by 0.7 based on the results of an investigation of the National Institute of Science and Technology Policy.

Source: It is the same as that of figure 3-1-1. However, FTE compensation coefficient is removed.

See: appendix table 3-1-6 and table 4-1-5

The Classifications of Organizations in the R&D Statistics in Selected Countries

The organizations in the R&D statistics of each country are generally classified into four sectors: governmental sector, university sector (or academic sector, which consists of universities and affiliated institutes), industrial sector and private non-profit sector. However, this classification somehow differs between countries due to differences in organizational structures and institutions. Therefore, we will explain the classifications in the R&D statistics in each of selected countries. The charts below show an overview of the classifications of organizations in each country. They are drawn on the basis of the following principles:

1) R&D funding sectors are shown in the upper part of diagrams while R&D performing sector in the lower part.

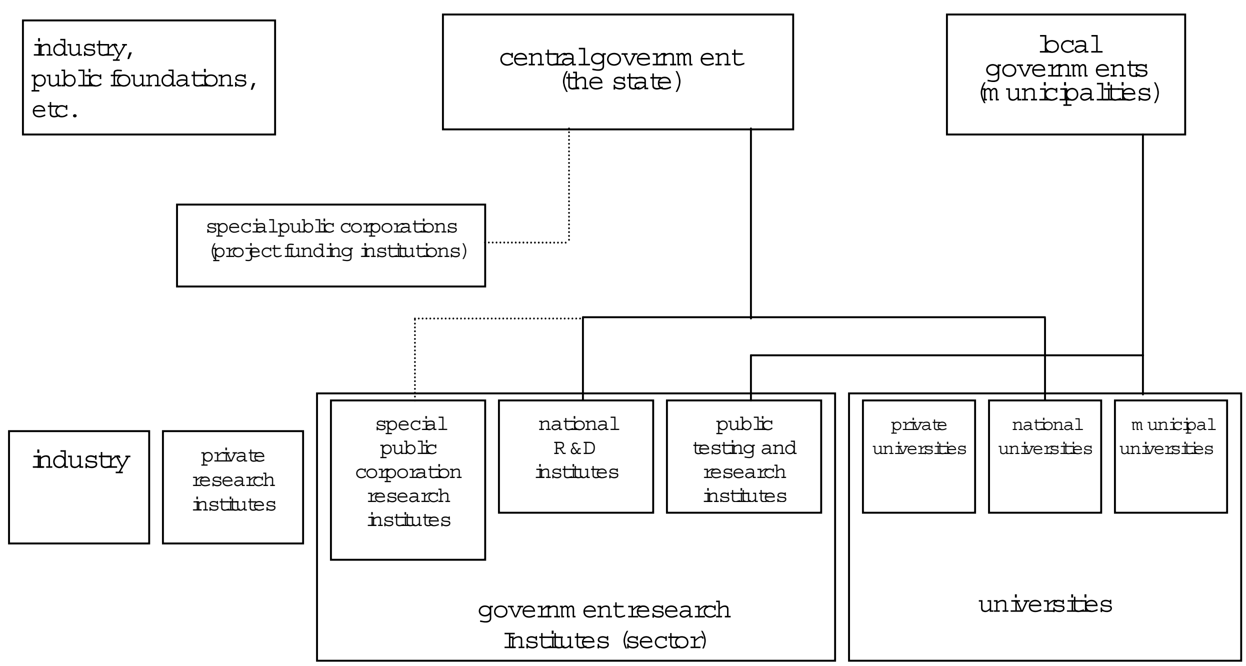
2) The R&D funding sectors which are only responsible for performing R&D inside are omitted. For example, private universities in Japan perform R&D by using both extramural funds and their own funds, and rarely disburse externally. Such a sector is exhibited only as a R&D performing sector.

3) The lines connecting organizations in the upper and lower parts show the relationships between the organizations, with a solid line representing direct control and a broken line representing supervision.

(1) Japan

In Japan, R&D funding institutions often provide funds on the institutional basis to R&D performing institutes which are directly controlled or supervised by them. In the "governmental sector", national universities and national R&D institutes themselves are governmental institutes. Research institutes which have the status of public special corporation are not governmental institutes, are supervised by the government and are provided funds by the government as an institutional basis including the form of capital investment. Municipalities have municipal universities or col-

Main R&D Organizations in Japan



leges and publicly-established testing and research institutes which are provided funds as the institutional basis by the municipal governments.

Ministries and agencies in Japan also distribute extramural R&D funds on the project basis to the organizations which are not directly controlled or supervised, although the amount is not so large. Such funds include the Grants-in-Aid for Scientific Research and the Special Co-ordination Funds for Promoting Science and Technology, which are distributed to R&D performing sectors through ministries, agencies or public special corporations for funding.

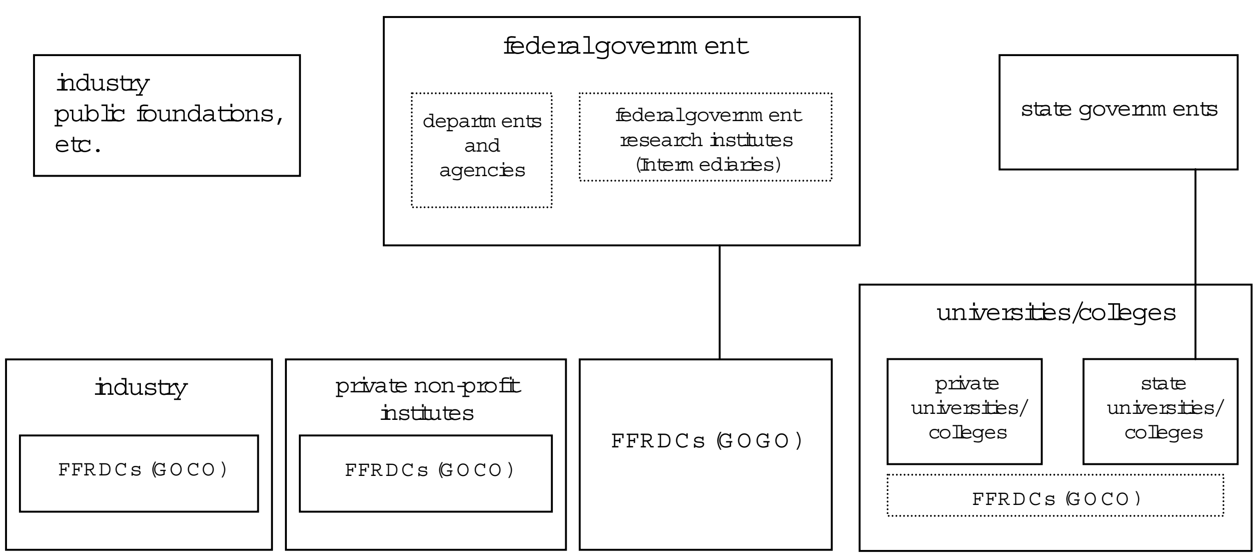
In addition, "private research institutes" mingle non-profit research institutes, such as public interest corporations, and organization established by private companies. Therefore, it is required to be careful that "private research institutes" in Japan do not mean private non-profit institutes. This differs from many other countries.

(2) The United States

In the U.S., the federal government owns not only directly-controlled research institutes, so-called government-owned government-operated institutes (GOGO), but also institutes operations of which are committed to private sector, so-called government-owned contractor-operated institutes (GOCO). The major example of the former type is the National Institutes of Health (NIH), which is well known as large-scale institutions. The latter are also called as Federally Funded R&D Centers (FFRDCs), which are provided R&D funds as the institutional basis by the federal government and are commissioned the administrations to universities, private companies and private non-profit instates based on contracts. In this report, FFRDCs are classified according to the types of organizations on the operation sides. For example, a FFRDC commissioned to a university is classified into university sector.

The federal government also provides R&D performing organizations through other mechanisms. Institutions such as the National Science Foundation (NSF) and NIH distribute R&D funds as a project basis. Departments and agencies also commission R&D to university, industry and private research organization.

Main R&D Organizations in the United States



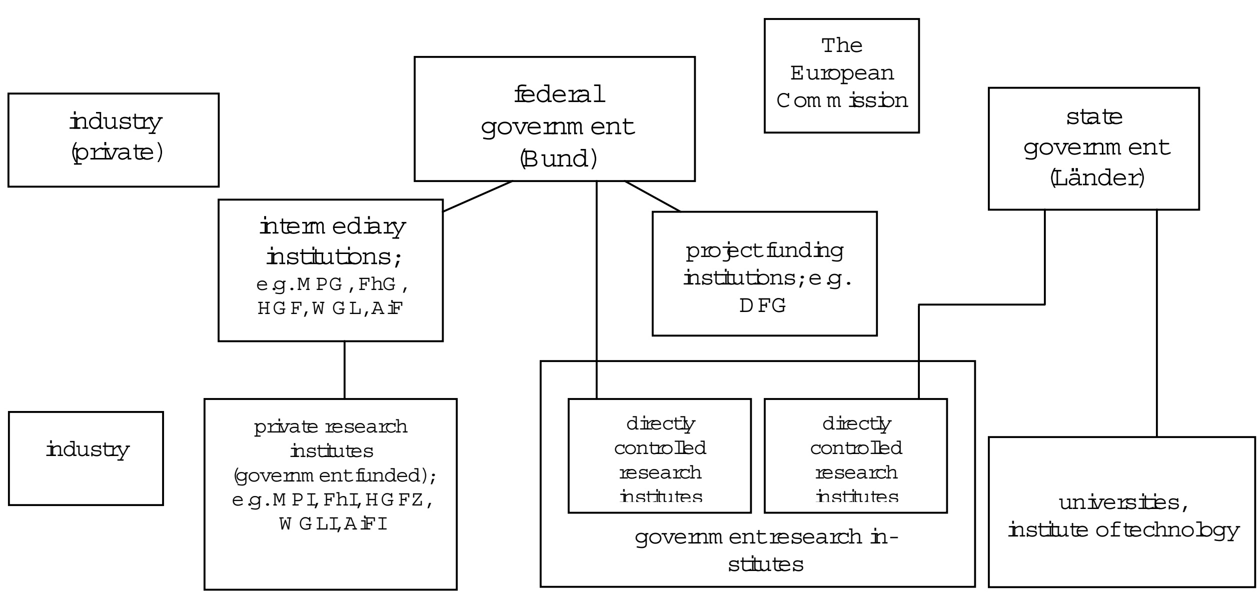
(3) Germany

The German R&D system has a characteristic of a dual structure of federal (Bund) and state (Land). Most of universities are established by states. Another characteristic is that major government-funded R&D performing institutes are private. They are funded by both of the federal government and the state governments as the institutional basis. The funds of the federal government are firstly disbursed to "intermediaries", such as the headquarters of the Max-Planck Society (MPG: Max-Planck-Gesellschaft) and the Fraunhofer Society (FhG: Frauhofer-Gesellschaft).
Then, the funds are distributed into the subordinate research organizations, such as the Max-Planck Institutes (MPI) and the Franhofer Institutes (FhI). These private research institutes strongly have the public characteristics. In this chapter, therefore, these research institutes and research institutes directly controlled by the federal government and the state governments are classified into "governmental and private research institutes". The research institutes directly controlled by the governments are not large. As for funding institutions on the project basis, DFG (Deutsche Forschungsgemeinschaft) funds to universities. Institutions called as project agencies (Projektträger) distribute project-basis funds of the federal government.

(4) France

In France, major government-funded R&D performing institutes are higher education establishments and research public establishments, which have the legal personality and the financial autonomy. The higher education establishments include university and technical institutes (grandes écoles). The research public establishments consist of mainly government-funded establishments conducting S&T activities (EPST: établissement public à caractère scientifique et technologique), establishments required to seek funds from private sector (EPIC: établissement public à caractère industriel et commercial) and establishments conducting administrative missions by government funds partly including S&T activities (EPA: établissement public à caractère administratif). The research public establishments are classified into "governmental research institutes" in the statistics, although EPIC falls under private law.

Main R&D Organizations in Germany

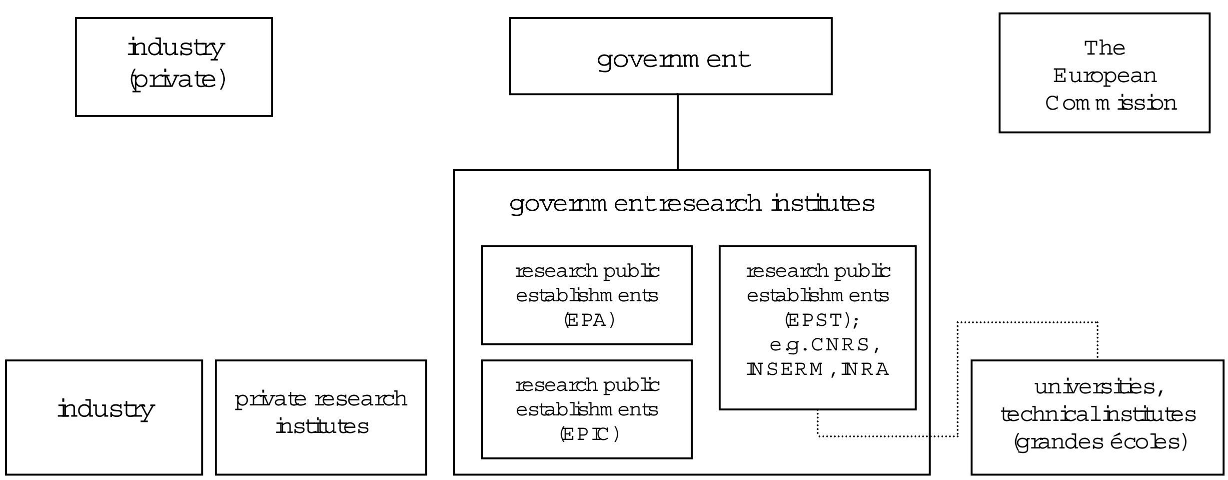


Some of these institutes not only perform intramural R&D but also are able to commission research to higher education establishments. In addition, some research units of the research public establishments of EPST, such as CNRS (Centre National de la Recherche Scientifique) and INSERM (Institut National de la Santé et de la Recherche Médicale), are established in the facilities of universities and university hospitals to provide research functions.

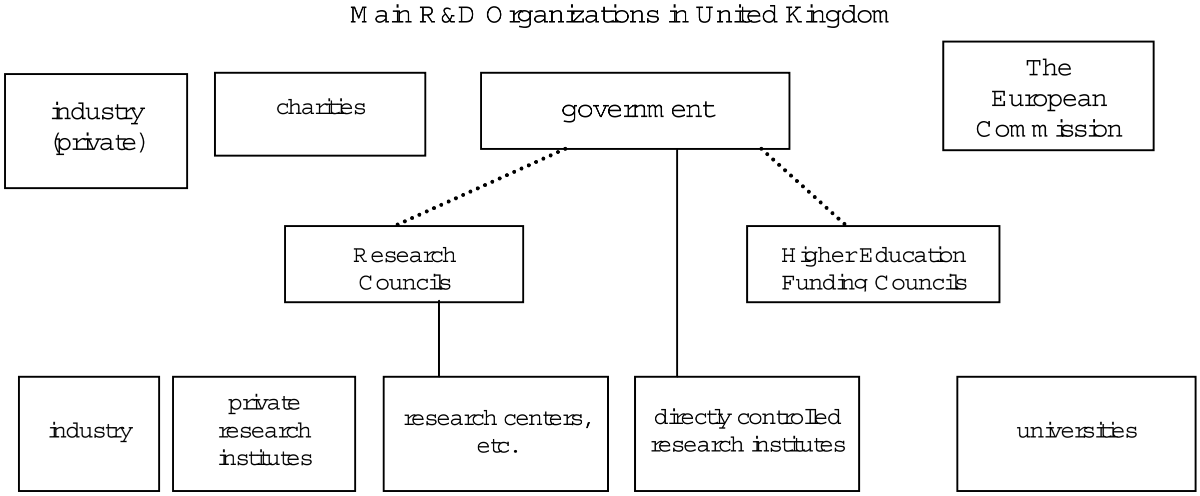
(5) The United Kingdom

The U.K. R&D system has the characteristic that the government entrusts many authorities to the subordinate institutions. The governmental departments and agencies are responsible for R&D with specific missions and have directly controlled research institutes. Research Councils are entrusted by the government for R&D without specific missions and then distributes funds to R&D performing sector. There are six Research Councils, which have the function of funding and are established by research field and some of which have subordinate research institutes and centers. The research funds for universities are also distributed through Higher Education Funding Councils (HEFCs). Each HEFC (and their equivalent in Northern Ireland) is established in England, Wales, Scotland and Northern Ireland.

Main R&D Organizations in France



Main R&D Organizations in United Kingdom



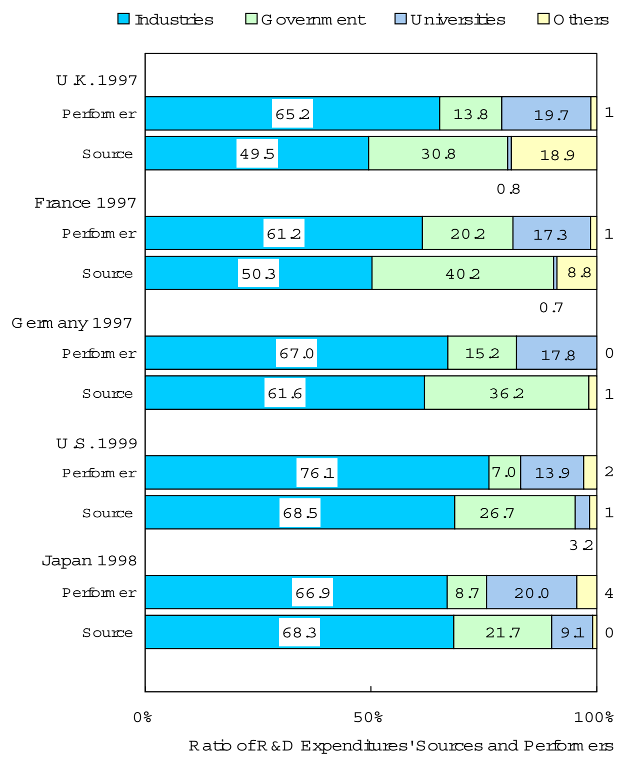
3.1.2 R&D in the Industrial, Academic and Government Sectors

Although the R&D system of an entire country is made up of various activities, the most general classifications are based on the public sector and the private sector. From there, the sectors can be further divided into four sectors: the university sector (or the academic sector with facilities connected to universities), the industrial sector and the non-profit, private sector, which are part of the private sector. (Refer to "The Classification of Organizations within the R&D Statistics of the Major Countries"). This book makes comparisons on the conditions in each country based on this division of sectors. The R&D conditions of each sector and the international comparisons of those conditions are dealt with in separate chapters or sections. Here, we pay attention to the source of distribution of R&D funding to each sector, and make a comparison between the R&D systems of each country.

For the breakdown of R&D expenditures by sector, there is an important indicator which shows the characteristics of the R&D system of an entire country. With this indicator, it is necessary to consider not only the R&D expenditures associated with the sectors using the funds, but also the sectors responsible for providing the funds. Figure 3-1-7 shows the R&D expenditures broken down into the source and usage ratios by sector. With regard to the source of R&D expenditures, there are many cases which include a foreign source in addition to the four sectors mentioned above. This source has been included in "Other" here. However, for the U.S. statistics, there is no distinction for foreign sources.

In every country, the industrial sector accounts for the largest portion of both the source and use of research funds. The current data clearly shows that industry is the greatest driving force behind technology. This is clearly shown by examining the R&D expenditures from the usage side (i.e. the sector implementing R&D) given that the usage ratio for the industrial sector exceeds 60% in each country.

Figure 3-1-7 Ratio of R&D expenditures by sources and performers in selected countries



Note: Refer to boxed items "The Classification of Organizations in the R&D Statistics of selected countries"
Source: Japan, U.S. and Germany – Same as Figure 3-1-1,
France – "Basic Science and Technology Statistics 1999",
U.K. – "White Paper on Science and Technology"
See: appendix table 3-1-7

In comparison, there are apparent differences between the countries with regard to the industrial sector's position as the provider of R&D funds. While there is not a big difference between the provision and usage of funds by the industrial sector in the U.S. and Japan, there is a big difference in France and the U.K. The reason for this is that industry in France and the U.K. receive a large amount of R&D funds from the government and from abroad. This point is expressed in greater detail in Figure 3-1-8. Japan's industrial sector is the only one among the 5 countries which provides a larger percentage of funds (68.3%) than it uses (66.9%).

There are significant differences between countries in the ratio of funds provided and used by governments. The ratio of funds provided by the Japanese government is the smallest among the five countries, while it uses the second to least funds, after the U.S. These ratios are a source of debate with regards to R&D expenditures by the government, especially in Japan, where it is frequently the point at issue for policy formation.

The ratio of funds used by Japanese universities is the highest among the five countries. This is partly because of the overestimation which occurs due to the Full Time Equivalent problem mentioned above. Although the data for appropriately implementing the estimation of Full Time Equivalent for R&D expenditures is inadequate, based on the estimated Full Time Equivalent values used in Figure 3-1-6, the percentage of funds used by Japanese universities is 16.3% [4]. Since the estimated values are probably lower than the actual values, the percentage of funds used by Japanese universities is not insignificant from an international perspective. Nonetheless, a conclusion cannot be easily drawn, and more complete methods for statistics and comparisons are desirable.

Another characteristic of Japanese universities is that they provide 9.1% of R&D funds — the highest among the five countries. Even in the U.S., which ranks second behind Japan, this ratio does not exceed 3.2%. The majority of the funds provided by Japanese universities come from private universities.

Following is a comparison of the flow of R&D expenditures for each sector, in each of the five countries, as an indicator of the relationships between the sectors. These relationships appear in Figure 3-1-8, and show the flow of funds from the sectors providing the funds to the sectors using them, depicting the R&D system of each country in more detail.

In Japan, the meager flow between the different sectors is an overall feature of the system. This is especially true for the flow of funds from the government, most of which are concentrated in government facilities and universities. The percentage of expenditures flowing to the industrial sector is small compared to the other countries. In addition, the majority of funds from the government to the universities go to government facilities in the natio-nal universities, with few expenditures going to the other sectors. In comparison to its function in providing funds to other sectors, the Japanese government plays a stronger role in carrying out R&D functions. From this perspective, the government's position within the R&D system has a slightly different character than that in other countries.

The enormous flow of funds within the Japanese industrial sector can be seen from the graph. This is the most common feature of all the countries: within the flow of research funds between each of the sectors, the flow from industry to industry is the largest. In the case of Japanese industry, the R&D funds received by industry from other sectors is the smallest among the five countries. On the other hand, the flow of R&D expenditures from industry to other sectors is relatively large. Further, the R&D funds flowing from the industrial sector to privately operated research facilities is comparatively large. However, when making this comparison between countries, it is important to be aware of differences in classification. In other countries, these facilities are classified as non-profit facilities, as opposed to being "privately operated research facilities" in Japan.

[4] From the beginning, the personnel expenses for each type of R&D occupation (researchers, assistant researchers, etc.) should be calculated by taking advantage of the individual R&D employment rates. However, since the breakdown of personnel expenditures or the employment rates of those engaged in R&D (other than researchers) are not clear, we have based the employment rates of researchers (the values used for the estimates in Figure 3-1-6) on the personnel expenditures for all those engaged in research.

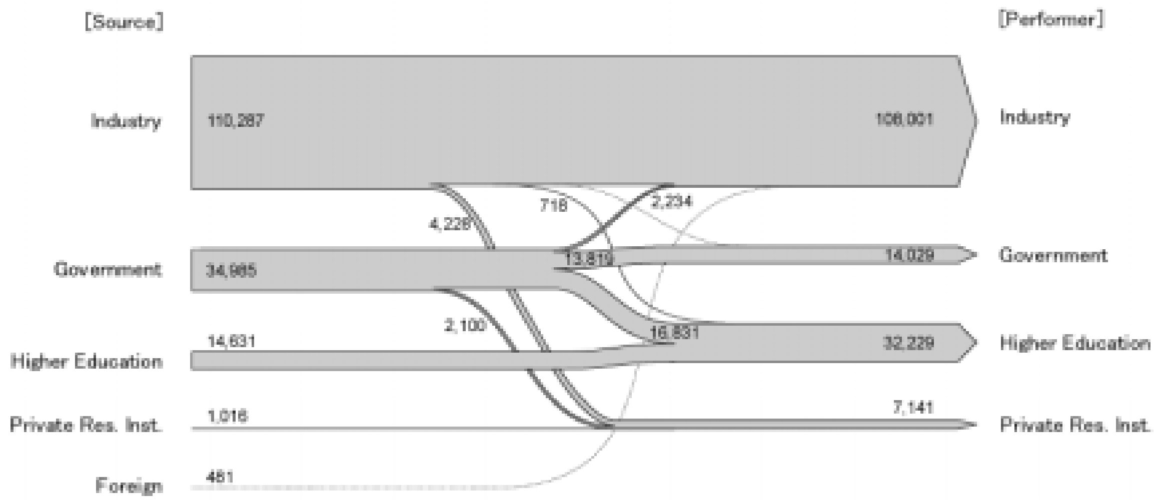
Next, we describe the characteristics of the other countries. In the U.S., the flow of R&D expenditures from the government to the industrial sector is large, and accounts for a large percentage of government expenditures and of funds received by the industrial sector.

In Germany, there is a sizeable flow from the government to universities. Moreover, the government sector and non-profit private sector in Germany are grouped together, with the flows within this sector accounting for a comparatively large percentage of the total. The majority of non-profit, privately operated research facilities in Germany are mainly funded by government, and play the same role as the government research facilities in other countries.

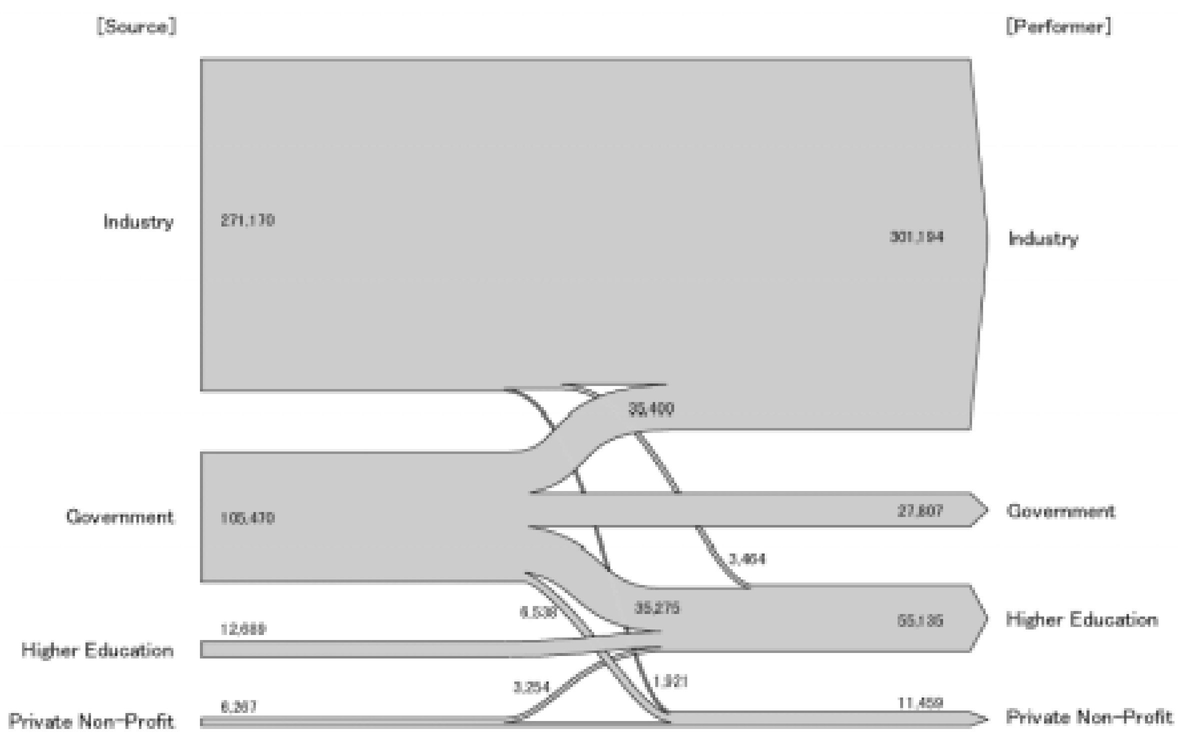
In France, R&D expenditures by the government account for a relatively large percentage of the expenditures used by research facilities in each sector. Of particular note is the flow from the government to the government, which exceeds the amount flowing to universities. In the U.K., the government provides roughly the same amount of funds to universities and government research facilities. Moreover, flows to the industrial sector are relatively large. A large amount of funding is also received from abroad.

Figure 3-1-8 R&D expenditures Flow in selected country

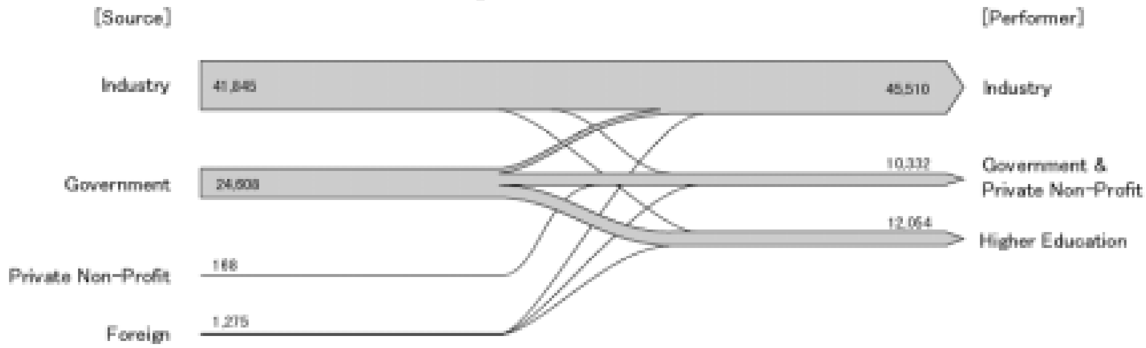
(A) Japan (1998) [100 million Yen]



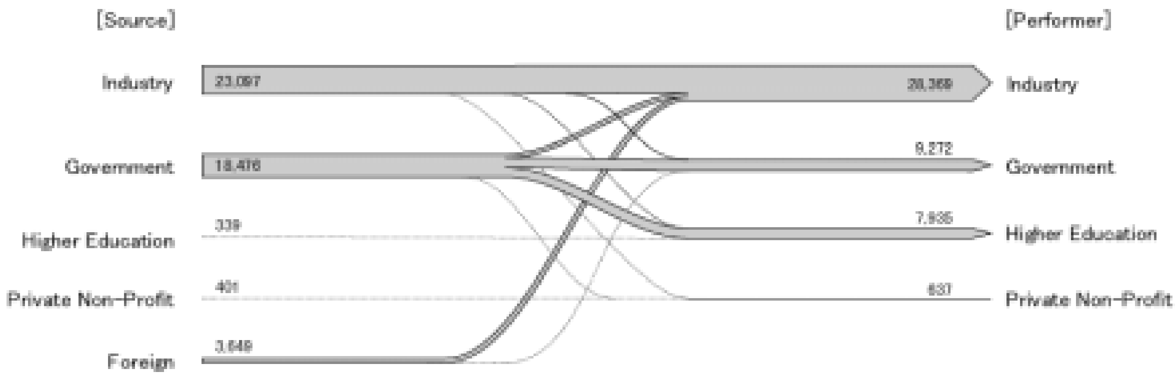
(B) U.S. (1999) [100 million Yen]



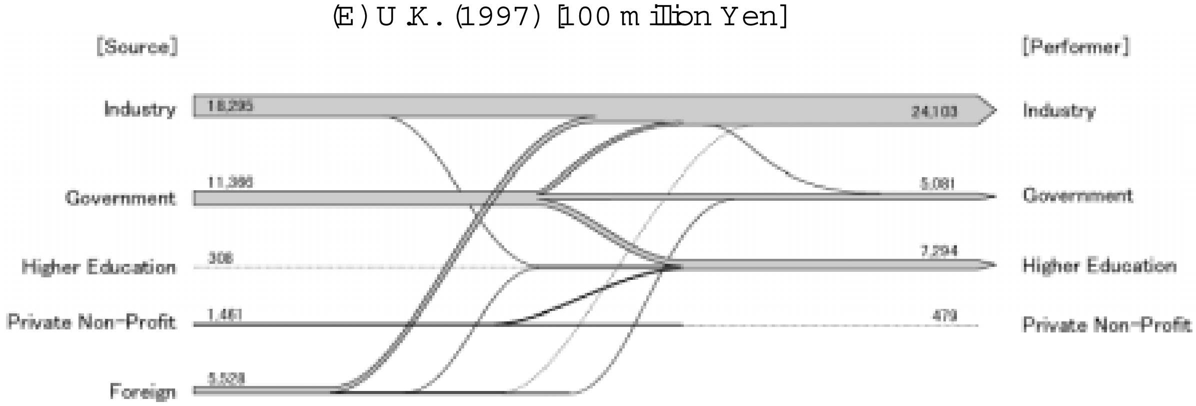
(C) Germany (1997) [100 million Yen]



(D) France (1997) [100 million Yen]



(E) U.K. (1997) [100 million Yen]



Note: 1) Research and development costs other than Japan were converted into Japanese currency (Yen) using the purchasing power parity of OECD. It omitted about the less than 10 billion en flow by a diagram, and the dotted line showed the less than 50 billion yen flow of 10 billion yen or more.

2) About the organization classification of each country, it is referring to the boxed item "an organization classification in research-and-development statistics of a major power".

Source: same as figure 3-1-7

See: appendix table 3-1-8

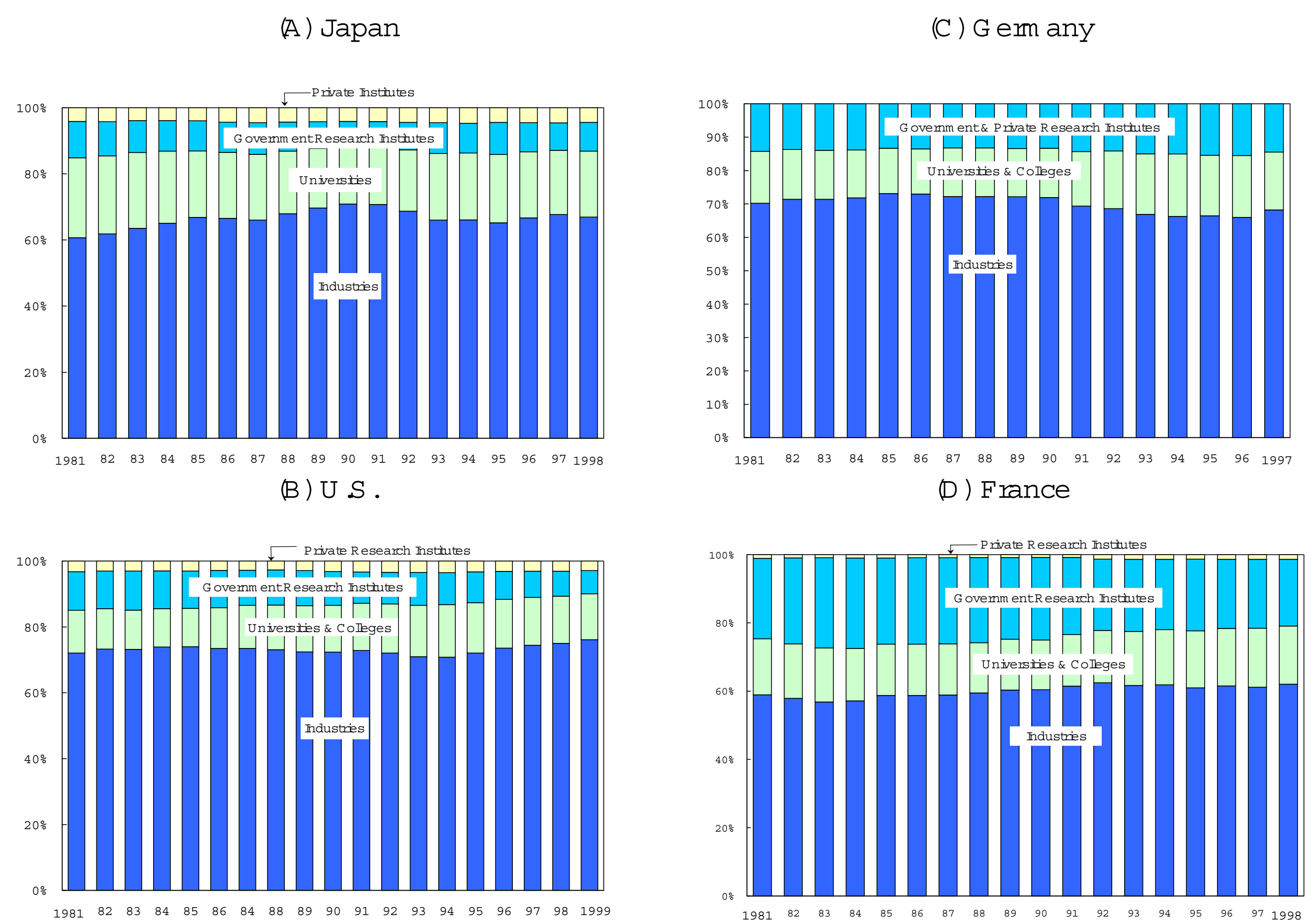
The R&D expenditures by sector show more changes over time. Here, we examine the changes in the position of each sector by country, according to changes in the percentages of R&D expenditures for each sector. Changes in the percentages of funds provided by each sector will be left to a later analysis of the governments (in Section 3.2) and universities (in Chapter 4).

If we look at the breakdown of R&D expenditures by sector in Japan (Figure 3-1-9), the ratio for the industrial sector increased during the 1980s. Conversely, there was a downward trend in the ratio for university and government research facilities. In contrast to the ratio for industry falling from 1992, and leveling off after that, there was a slight upward trend of the ratio for university and government research facilities in the 1990s.

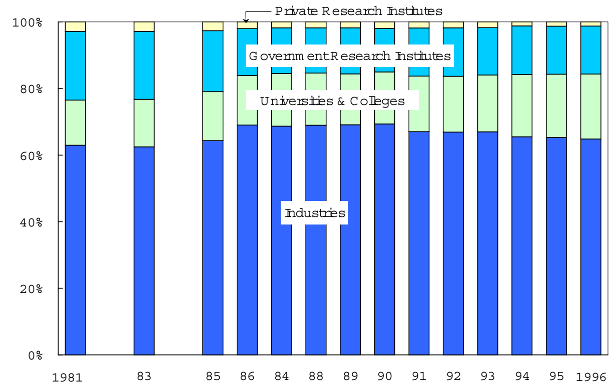
In the U.S., there is an obvious long-term reduction in the ratio for the government research facilities. On the contrary, the ratio for universities shows an upward trend over the long term, showing a growing influence in the R&D sector. Further, despite a large increase in the actual amount of R&D expenditures by the industrial sector, (see Figure 5-1-1 in chapter 5), there was not a particularly large change in the usage ratio.

In Germany, France and the U.K., the changes are relatively small compared to Japan and the U.S. The ratio for universities in all three countries rose slightly. In Germany and the U.K., the ratio for industry decreased in the 1990s compared to the 1980s. On the other hand, the ratio for industry rose in France, while the ratio for government research facilities showed a downward trend.

Figure 3-1-9 Trends in R&D expenditures and ratio by performing sector in selected countries



(E) U.K.



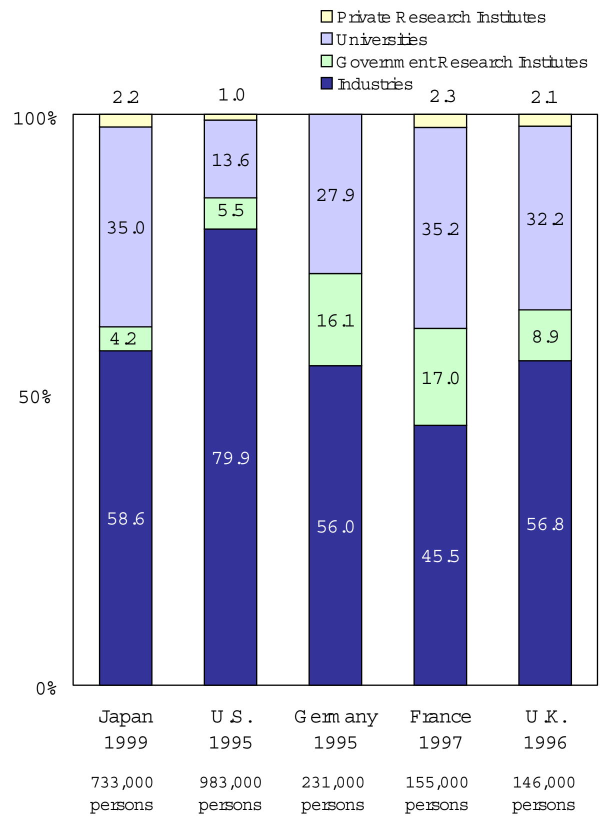
Note: Data are the total natural science and humanities/social science. Data for Japan include software industry since FY1996.
The numerical value in 1998 of France is assumption value.
Germany is contained in the federal government.
Source: Japan, U.S. – same as Figure 3-1-1
Germany – "Faktenbericht 1998"
France, U.K. – "Main S&T Indicators 1999/2, "Basic Science and Technology Statistics 1998"
See: appendix table 3-1-9

If we look at the percentage of researchers by sector for the selected countries, we can see that the industrial sector has the highest percentage in every country, just as it does for R&D expenditures. This is followed by universities and then government research facilities (Figure 3-1-10). However, there are differences between countries in the statistics for the number of researchers by sector. The accuracy of the ratios shown here is difficult to guarantee, and should only be used for as a guide.

The ratio for Japanese universities is relatively high, while that of the government research facilities is the lowest of the five countries. Because the Full Time Equivalent values are not used in Japan, we have calculated the various ratios based on estimated Full Time Equivalent values. This gives a ratio of 28% for universities, which is lower than France and the U.K., but about the same as Germany (see Table 3-1-6).

The ratio for the American industrial sector is the highest of the five countries, while the ratio for universities is the lowest. However, as mentioned earlier, in the U.S. case it is believed that the number of university researchers is underestimated, in contrast to Japan. Therefore, it can be assumed that the actual ratio is greater than the ratio shown here.

Figure 3-1-10 Number of R&D scientists and engineers by sector in selected countries



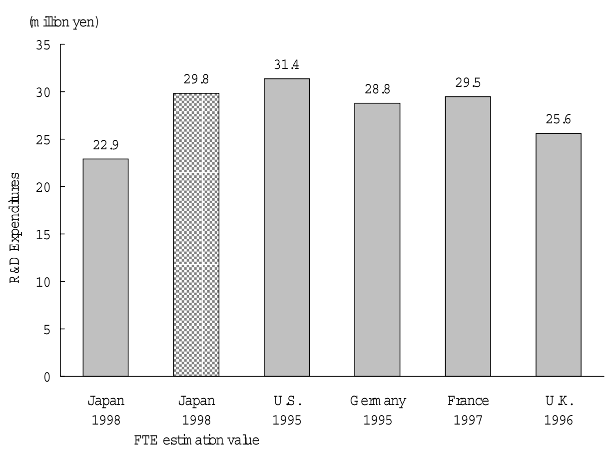
Note: Japan R&D scientists and engineer are not FTE.
Source: Japan, U.S. & Germany – same as figure 3-1-1
France – OECD, "Main S&T Indicate 1999/2"
U.K. – OCED, "Basic Science and Technology Statistics 1998"
See: appendix table 3-1-10

3.2 Features and Issues of R&D in Japan

3.2.1 R&D Expenditures per Researcher

In the previous section, researchers and R&D expenditures were treated independently. Nonetheless, it is important to analyze the balance between the two. We will therefore examine the R&D expenditures per researcher. Although there are large differences in these values due to the characteristics of the R&D fields and facilities, we will compare the values for entire countries. If we make a comparison between the five countries using the latest statistics, we find that the R&D expenditures per researcher in Japan are 22.91 million yen — the lowest of the five countries (Figure 3-2-1).

Figure 3-2-1 Trends in R&D expenditures per R&D scientist/Engineer in selected countries

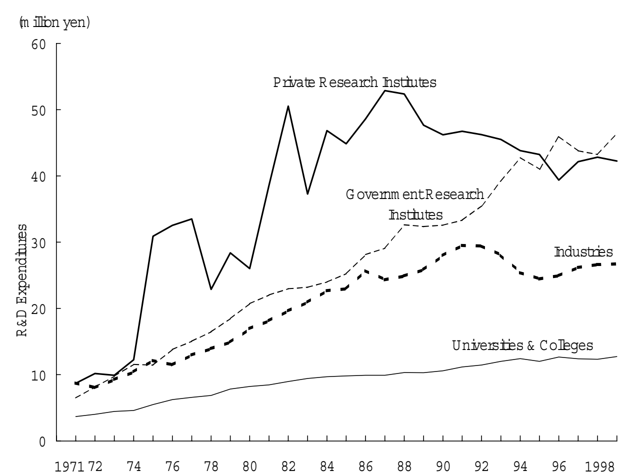


Note: same as figure 3-1-1, 3-1-3
Source: same as figure 3-1-1, 3-1-3
See: appendix table 3-2-1

The estimated Full Time Equivalent value (29.84 million yen/researcher) is taken into consideration and shown in the chart. When this value is compared to the other countries, it is roughly equal to Germany and France. However, due to the unsatisfactory nature of the data necessary to estimate this value, its accuracy cannot be guaranteed. Nevertheless, it is clear that the amount exceeds the amount before the estimation. At any rate, there were no significant differences discovered for expenditures per researcher between the five countries.

The change over time by sector for the R&D expenditures per researcher in Japan shows that amounts for universities are small compared to the other sectors. Nevertheless, a moderate long-term increase is evident. The growth in the amounts for the industrial sector stagnated from the late 1980s, while there was conspicuous growth for government research facilities starting in 1990. Moreover, among the government research facilities, the amounts for semi-governmental corporations carrying out large-scale R&D were notably large. The actual breakdowns appear in Section 3.5 (Figure 3-5-5).

Figure 3-2-2 Trends in R&D expenditures per R&D scientist/engineer in Japan



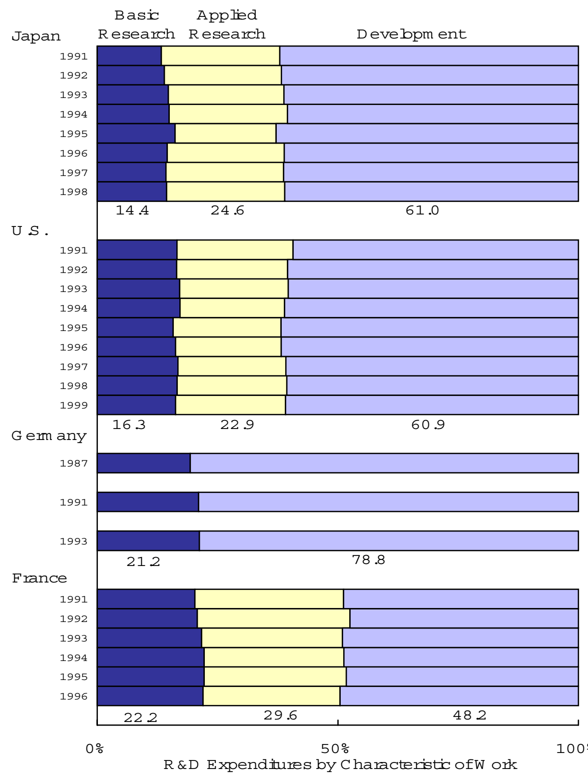
Note: R&D expenditures include natural science and humanities/social science. R&D expenditures include software industry since FY1996. R&D scientist and engineer not used FTE. R&D scientist and engineer include software industry since 1997.
Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development".
See: appendix table 3-2-2

3.2.2 Breakdown of R&D Expenditures and Basic Research Expenditures by Type

As we saw earlier, one of the features of R&D activities in Japan is the especially large ratio the industrial sector accounts for, in contrast to the ratio for the government sector, which is small in comparison to the other major industrialized countries. Under these circumstances, the adequacy of distributions to basic research expenditures, applied research and development are topics of frequent debate. This is because in general, basic research expenditures are high for universities and low for the industrial sector.

Figure 3-2-3 shows a comparison of data for basic research expenditures between the four countries, excluding the U.K., for which this data is unavailable. The ratio of basic research expenditures for Japan and the U.S. are low relative to Germany and France. The ratio for Japan is consistently the lowest among the four countries, except in 1995, when it exceeded that of the U.S. The small ratio for basic research expenditures for Japan and the U.S. is influenced by the large ratio of research expenditures accounted for by the industrial sectors of both countries.

Figure 3-2-3 Trends in R&D expenditures in selected countries by characteristic of work



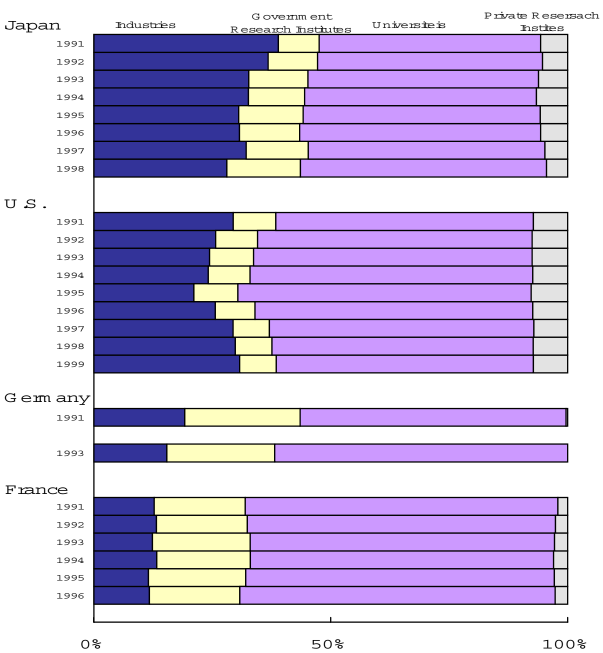
Note: Data for Japan include software industry since FY1996.
R&D expenditures for Japan is only natural science. However, It is include another sector using amount.
R&D expenditures for other countries are the total of natural science and humanities science. However, R&D expenditures in 1981 for Germany is natural science only. There is no difference between applied research and development research in Germany. The 1998,1999 value of U.S. is reserve value.

Source: Japan, U.S. – same as figure 3-1-1
Other countries – OECD, "Basic S&T Statistics1999"

See: appendix table 3-2-3

Next, we compare which sectors are responsible for basic research in each country. If we look at the changes in the ratios of basic research expenditures by the sectors using them in Figure 3-2-4, we see that the ratio for Japan's industrial sector is comparatively high. However, there was a continuous downward trend in the 1990s, particularly in 1992 and 1998, when there were significant drops. This coincided with a period of cuts in the total amount of R&D expenditures by the majority of companies. At the same time, there was an upward trend in the ratio for government research facilities.

Figure 3-2-4 Trends in basic research expenditures by sector in selected countries



Note: R&D expenditures is sum total of natural science and humanities science. The 1998, 1999 values of U.S. is reserve value. And "government research Institute" include "local government (Japan)" and "state government (U.S.)". Data for Japan include software industry since FY1996.

The Federally-Funded Research and Development Centers (FFRDCs) of each sector is included "Industry", "University" and "private management research organization" in U.S..

A private management research organization is included in a German government research organization.

Source: same as figure 3-2-3

See: appendix table 3-2-4

In the U.S., there is a slightly declining trend for both government research facilities and privately operated research facilities. However, large changes can be seen mainly in the industrial sector and universities. In the early 1990s, the ratio for the industrial sector fell similarly to that of Japan, but unlike Japan, it started rising again in the mid-1990s.

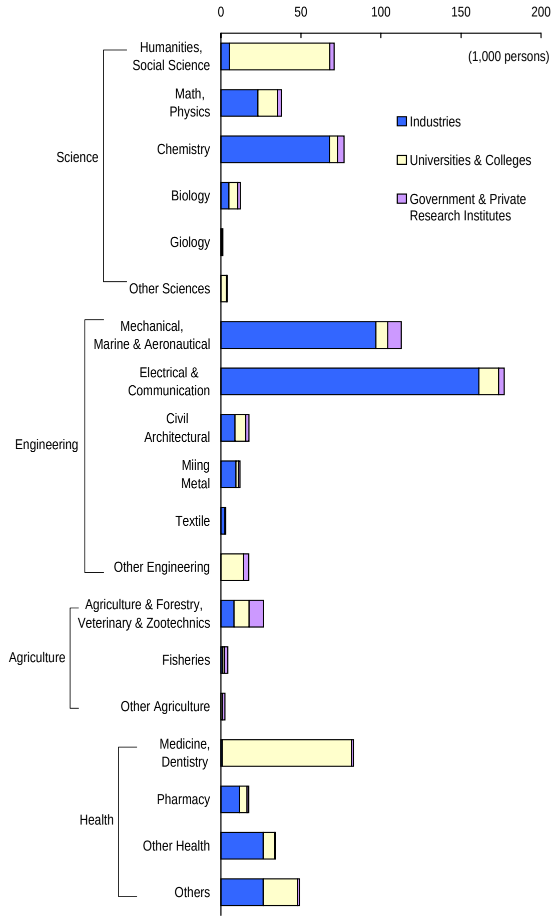
Compared to Japan and the U.S., Germany's industrial sector ratio is small. France's industrial ratio is even smaller, while the ratio for universities is relatively large.

3.2.3 Number of Researchers by Specialty

As the basis of science and technology strategy planning, the question of the distribution of R&D funds and personnel among fields in Japan is extremely important. The preparation of statistics for the breakdown of R&D by field is difficult since the appropriate data does not presently exist. Nonetheless, we present the number of researchers by specialty in Figure 3-2-5 as reference data. The specialties used as classifications here are based on the specialized knowledge possessed by researchers. Consequently, this indicator shows the results of the past promotion of human resources rather than the R&D fields at the time of the survey.

Among the specialties, the largest field is "Electronics and Communications," followed by "Machinery, Shipping and Aviation." Within these engineering-related and physics-related fields, as well as the largest field – "Chemistry" – the largest proportion of the researchers belong to the industrial sector. On the other hand, in the third largest category – "Medical and Dentistry" – most belong to universities and other higher education institutions, along with those in the "Humanities and Social Sciences" field.

Figure 3-2-5 Number of R&D scientists engineers by specialty and by sector in Japan (1999)

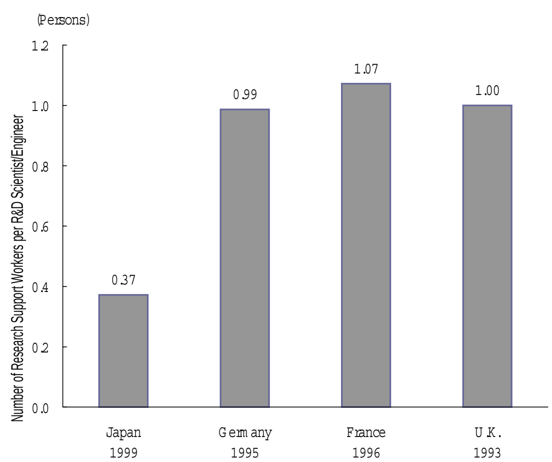


Source: The Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 3-2-5

3.2.4 Research Assistants and Post Doctorates

Despite the vital role assistant researchers play in R&D, there is a tendency for them to be thought of as being on the periphery of R&D, perhaps because of the terminology. Nonetheless, with the growing complexity and scale of present-day R&D, researchers and research assistants are both essential, and the terms should be thought of only as a categorization of work duties. When attempting to gain a clear picture of R&D activities by means of statistics, it is inappropriate to use researchers only; research assistants should also be included. As with the definition of a researcher, the definition for a research assistant varies from country to country. In Japan, the definition includes "research assistant," "technician," and "other personnel involved in research work."

Figure 3-2-6 Number of Research Support workers per R&D scientist/engineer in selected countries

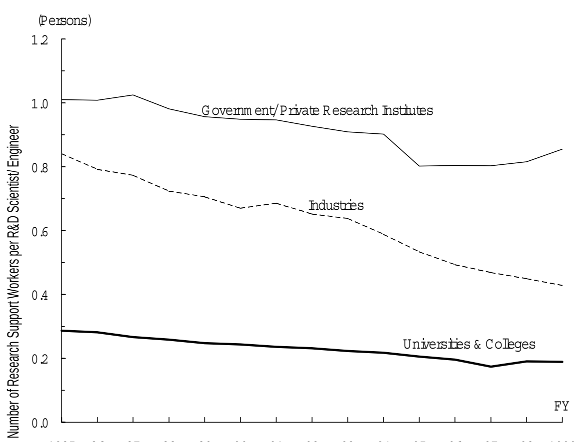


Source: Japan, U.S. and Germany - same as figure 3-1-1
France, U.K. - OCED, "Basic S&T Statistics 1999"
See: appendix table 3-2-6

Although there are statistics for the number of personnel engaged in research, which includes research assistants available in each country, there are differences in definitions and survey methods. Here, we compare the ratio of the number of research assistants to the number of researchers. In other words, the number of research assistants per researcher. In Japan, the number of research assistants per researcher was 0.37 in 1999, which is small in comparison to the selected countries in Europe. (See Figure 3-2-6).

If we look at the number of research assistants per researcher by sector in Japan, we see that in 1999, the number was 0.86 in research facilities and 0.43 in the industrial sector, compared to an extremely low 0.19 in the universities (Figure 3-2-7). Moreover, these numbers have continued to fall in the industrial and university sectors, which is an extremely serious problem in light of the importance of research assistants mentioned above. Despite a slight increase within research facilities from 1995, the values are small when compared to those previous to 1994.

Figure 3-2-7 Trends in number of research support workers per R&D scientists/engineer in Japan

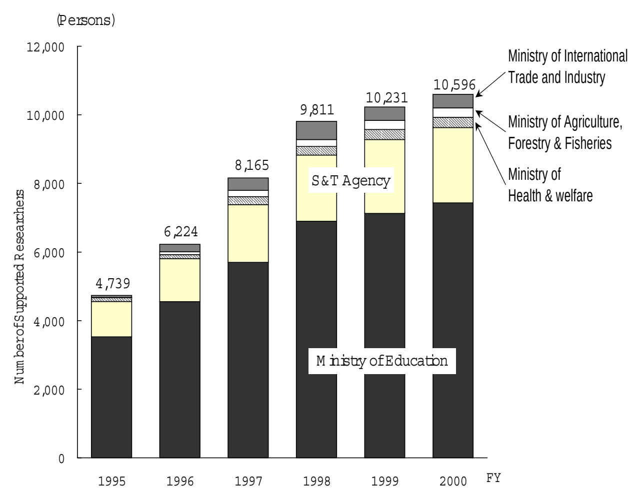


Source : The Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 3-2-7

Next, we touch on the post-doctorate situation in Japan. In an effort to train and expand the tier of young researchers in Japan there has been a promotion of The Support Program for 10,000 Post Doctorates since 1995. By FY2000, this program endeavors to have approximately 10,000 post doctorates engaged in creative research activities in national laboratories and universities, and so on, and to expand a variety of assistance systems through each of the ministries and agencies.

As a result, in FY2000, steps were taken for the budgetary support of 10,596 people at the post-doctorate level (Figure 3-2-8). In comparison to the 4,739 people in FY1995, this is a substantial increase of 220% over a five-year period.

Figure 3-2-8 Trends in number of researchers supported by plan for 10 thousand post-doctoral researchers



Note: Each fiscal year shows the budget measure number, and a part for a supplementary budget is included (the supplementary budget in the 2000 fiscal year is undecided).
Source: The Science and Technology Agency data
See: appendix table 3-2-8

3.3 Government Supported R&D

Although the government is not the main constituent of the most significant activities within a country's system of science and technology activities, it is at the core of functions relating to funding provisions for other sectors and regulations between sectors. In this section, we analyze the situation surrounding government supported R&D from the perspective of funding.

There are two methods for examining R&D funding by governments. One method is to examine the R&D expenditures used by each performing sector and to total the portion provided by the government. The other method is to look at the R&D related expenditures within the government's annual expenditures.

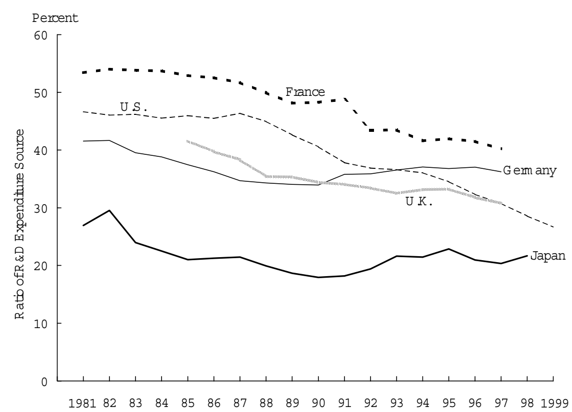
The former method of the two (i.e. measuring at the performing sectors) is the main method used in compiling R&D statistics, and is not limited to government funding. Even if R&D expenditures go through a complex flow, it is possible to get a clear picture of the total amount of R&D expenditures for an entire country for survey purposes. However, because it is not always possible to accurately determine the source of funds, the latter method (i.e. measuring at the funding sectors) is also necessary. Nonetheless, it is difficult to gain a clear picture of R&D expenditures using this method because of disparities between actual R&D expenditures. In Section 3.3.1, we start by using the data measured at the performing sectors, showing the R&D expenditures absorbed by the government. This is followed by an analysis of science and technology related outlays from within a government's annual expenditures in Section 3.3.2.

3.3.1 R&D Expenditures Supported by the Government

Examining the changes in the proportions of the total R&D expenditures supported by the governments of the major nations in Figure 3-3-1, the graphs show a basic downward trend after 1981 for all of the countries except Japan, which suggests a change in the role of the governments. The decline in the U.S. is particularly large, where the government support ratio of 46.6% in 1981 fell to 26.7% in 1999. After German unification, there was a slight upward trend there until 1997, when the ratio fell.

Of the five countries, Japan consistently has the lowest ratio, with a government support ratio of 21.7% in 1998. Although there were no significant changes in the ratio for Japan in the long term, the ratio for government support was slightly higher in the 1990s in comparison to the late 1980s.

Figure 3-3-1 Trends in Ratio of R&D expenditures sources by government in selected countries



Note: The government is a country, municipal corporation, government management, public management and the research organization of a special public corporation, national, and a public university (a junior college etc. is included). A research and development cost is the sum total of natural science and humanities, social science (each country).
Japan-Software business will also be included from the 1996 fiscal year.
U.S.-Research and development cost is reserve value. The government is the federal government and a federal government research organization.
Germany-It is an old federal area till 1990 and it is Germany in 1991 and afterwards.
France - The government is a public research organization
U.K.-The government is a center and the local government.
Source: Japan, U.S. and Germany - same as figure 3-1-1
France - OECD, "Basic S&T Statistics 1999"
U.K. - DTI, "SET Statistics 1999"
See: appendix table 3-3-1

Next, we examine the breakdown of the use of government disbursements of R&D expenditures by sector (Figure 3-2-2). In the breakdown for Japan, we cannot see any conspicuous changes during the period covered by the chart. The university and government research facilities account for a large proportion. As discussed in the explanation of the flow of R&D expenditures (Figure 3-1-8), the flow of funds to the industrial sector is small relative to the other countries. This is a unique feature of the Japanese system.

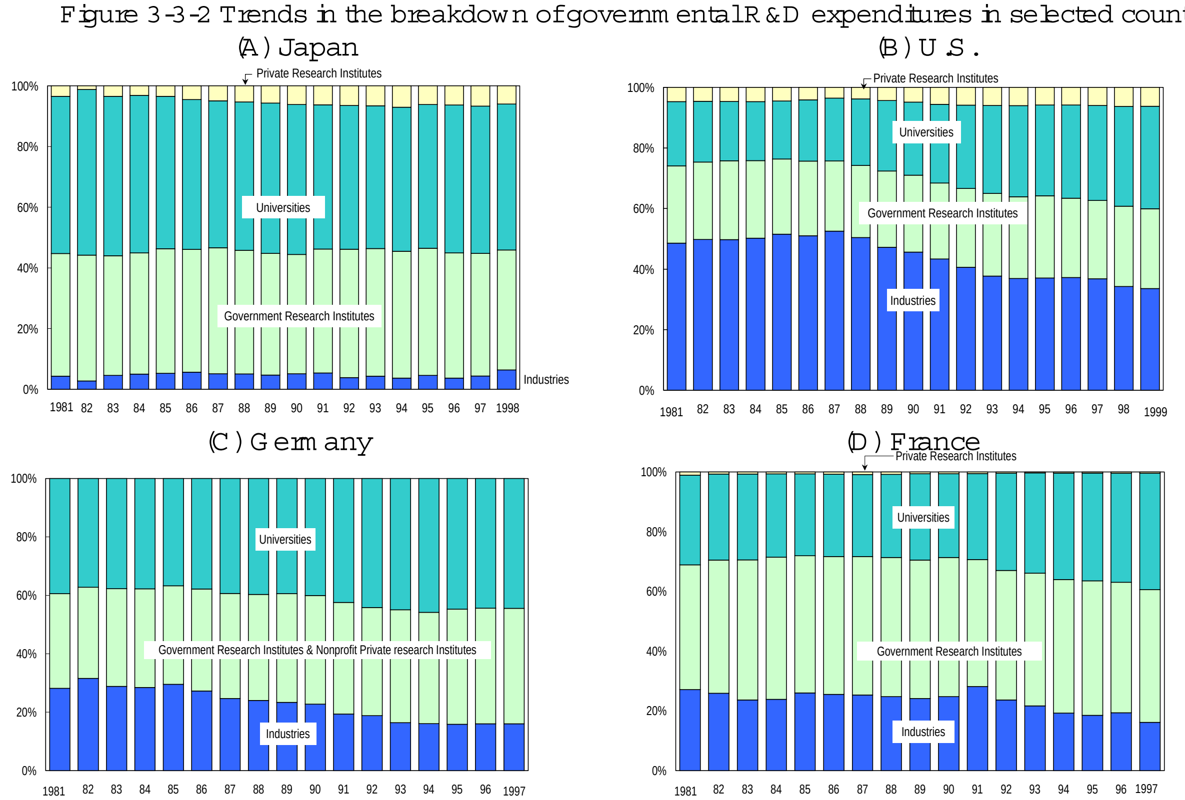
The proportion of R&D expenditures by the U.S. government for the industrial sector has been traditionally high, especially in 1984 to 1988, when it surpassed 50%. However, while there was a substantial decline in this ratio from the late 1980s to the early 1990s, the ratio for universities climbed. The fall in the expenditures for the industrial sector was influenced by a reduction in the traditionally large expenditures for national defense. The ratios for government research facilities, along with privately operated facilities, have not seen any large changes, and were relatively stable in the 1990s.

In Germany, the industrial ratio fell from the 1980s to the beginning of the 1990s, while the ratios for universities and government, together with non-profit, privately operated research facilities increased. In the late 1990s, the industrial sector leveled off, while the university sector experienced a slight decline as the ratio for government and privately operated research facilities increased.

In France, the ratio for government research facilities was large. The ratio for universities was comparatively small, but started increasing in the 1990s.

In conclusion, the reduction in the disbursements of R&D expenditures to the industrial sector by the governments in the countries other than Japan were reciprocated by an increase in disbursements to universities.

Figure 3-3-2 Trends in the breakdown of governmental R&D expenditures in selected countries

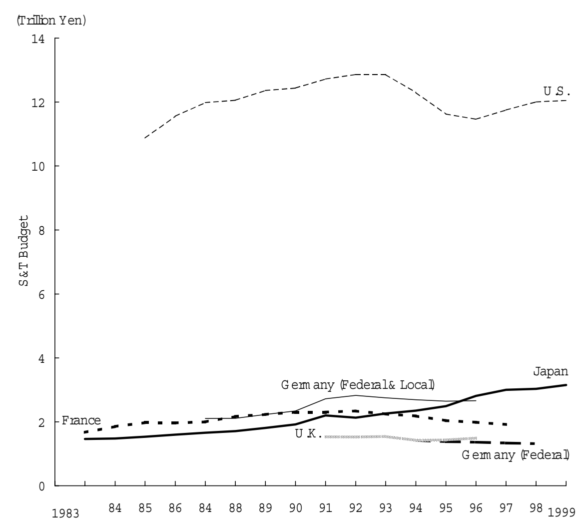


Note: same as figure 3-3-1 Source: Japan, U.S., & Germany - same as figure 3-1-1, France - OECD, "Basic S&T Statistics 1999"
See: appendix table 3-3-2

3.3.2 Science and Technology Budgets by Government

In this section, we will consider the science and technology related expenditures from the annual budget of government. As with R&D expenditures, there is no rigorous international definition for science and technology budgets, and although every country includes R&D expenditures, other expenditures may also be included. In Japan, R&D expenditures are not calculated separately from science and technology budgets, and will not be covered in this book.

Figure 3-3-3 Trends in governmental science and technology budgets in selected countries



Note: Technology relation cost of Japan is only the initial budget of a country, the thing only about humanities/society does not contain. The object range is improved in 1996 and afterwards.

U.S.- This numerical value is budget authority amount. 1998 value is provisional value and 1999 value is presumed value.

Germany- The 1996 value of a federation and state government is provisional value. It is an actual result till the federal government's 1996 fiscal year, the 1997 fiscal year is budget, the 1998 fiscal year is a government budget.

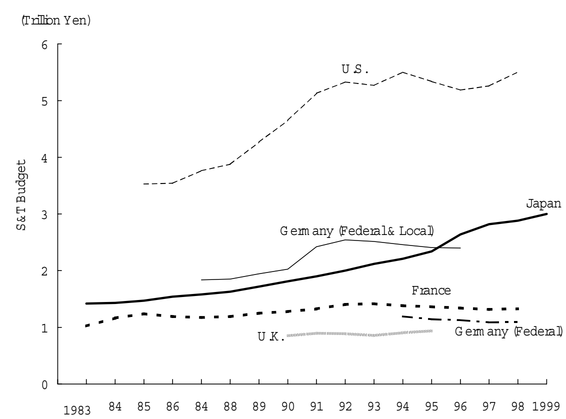
U.K.- Budget is governmental research-and-development budget, and is an actual result till the 1994 fiscal year.

Source: Science and Technology Agency, "White Paper on Science & Technology", "The Science and Technology Directory"

See: appendix table 3-3-3

Figure 3-3-3 shows the science and technology related budgets of the governments of the selected countries. The amount for Japan was one-quarter that of the U.S. in 1999, but about the same as that of France and Germany. Because of differences in the economic scales and systems of each country, a simple comparison is not possible. Nevertheless, taking scale into account, Japan's science and technology related budgets can be considered small. As a result, it has been frequently argued that an increase in the science and technology related budgets of the Japanese government is required. If we examine the yearly changes, however, there has been an obvious increase in the science and technology related budgets in Japan, especially in the late 1990s.

Figure 3-3-4 Trends in government science & technology budgets for civil in selected countries



Note: same as figure 3-3-3

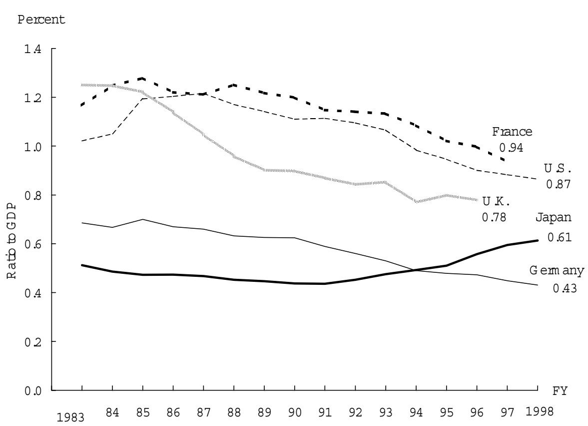
Source: same as figure 3-3-3

See: appendix table 3-3-4

When making international comparisons of science and technology related government budgets, national defense expenditures are often excluded because of the difference in character to other expenditures. This is especially true when comparing Japan to other countries, and in many cases it is more appropriate to exclude these expenditures. Figure 3-3-4 shows the science and technology related government budgets, excluding expenditures related to national defense (i.e. only non-military expenditures).

In Japan, the ratio of non-military expenditures account for 95.4% (1999) of the science and technology related budgets.
In contrast, the percentage of non-military expenditures used in the U.S. does not exceed 51.2% (1999). As a result, a comparison of non-military expenditures shows that the amount for Japan was half that of the U.S. in 1999. From the perspective of yearly changes, all of the trends are roughly the same as those for total amounts.

Figure 3-3-5 Trends in ratio of governmental S&T budgets to GDP in selected countries

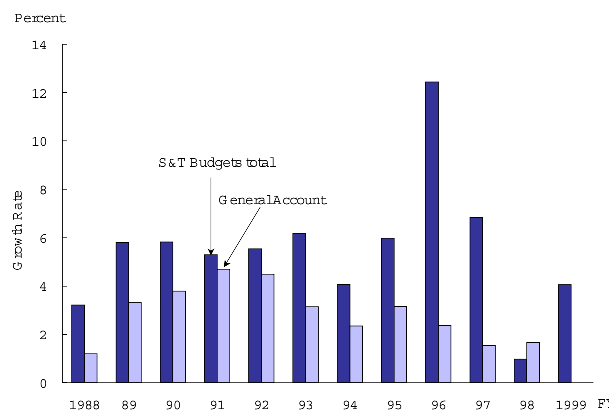


Note: same as figure 3-3-3
Source: same as figure 3-3-3, GDP - same as figure 3-1-2
See: appendix table 3-3-5

Figure 3-3-5 compares science and technology related budgets relative to GDP in order to take the differences in scales between countries into consideration. The values for the countries apart from Japan exhibit a downward trend from the late 1980s. It can be argued that the declining science and technology budgets are a result of reductions in the national defense expenditures and reforms to the government sector. Only the values for Japan have been climbing since the start of the 1990s. Nonetheless, up to now, the values for Japan have been low among the major industrialized nations, and despite surpassing Germany after 1995, the values are still below those of the U.S., France and the U.K.

Figure 3-3-6 shows a comparison between the general annual budget and the previous year's growth in science and technology budgets. From this we can see that the growth of science and technology budgets exceeds that of the general annual budget for the period displayed, except for FY 1998. The 12.4% in 1996 is particularly large. However, both of the growth rates shown here are values based on original budgets. In reality, in addition to the original budgets, disbursements are made for science and technology budgets according to revised budgets.

Figure 3-3-6 Trends in growth rates of governmental S&T budgets in Japan

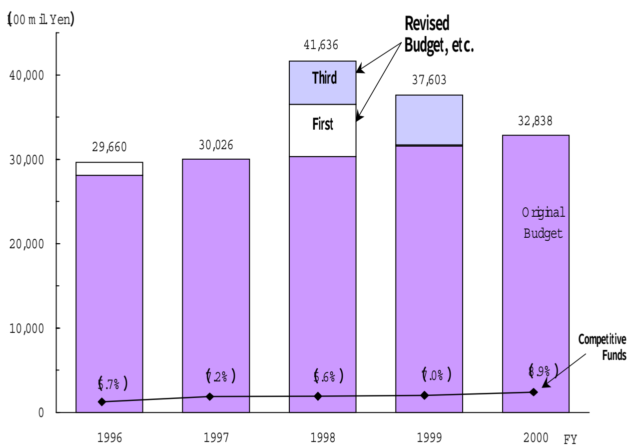


Note: same as figure 3-3-3
Source: Science and Technology Agency, "The Science and Technology Directory", "Science and Technology Expenditures Overview"
See: appendix table 3-3-6

In Japan, the Science and Technology Basic Plan (referred to as the Basic Plan below) was decided by the Cabinet in July 1996. The Fundamental Plan stated that "... with regard to the short-term doubling of Research and Development funding, underlying the idea of raising the rate relative to GDP in the early 21st century in line with Western nations, there is a strong desire to realize a doubling within the period of the Basic Plan. This would require a large-scale budget for science and technology expenditures of approximately 17 trillion yen between fiscal years 1996 and 2000."

For the actual science and technology expenditures, the total of the budgets for the five-year period from FY1996 to FY2000 came to 17.1763 trillion yen, achieving the 17 trillion yen written in the Basic Plan. Examining the changes during the five year period, we see that the amount in 1998 was large. This is due to the large contributions made under the revised budget which was aimed at grappling with the stagnant economy. (See Figure 3-3-7.)

Figure 3-3-7 Trends in the S&T budgets in the S&T basic plan in Japan



Note: Competitive capital showed the amount of money (vertical axis) by the polygonal line, and displayed in the parenthesis the rate for which it accounts to the whole. It is the proposal general invitation of a science research cost subsidy (Ministry of Education), technology promotion adjustment expense (Science and Technology Agency), a welfare science research cost subsidy (Ministry of Health and Welfare), earth-environment research synthesis promotion expense (Environment Agency), the new basic research promotion system (each ministry agency) by the special public corporation, and reformist technical development which was made into competitive capital here.

Source: Science and Technology Agency data

See: appendix table 3-3-7

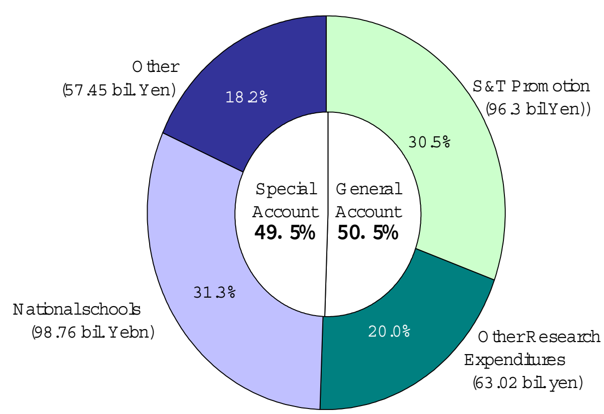
In the Basic Plan, one of the policies for realizing a flexible and competitive R&D environment was to promote the expansion of competitive funds. In Figure 3-3-7, the amount of competitive funds is shown as part of the science and technology budgets, together with the numerical values of their ratios.

However, since the definition and range of competitive funds cannot always be clearly determined, the amounts indicated here are the total amounts for the major funding. Even this data shows an apparent increase in the ratios during the five-year period.

In comparison to other countries, the ratios for the competitive funds cannot necessarily be considered high. Again, in the other countries, the definition and range of competitive funds is not always clearly determinable, which makes a simple comparison difficult.

None-theless, in the U.S. and the U.K., over 30% of the government's science and technology budget consists of competitive funds, which considerably exceeds Japan's rate (around 10%)[5].

Figure 3-3-8 Breakdown of government S&T budgets in Japan (FY1999)



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

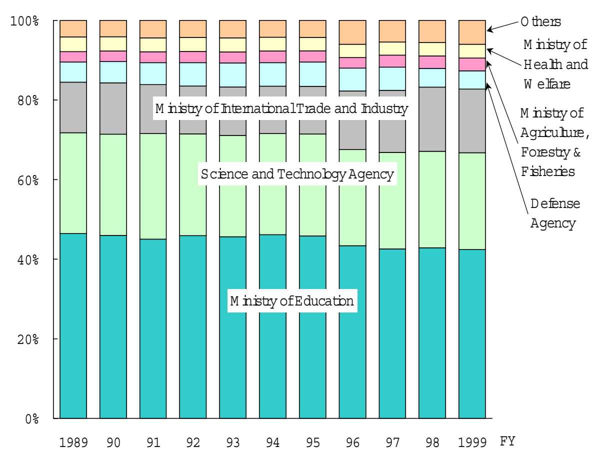
See: appendix table 3-3-8

[5] In the U.S., the R&D budget of the Merit Reviewed Program accounted for 34% of the total in FY2000. In the U.K., the total budgets of the Research Council and the HEFCs accounted for 40% of the government's science and technology budget in FY1999

The science and technology budgets in Japan consist of portions from the general accounts and special accounts - roughly 50% each (Figure 3-3-8). The general accounts portion consists of expenditures for the national testing and research institutions, the Budget for the Promotion of Science and Technology comprising a variety of different types of subsidies, and other research related expenditures. On the other hand, the national schools special account accounts for the main portion of the special accounts.

The ratios of science and technology related budgets by ministry or agency (Figure 3-3-9) do not show any large changes, except for 1996, for the range of targeted expenditures. The Ministry of Education consistently has the largest ratio. In FY1999, it accounted for 42.7%, followed by the Science and Technology Agency (24.5%), the Ministry of International Trade and Industry (16.1%) and the Ministry of Agriculture (4.6%), Forestry and Fisheries (3.5%).

Figure 3-3-9 Trends in S&T budgets by government ministry/agency



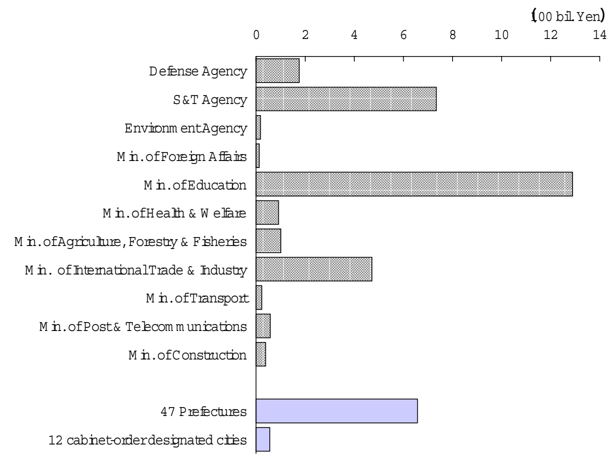
Note: The object range is improved after the 1996 fiscal year. About the Japan Key Technology Center cost, duplication appropriation is carried out at the Ministry of International Trade and Industry and each Ministry of Posts and Telecommunications. (In addition about sum total, it is made not to become duplication appropriation). This table is totaled the Science and Technology Agency.

Source: Science and Technology Agency, "The Science and Technology Directory"

See: appendix table 3-3-9

When making an international comparison of science and technology related government budgets, there are cases in which not only the central government, but also local government must be included. The science and technology budgets shown here for Japan do not include budget by local governments. Although the data has not been created to the same standards as that of the national expenditures, data for reference purposes is shown in Figure 3-3-10.

Figure 3-3-10 S&T budgets of government ministries/agencies and local government (FY1997)



Source: Science and Technology Agency, "The Science and Technology Directory", "Science and Technology Expenditures Overview", National Institute of Science and Technology Policy, "Study of Regional Science and Technology Promotion (Fourth Survey)"

See: appendix table 3-3-10

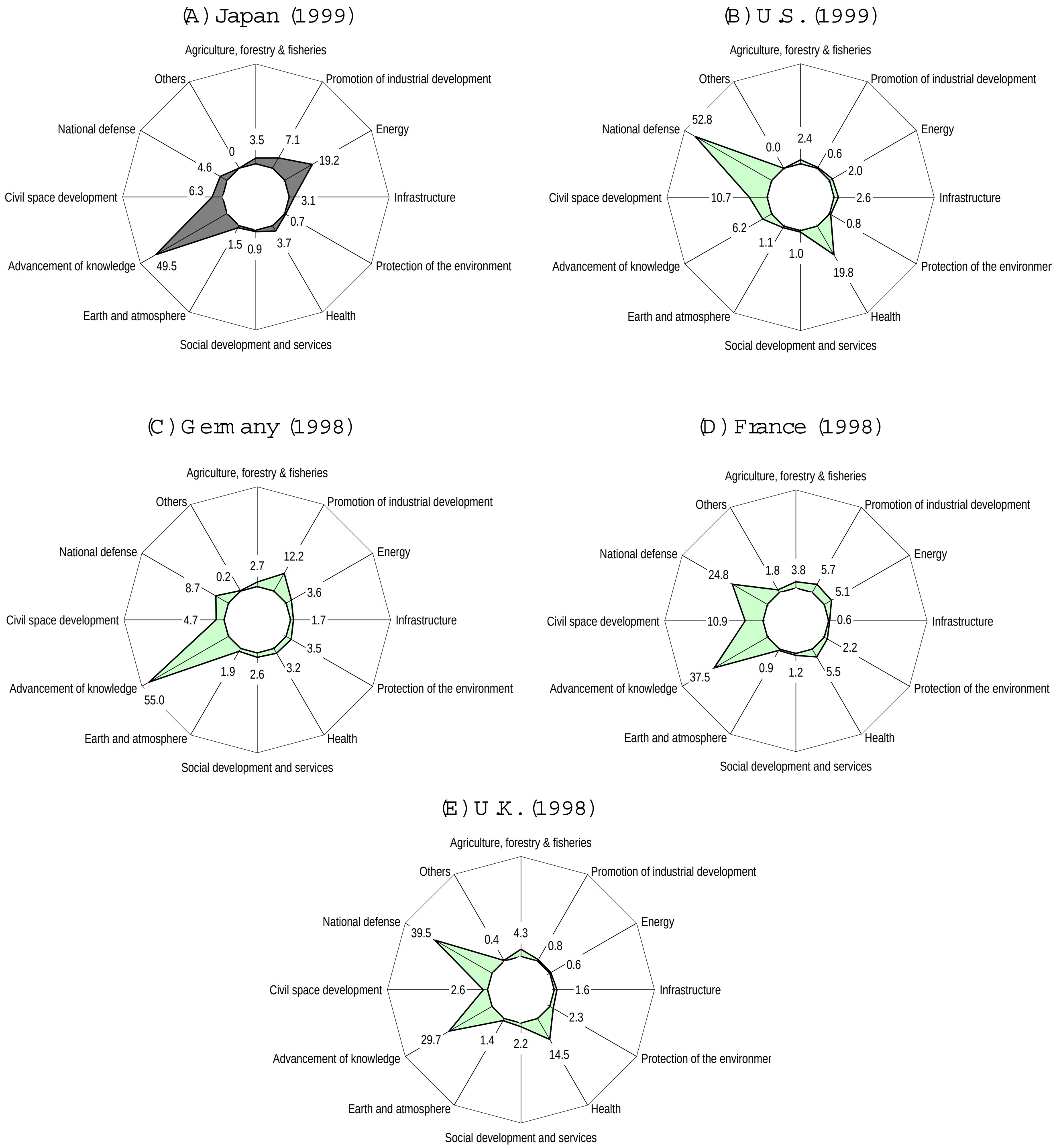
The total science and technology budgets of the local governments of Japan were 862.3 billion yen in FY1997. This is equivalent to a considerable 29% of the budget of the central government in the same year (3.0026 trillion yen). Moreover, compared to the science and technology budgets of the main national ministries and agencies, the total expenditures of the 47 prefectures (749.1 billion yen) exceed those of the Ministry of International Trade and Industry.

For science and technology related government budgets, the OECD proposes a classification method by social and economic objectives. An international comparison was reimplemented using the data according to these classifications, but due to large differences in the systems and classification methods of each country, we can only view broad trends, as opposed to making a precise comparison (Figure 3-3-11).

For science and technology budgets in Japan, the largest classification is "General progress in knowledge" (48.2%), which is similar to France and Germany. The large ratio for "Energy" (20.2%) is unseen in any other country, whereas the 5.6% ratio for "National defense" is the smallest among the five countries.

The U.S. ratio for "National defense," on the other hand, stands out at an enormous 54.1%, with large ratios for "Health" (18.5%) and "Non-military space development" is (11.2%). The ratio of 14.5% for "Health" in the U.K., 11% for "Non-military space development" in France, and 12.9% for "Industrial development" in Germany are all relatively large.

Figure 3-3-11 Governmental S&T budget by socio-economic purpose



Note: A numerical value of Japan is only the initial budget of a country, the cost only about humanities/society does not contain. An U.S. numerical value is budget authority amount. A numerical value of Germany is the budget (presumed value) of the federal government and a state government. Germany, France, and U.K. are presumed value.

Source: OECD, "Basic S&T Statistics 1999"

See: appendix table 3-3-11

3.4 Science and Technology Foundations

Foundations which provide funding support for science and technology activities play a similar role to that of the government in its support of R&D, discussed in the previous section. In this section, we discuss the data for the science and technology foundations, and make an analysis of the situation in Japan, together with that of Europe and the U.S.

3.4.1 The History of Foundations

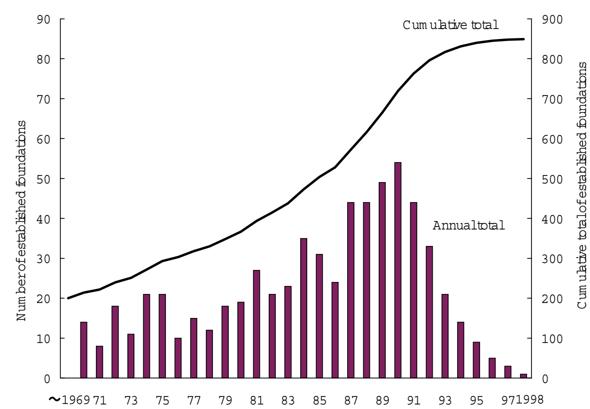
In 1998, there were 13,553 incorporated foundations in Japan (according to the Management Office of the Prime Minister's Secretariat). Some incorporated foundations are "working foundations", which carry out their own work independently, and some are "support foundations", which support the work of others. In this section, we introduce the activities of "support foundations" (referred to simply as "foundations" below). The data for the foundations in Japan is from the Support Foundations Center, unless stated otherwise.

Foundations supporting scientific research have existed since the Taisho Period. Examples of these were the Harada Sekizen Group and the Mitsui Houon Group, which possessed an enormous 30 to 40 billion yen in capital, at current values. However, after the war, the fi-nancial basis of most foundations was wiped out by sudden inflation and the loss in value of wealth held in stocks.

If we look at the foundations that were established after the war, we see that up until the 1960s there were only six to seven foundations established per year. The number of foundations carrying out work previous to 1969 was only 188 (Figure 3-4-1). The number of foundations established increased at the start of the 1970s, with over 20 being set up in some years. The period of greatest activity was the five-year period starting in 1987, with an average of 45 foundations being incorporated per year, which accounted for a quarter of the total number. After 1993, the number of foundations being established fell sharply in step with the recession, with a small number being established in recent years. Of the 849 foundations, 32% were established after 1987, and 50% after 1982. From this, it can be said this is a relatively new sector in Japan.

Next, we will examine the U.S., which has the world's largest foundations. At the beginning of the 1990s, the number of foundations increased by 1000 to 2000 per year, with 41,588 foundations carrying out activities in 1996. With the increase of newly active foundations, together with the traditional large-scale foundations, there have been many cases of large expansions in the scale of support in the past ten years.

Figure 3-4-1 Trends in S&T related foundation establishment

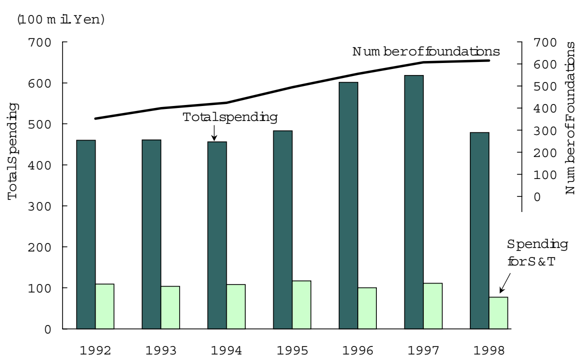


Source: Based on Japan Foundation Center data, it creates in the National Institute of Science and Technology Policy.
See: appendix table 3-4-1

3.4.2 The Support and Asset Scales of Foundations

The scale of assistance is shown in Figure 3-4-2. In FY1998, 615 foundations were carrying out 1,391 assistance programs, totaling 47.9 billion yen. Of this total, roughly 16% (7.7 billion yen) was for research assistance, which corresponded to a mere 10% (117.9 billion yen) of the budget for science research grants by the Ministry of Education in the same year.

Figure 3-4-2 Trends in number of Grant-Making foundation and size of assets (FY1998)

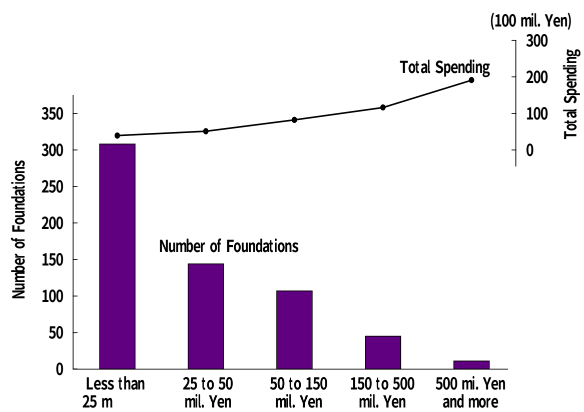


Source: same as figure 3-4-1
See: appendix table 3-4-2

Figure 3-4-3 shows the scale of assistance given by foundations. Of the total, 50% give assistance of less than 25 million yen per year, while 74% give assistance below 50 million yen per year, indicating that small-scale foundations account for the majority. On the other hand, despite the number of large-scale foundations with annual assistance amounts exceeding 500 million yen being a meager 11 (2%), they account for 30% of the total amount of assistance.

In contrast, the total assistance of the 44,146 foundations active in FY1997 in the U.S. was 16 billion dollars – approximately 43 times that of Japan (based on a purchasing power parity exchange rate of 166 yen per dollar). Of this, research assistance was about 8.5%, which is half that of Japan. Figure 3-4-4 shows a breakdown of foundations by size. From this we can see that foundations with an annual assistance amount of less than 100,000 dollars account for 74% of the total, indicating that the proportion of small-scale foundations is extremely high compared to Japan. At the same time, despite the number of large-scale foundations with an annual assistance of over 250 billion dollars being an insignificant 0.2%, they account for 30% of the amount of assistance, and though they may be few in number, extremely large-scale foundations do exist.

Figure 3-4-3 Size of grant programs and grant spending of Grant-Making foundation in Japan (1998)

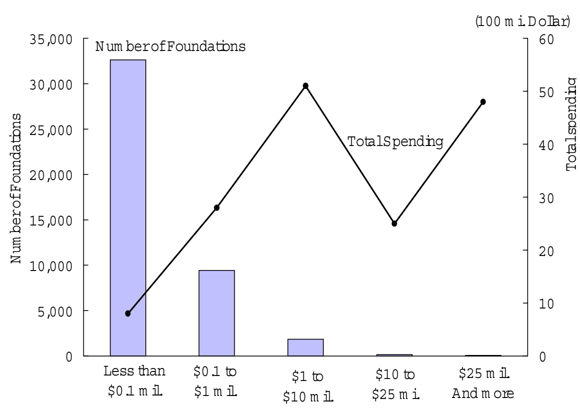


Source: same as figure 3-4-1
See: appendix table 3-4-3

From the perspective of assets, there is an even larger disparity between the scale of foundations in Japan and the U.S. The foundation with the largest amount of assets in Japan is the Sasakawa Peace Foundation, worth 73 billion yen, followed by the Heiwa Nakajima Foundation with 51.8 billion yen in assets. Next is the Inamori Foundation (43.6 billion yen), the Foundation of River and Basin Environmental Supervision (28 billion yen) and the Toyota Foundation (27 billion yen). The foundation in 19th position has assets exceeding 10 billion yen, and the total assets of all the foundations together was 1 trillion, 267.8 billion yen in 1998. At the same time, the Ford Foundation in the U.S. possesses 8.2 billion dollars (1.36 trillion yen) in assets, and there are 12 foundations with over 3 billion dollars in assets. The total assets owned by all the foundations exceeds 267.6 billion dollars (i.e. 44 trillion yen based on the 1998 purchasing power parity rate of 166 yen per dollar).

In contrast to the many corporate founda-tions in Japan, independent foundations are the mainstream in the U.S. (71%), with the pro-portion of corporate foundations being a mod-est 13.4% - another large discrepancy between the two countries.

Figure 3-4-4 Size of grant programs and grant spending of Grant-Making foundations in U.S. (1997)

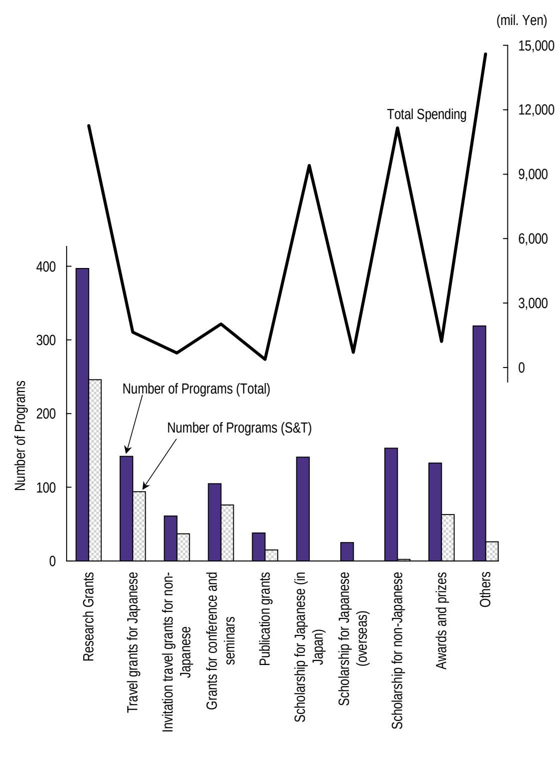


Source: same as figure 3-4-1
See: appendix table 3-4-4

3.4.3 The Types of Assistance and the Targeted Fields

The number of assistance programs imple-mented in 1998 in Japan is shown together with a breakdown of the type of assistance in Figure 3-4-5. Within the various categories of assistance programs, an overwhelming ma-jor-ity were research assistance programs — as many as 397 in total. The second largest cate-gory was scholarship assistance to foreigners, with 153 programs. There were 376 programs (roughly 27% of the total) targeted at the sci-ence and technology fields. The overwhelming majority of those — 246 (65%) — were for research assistance, followed by 94 (25%) for overseas secondment assistance, 76 (20%) for conference assistance, and 63 (17%) for com-mendation awards. The breakdown shows a relatively large portions was designated for the assistance of visiting foreigners(6). (Since sev-eral of the categories for the assistance pro-grams are repeated, the total of the ratios ex-ceeds 100%.)

Figure 3-4-5 Type of grant programs in S&T field (1998)



Source: same as figure 3-4-1
See: appendix table 3-4-5

(6) Large-scale foundations, which carry out assistance programs targeted at the science and technology fields, appear in Figure 3-4-6.

For foundations in the U.S., the main sponsors of science research were the Rockefeller and Carnegie Foundations, from the time of their establishment until the middle of the 20th century. It is claimed that the National Science Foundation (NSF) and the National Institute of Health (NIH), which are at the core of the current American research assistance system, introduced research assistance programs by modeling themselves on the system of the Rockefeller Foundation. After that, there was an expansion of the scale of assistance by the public sector through such institutions as the NSF and NIH. The result was that foundations that operated on the principles of "innovation," "creativity," "risk," and "flexibility" reduced the scale of their research assistance, and as we saw earlier, that ratio became a meager 8.5% on an assistance basis. Irrespective of the type of assistance, the proportion of programs directed at science and technology fields became even lower — a mere 2.7% on an assistance basis - in 1997[7]. Apart from these, programs (1.8% on an assistance basis) mainly directed at research activities in the medical field may also be given as an example of a related field[8].

For European foundations, there were 1,714 assistance programs worth a total of 0.15 billion ECUs in 1996[9]. Of these, the assistance to research programs reached 77.69 million ECUs (51% of the total). As with Japan, this accounts for the main assistance work done by foundations. Of this amount, 28.77 million ECUs (18.8% of the total) went to science and technology fields, and 35.74 million ECUs (23.3% of the total) went to medical research. (Several of the fields targeted by assistance programs have been repeated.)

[7] A breakdown of the number of programs and assistance amounts by field for American foundations is shown in Figure 3-4-7.

[8] Large-scale foundations carrying out assistance programs directed at science and technology fields in the U.S. are shown in Figure 3-4-8.

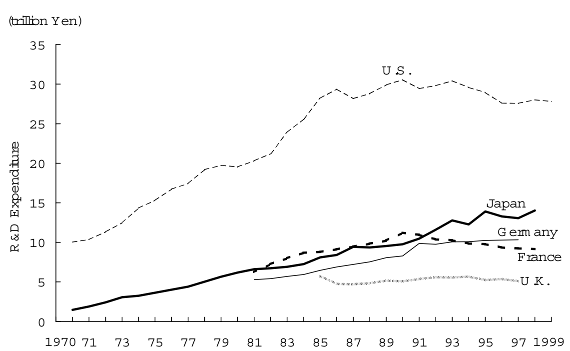
[9] A breakdown of the number of programs and assistance amounts by field for European foundations is shown in Figure 3-4-9.

3.5 R&D in the Government Sector

In this section we describe the government arm of the R&D sector. In addition to actual government research facilities, the government sector discussed here includes R&D facilities (excluding higher education facilities, such as universities) with public funds as their main source of funding, which in some countries includes nonprofit, privately operated research facilities. Here, they are called the government sector or government research facilities.

In Japan, the category known as government research facilities is not used in the R&D statistics (of the Science and Technology Survey from the Statistics Department of the Management and Coordination Agency). The "Research facilities" category includes government-operated, publicly operated and privately operated facilities. In this section, privately operated facilities are not treated as government research facilities.

Figure 3-5-1 Trends in use of R&D Expenditures in government research institutes In selected countries



Note: Data are the total of natural science and humanities/social science. Data for Japan include software industry since FY1996. The 1998 and 1999 value of U.S. is reserve value. Data for Germany up to 1990 are old federal area and it is Germany in 1991 and afterwards.

Source: Japan, U.S. and Germany - same as figure 3-1-1. France & U.K. - OECD, "Main S&T Indicators 1999/2" "Basic S&T Statistics 1998"

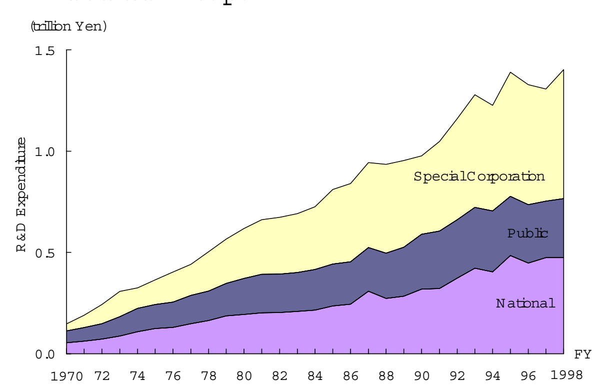
See: appendix table 3-5-1

Figure 3-5-1 displays the changes in the government R&D expenditures (amount used) for the five selected countries. The R&D expenditures for the countries other than Japan have been converted to yen according to the OECD's GDP purchasing power parity.

The R&D expenditures used by the government sector in Japan are roughly the same as Germany, France and the U.K., which are relatively small when the economic scales of the countries are taken into consideration.

Examining the changes in the R&D expenditures used by the government research facilities in Japan, we see that growth has continued for all research facilities, excluding a few exceptional years. However, in contrast to moderate increases for government- and publicly operated facilities, there was relatively large growth for semi-governmental corporate research facilities (Figure 3-5-2).

Figure 3-5-2 Trends in use of R&D expenditures in government research institutes in Japan

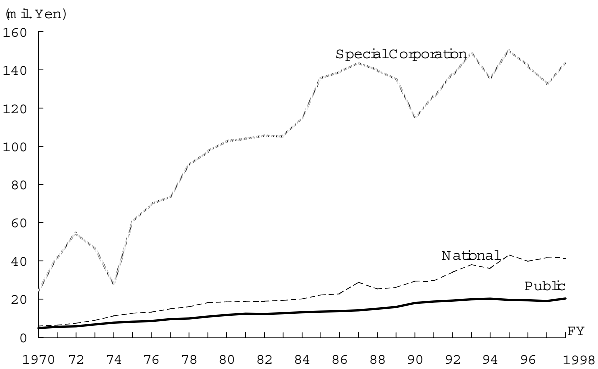


Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"

See: appendix table 3-5-2

The R&D expenditures per researcher at Japanese government research facilities increased remarkably for semi-governmental corporations from the late 1970s, and are by far the largest in recent times (Figure 3-5-3). This is influenced by large-scale R&D activities such as atomic power, and space development being carried out by the semi-governmental corporations.

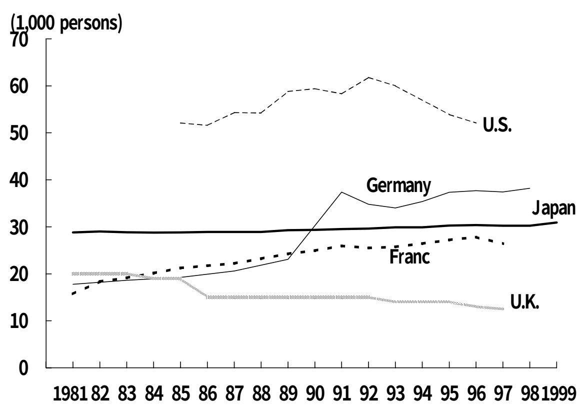
Figure 3-5-3 Trends in R&D expenditures per R&D scientists/engineers in research institutes in Japan



Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 3-5-3

Next, we consider the data for R&D expenditures and the number of researchers in the government sector of the five selected countries shown in Figure 3-5-4. A unique characteristic of the Japanese government research facilities is the exceedingly small changes in the number of researchers over time.

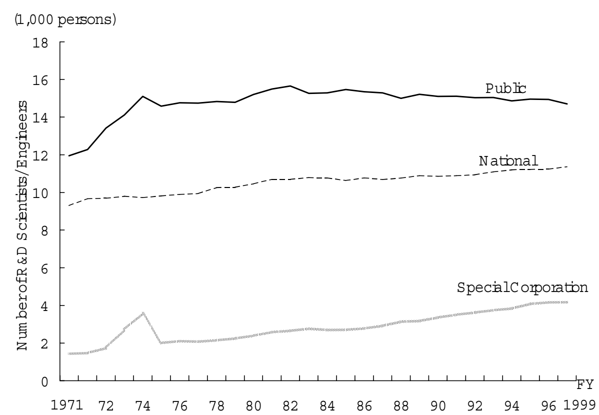
Figure 3-5-4 Trends in number of R&D scientists/engineer in government research institutes in selected countries



Note: Data include natural Science and humanities/social science.
Source: Japan, U.S. and Germany - same as figure 3-1-1. Germany, France and U.K. - OECD "Main S&T Indicators 1999/2, "Basic S&T Statistics 1998"
See: appendix table 3-5-4

Figure 3-5-5 displays the number of researchers by the type of government research facility in Japan. As of 1999, this number was the greatest at publicly operated research facilities, followed by government-operated facilities. Beginning in the 1980s, the publicly operated facilities exhibited a slight downward trend, with been only a very slight increase in the number of researchers at government operated facilities. Although semi-governmental facilities have the fewest number of researchers, there has been a comparatively large increase since the 1980s.

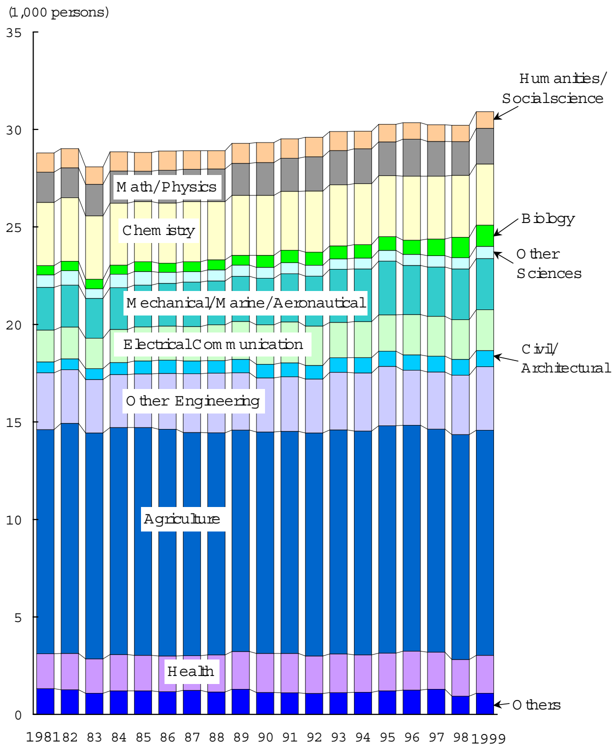
Figure 3-5-5 Trends in number of R&D scientists/engineers in government research institutes in Japan



Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 3-5-5

From the breakdown of the number of researchers by specialty at government research facilities in Japan, it is apparent that agriculture accounts for the largest ratio. This field does not have any particularly large fluctuations; instead, it displays few changes.

Figure 3-5-6 Trends in number of R&D scientists /engineers in government research institutes by specialty in Japan



Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 3-5-6

The promotion of researcher mobility is important for opening up the flexibility and competitiveness of the Japanese R&D environment. As a means of making researchers mobile a new policy of "tenure by appointment system" has been introduced in national testing laboratories[10]. As part of the "tenure by appointment system," the national testing laboratories have introduced two systems: the "appointment type" and the "training for young people type" in order to improve the recruitment of particularly talented researchers. The results according to these systems show that by December 31, 1999, of a total of 163 cases, 15 were of the appointment type and 148 were of the training for young people type (according to data from the Science and Technology Agency).

[10] Based on the June 1997 issue of, "Laws Concerning the Employment, Salaries and Exemption of Working Hours for Tenured Researchers.

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Chapter 4 R&D In Universities

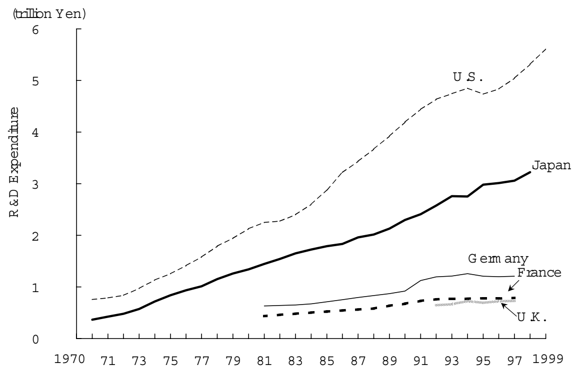
4.1 Universities as R&D Organizations

Universities and other higher education institutions have functions as R&D institutions, and play an important role in the R&D systems of countries throughout the world. As shown in Section 3.1.3, these institutions use some 13.9% to 20% of R&D expenditures in the five major industrialized countries of the world, and these percentages are continuing to increase in each of these countries. Qualitative changes are also evident in R&D, such as increasing cooperation with the industrial sector.

Although the scope of higher education institutions varies from country to country, universities are the main institutions in each country, and in this chapter, except where particularly necessary, we will use the term "university sector" in place of "higher education sector." As of FY 1999 there were 622 universities in Japan (99 national universities, 66 public universities and 457 private universities), but in this chapter the term "universities" encompasses junior colleges (585), colleges of technology (62), university laboratories (214) and other institutions (214)[1]. These institutions are referred to as "universities" below.

Figure 4-1-1 shows changes over time in the amount of R&D expenditures used in the university sectors of the major industrialized countries. For the university sector, it is difficult to separate education activities and R&D activities, so care needs to be taken in that there are some problems in statistical data. Overall, figures for the U.S. are roughly double those of Japan, evidence that the mutual relationships and long-term trends of the five countries resemble those of the total amount of R&D expenditures of the various countries (see Figure 3-1-1).

Figure 4-1-1 Trends in R&D expenditures in universities/colleges in selected countries



Note: It converted into Japanese currency (Yen) using the purchasing power parity of OECD.
The 1998 value of France is assumption value.
The 1998, 1999 value of U.S.. is numerical reserve value.

Source: Japan – Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development".
U.S. – NSF, "National Patterns R&D Resources 1999 Data Update"
Germany – BMBF, "Budesbericht Forschung 1996", "Faktenberidht 1998"
France – OECD, "Basic Science and Technology Statistics 1998" (1997,8 data is Main S&T Indicators 1999/2)
U.K. – OCED, "Main S&T Indicators 1999/2"
Purchasing Power Parity – OECD, "Main S&T Indicators 1999/2" "National Accounts, 1999

See: appendix table 4-1-1

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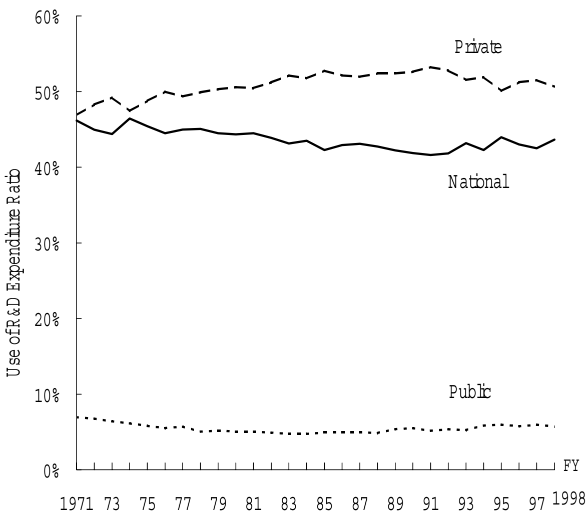
[1] The numbers of universities, junior colleges and colleges of technology are according to the Ministry of Education, Science, Sports and Culture's "Report on Basic Survey of Schools (FY 1999)." In the "Report on the Survey of Research and Development" of the Statistics Bureau, Management and Coordination Agency of Japan, which is used as statistical data for Japan's university sector in this chapter, universities are surveyed according to faculty (by departments for graduate schools), and the total number was 1,585 in FY 1999. In addition, "other institutions" refers to National Institute of Multimedia Education, National Center for University Entrance, the National Institution for Academic Degrees, the Center for National University Finance, and research facilities under the jurisdiction of the Ministry of Education, Science, Sports and Culture.

The amount of R&D expenditures utilized in Japan's universities was 3.2 trillion yen in FY 1998, equivalent to 20% of Japan's total R&D expenditures. Looking at the trends in these figures, throughout the period shown in the graph, the figures show a linear increase, with only FY 1994 increasing from the previous year's figures. With regard to the remaining countries, the impact of currency conversion and other factors make it impossible to read off changes over time from this graph alone, but the increase from the mid 1990s in the U.S. is quite marked. In the three European countries the amounts have remained roughly constant, but as mentioned in Chapter 3 (Figure 3-1-9), the percentage of R&D expenditures of countries as a whole used by universities has continued to increase throughout the 1990s.

Next, looking at the change over time in the percentage of R&D expenditures in Japan's universities (internal amounts used) according to the type of organization (Figure 4-1-2), the percentage used by national universities has decreased gradually from the start of the 1990s, while the percentage used by private universities had continued to increase, but from around 1991 the reductions in national universities stopped, and despite minor fluctuations has continued to remain at just over 40%. Meanwhile the percentage accounted for by private universities has tended to fall somewhat since FY 1992. In addition, the percentage of public universities has been increasingly slightly since the early 1990s. The percentages for FY 1998 were 43.6% for national universities, 5.7% for public universities and 50.6% for private universities. In addition, looking not at the percentage but at the actual amounts, each category is showing linear increases, but since FY 1994 the amount for national universities alone has clearly not been increasing, but is fluctuating every one to two years.

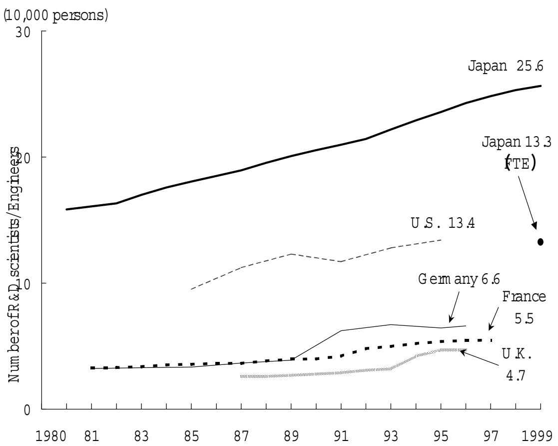
Figure 4-1-2 Trends in use of R&D expenditures in universities/colleges in Japan



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

Next we will examine the number of R&D scientists and engineers in the university sector. Statistics concerning the number of R&D scientists and engineers in the university sector of each country differ greatly due to differences in definitions and scope of survey coverage as well as survey methods, so these points need to be taken into account when making international comparisons. Initially we will compare the data generally used as R&D statistics (Figure 4-1-3).

Figure 4-1-3 Trends in number of R&D scientists and engineers in universities/colleges in selected countries



Note: Data are the total of natural science and humanities/social science. Japan R&D scientists and engineers are not FTE. Data for Germany up to 1990 East Germany and Since 1991 as of Germany.
Source: Japan, Germany, France and U.K. - same as figure 4-1-1
U.S. - NSF, "National Patterns of R&D Resources 1998"
See: appendix table 4-1-3

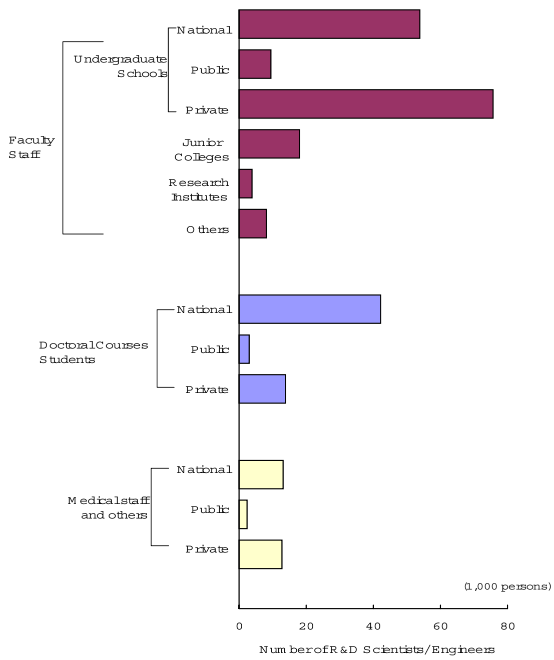
Statistics concerning the number of R&D scientists and engineers in Japan's universities does not only include full-time equivalence data but incorporates a wide coverage, resulting in a large value that is approximately double that of the U.S.. However, Japan's statistical data is values arrived at from clear definitions, as shown in Figure 4-1-4 below, and from these data it is possible to recognize that Japan's university R&D scientists and engineers are increasing in number.

Figure 4-1-3 also incorporates the FTE estimates for Japan's most recent year (1999). This figure is 133,000, almost the same as the U.S. figure for 1995 (134,000). The statistical methods used here are the same as the methods used in Figure 3-1-6 in Chapter 3.

In other countries, while data for the U.S. is not full-time equivalence data, its scope is much narrower than that of Japan, and it is a relatively small figure if population is taken into account. For the three European countries, full-time equivalence data is reported. For Germany, data since 1991 has been impacted by the unification of West and East Germany. The number of R&D scientists and engineers in the U.K. took a great jump between 1993 and 1994, which was largely the impact of a change to survey coverage resulting from reform in higher education institutions. The number of R&D scientists and engineers in France has continued to increase almost consistently.

In order to gain a better understanding of the number of R&D scientists and engineers in Japan's universities, we will take a more detailed look at the breakdown in figures (Figure 4-1-4).

Figure 4-1-4 Breakdown of R&D Scientists and engineers in universities/colleges in Japan (1999)



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

The total number of R&D scientists and engineers (people involved in research full-time) in Universities in Japan according to current statistics was 256,440 as at April 1, 1999, of which 169,070, or 65.9%, were teaching staffs. R&D scientists and engineers at universities also includes people enrolled in postgraduate doctoral courses (59,057 people) and members of medical staff (28,313 people).

Of the teaching staffs, some 139,052 people belong to university faculties, with the remaining belonging to junior colleges (18,059) and university-affiliated research laboratories (3,864). In these figures almost all university teaching staffs are counted as R&D scientists and engineers[2].

Next, we take a look at the number of R&D scientists and engineers in Japan's university sector once again through an international comparison. Here the comparison is restricted to Japan and the U.S.. There are great differences in particular in the survey methods used to obtain the statistical data for both countries, and as shown in Figure 4-1-3, a simple comparison is not appropriate.

In making a comparison, after eliminating the number of postgraduate students included in statistics for the number of R&D scientists and engineers of both countries[3], adjustments and estimates have been made to bring the conditions of the two countries closer together. In addition, only figures for 4-year universities are counted, so data for Japan was restricted to teaching staffs and members of medical staff of university faculties (including postgraduate school and excluding junior colleges) and university-affiliated research laboratories.

Taking a look at the statistics for both countries, as mentioned earlier, almost all university teaching staffs are added as R&D scientists and engineers in Japan's statistics, and full-time equivalence is not used. In data for the U.S., however, full-time equivalence is not used, but (1) figures are limited to R&D scientists and engineers who have PhD's granted by U.S. universities, and (2) only those personnel engaged mainly in R&D activities are included in figures.

Taking the above differences into account, the following estimates were made. For Japan's university teaching staffs, an estimate was made which is not a full-time equivalence value in the strict sense of the term, but which is equivalent to a full-time equivalence value in accordance with data from a variety of related institutions. With regard to members of medical staff, their numbers were halved, assuming that they spend half of their time in R&D.

Meanwhile, in the U.S., the statistical figure is 91,000 people engaged mainly in R&D, but one must take into account the existence of other people who are mainly engaged in teaching activities (102,000). Consequently, of those persons engaged mainly in other fields than R&D, the number of persons engaged in R&D as secondary duties was halved before adding this figure to the statistics.

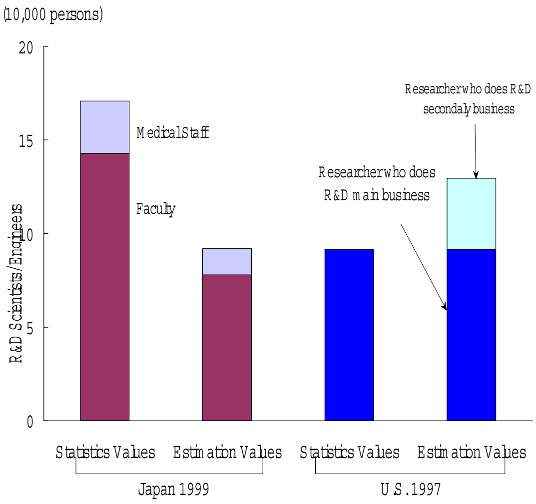
Figure 4-1-5 shows these results together with the original statistical values. In Japan the estimated number of R&D scientists and engineers is 92,000, while there are 130,000 in the U.S., with Japan and the U.S. turning the tables from the original statistics. Furthermore, due to the fact that U.S. statistics contain R&D scientists and engineers who have been granted their PhD's and R&D scientists and engineers

[2] Looking at the statistics for universities for comparative purposes (The Ministry of Education, Science, Sports and Culture's Report on Basic Survey of Schools, FY 1999 Edition), as at May 1, 1999, there were 147,579 persons primarily engaged in teaching in university faculties and university postgraduate schools, and 18,206 in such positions in junior colleges.

[3] The reason why university students were eliminated was the great differences between Japan and the U.S. in the conditions under which data concerning postgraduate students was obtained, and inadequate data is available to make those adjustments.

who have not been granted PhD's, the inclusion of these people would result in further increases to U.S. numbers.

Figure 4-1-5 Number of R&D scientists and engineers in universities/colleges in Japan



Note: 1) Japan and U.S. do not contain a graduate student.
2) The U.S. is the value of only a four years system university. Japan is the value of the sum total of a university faculty (a graduate school is also included) and a university arrangement research institute.
3) In estimation value of Japan, The number of teachers of a university faculty and a university arrangement research institute used full time conversion equivalent value, and the number of members of the medical staff used the value which multiplied statistics value by one half.
4) The U.S. number of researchers is the number of the person by whom statistics value and estimation value are employed by the system university among the holders of the doctor's degree granted from the U.S. organization for four years. Moreover, statistics value is the number of the person who does research and development main business, and estimation value is value which added the value which multiplied the number of the person who does research and development secondary business by one half to statistics value.

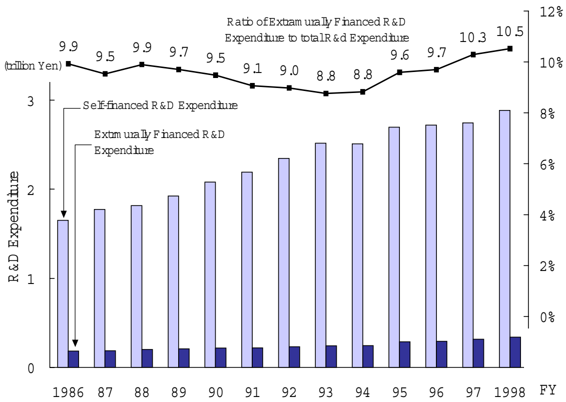
Source: Japan – Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development". However, Based on the data of the Statistics Bureau of the Management and Coordination Agency "Technology research investigation", the National Institute of Science and Technology Policy estimated.
U.S. – NSF, "Characteristics of Doctoral Scientists and Engineers in the United States: 1997"

See: appendix table 4-1-5

4.2 Features of and Issues Facing R&D in Japan's Universities

The R&D expenditures utilized by Japan's university sector, as touched upon in Chapter 3, are quite significant as a percentage of the R&D expenditures of the country as a whole, even when international comparisons are made. One feature is, however, that there is little accepted from outside parties. Figure 4-2-1 shows the portion of R&D expenditures used internally by universities that they are responsible for, and the amounts received from external parties.

Figure 4-2-1 Trends in internal expenditure on R&D in universities/colleges by source

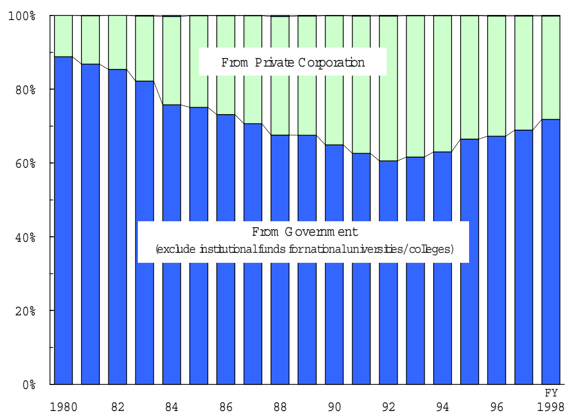


Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 4-2-1

The total amount of R&D expenditures used internally by Japanese universities was 3.2229 trillion yen in FY 1998, and while the portion that universities were responsible for by themselves was 2.8848 trillion yen, R&D expenditures received from external parties was 339.2 billion yen, accounting for no more than 10.5% of the total figure. This figure has been increasing since FY 1995. The portion of expenses that Japanese universities are responsible for includes the expenses of national universities.

With regard to the amount of R&D expenditures used internally which are received from outside parties, Figure 4-2-2 divides this amount up into the public and private sector, and shows the percentages for the respective sectors. Up until FY 1992, the percentage of R&D expenditures received from the government has been falling, while the percentage received in the form of private-sector funding is increasing. In FY 1993 and in subsequent years, however, this trends was reversed. As a result, the R&D expenditures received from the private sector, which were 39.2% in 1992, fell to 28.0% in 1998.

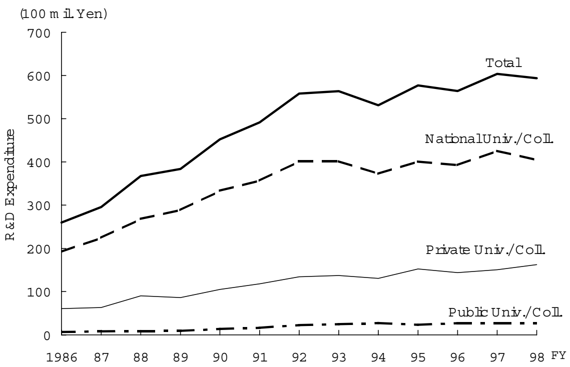
Figure 4-2-2 Trends in breakdown of R&D funs paid outside in Japan



Note: Although the part from a foreign country is also in an acceptance research and development cost from the exterior, it will be very as small as 0.2% in 1998, and does not appear in a figure.
Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 4-2-2

The R&D expenditures received by universities from companies is one indicator which shows the state of cooperation between industry and academia. Looking at changes over time in R&D expenditures received by universities from the industrial sector (Figure 4-2-3), major increases incurred up until FY 1992, after which they leveled off, and hardly any increase has been evident over the past six years. Furthermore, the amount in FY 1998 (59.4 billion yen) was only 1.6% of the amount of R&D expenditures used internally by universities in the same year (3.2229 trillion yen). Looking at figures according to government/public and private, the amount of R&D expenditures received from the industrial sector is largest for government institutions, but since FY 1993 growth has been greater in private universities.

Figure 4-2-3 Trends in R&D expenditures received from industry in universities/colleges in Japan

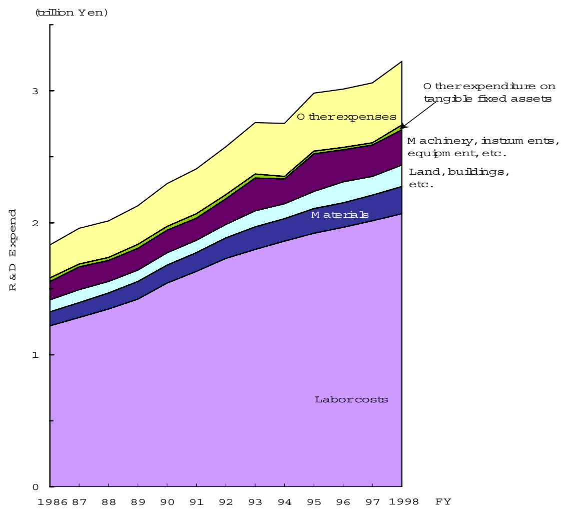


Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 4-2-3

Meanwhile, progress is being made in the provision of systems to promote cooperation between industry and academia, and looking for example the track record of utilization of the Joint Research with the Private Sector (established in 1983, and amended by a Notification by the Ministry of Education, Science, Sports and Culture in March 1997) system, in FY 1995 there were 1704 cases, which increased dramatically to 2568 cases in FY 1998 (according to Ministry of Education data). This data is valuable in that in contrast to Figure 4-2-3, it also incorporates joint academic/industry research which does not entail the direct receipt of R&D expenditures, but it is data that is restricted only to national universities, and as such the amounts are unclear. It is important that in the future indicators be developed to gain an appropriate picture of the actual state of cooperation between industry and academia. From the perspective of international comparison, however, as is also shown in Figure 4-2-3, cooperation between industry and academia in Japan is relatively small.

Next, taking a look at a breakdown of R&D expenditures of universities according to expense items, personnel expenses are high, and the amount of these expenses is increasing linearly (Figure 4-2-4). Personnel expenses for FY 1998 were 2.0685 trillion yen, accounting for some 64.2% of the total. Meanwhile, amounts other than personnel expenses amounted to 1.1544 trillion yen. Throughout the period shown in the diagram, there were no dramatic changes to the structure of expense items.

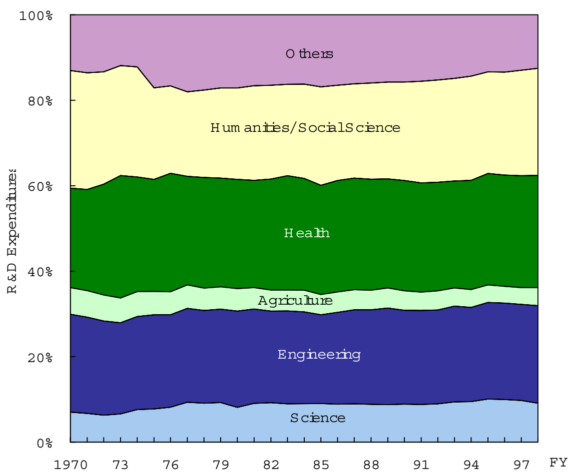
Figure 4-2-4 Trends in R&D expenditures by items in universities/colleges



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

Taking a look at the change over time in the percentage of university R&D expenditures according to academic field (Figure 4-2-5), it is clear that the changes between fields over the period shown in the diagram are small. However, the academic fields shown here are not the classifications according to the nature of R&D, but the classification according to the type of organization such as faculty. Consequently, it is impossible to read off changes in the content of R&D from this diagram, but trends in the structure of university organizations. It is noteworthy data in that it is possible to say that over the past 30 yeas, there have been no great changes in the organizational structure of Japan's universities.

Figure 4-2-5 Trends in R&D expenditures by fields of science in universities/colleges



Note: The Classification of a learning field is the classification by the kind of organization of a faculty etc.

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

See: appendix table 4-2-4

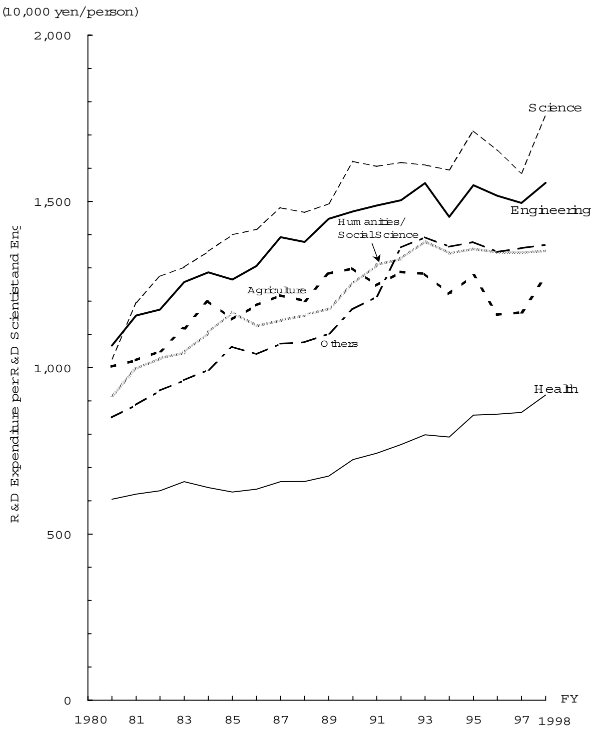
Next, taking a look at the changes over time in R&D expenditures for internal use per researcher in universities according to academic field, the amount for the science field is the largest, followed by engineering (Figure 4-2-6 (A)). While the amounts for both fields are increasing over the long term, it is evident that there has been a slowing of growth in the 1990s relative to the 1980s. Meanwhile, the amount for the field of health, the field with the smallest amount, has increased slightly since the early 1990s, but it still remains at a level much lower than the other fields. There has been a slight reduction in expenditures in the agricultural field from the early 1990s. The field of human and social sciences saw a marked increase from 1990 to around 1992, after which it leveled off.

When comparing R&D expenditures per researcher, R&D expenditures excluding personnel expenses for the people involved in R&D are sometimes used. Figure 4-2-6 (B) shows the amount of R&D expenditures per researcher, excluding personnel expenses. It is clear that on the whole, there have been few changes in the amount over the past ten years or so. In terms of academic fields, science has the largest amount, followed by engineering.

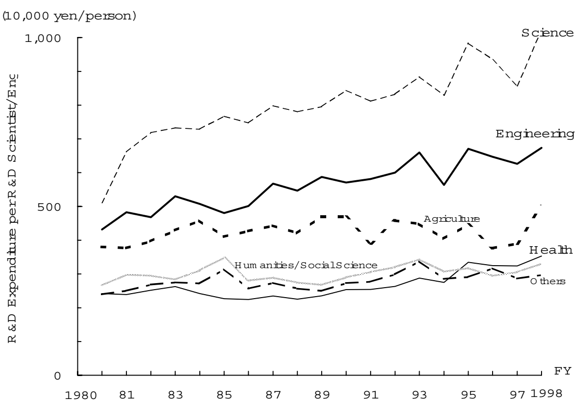
Next we examine Japan's universities from the perspective of R&D personnel. Firstly we used R&D expenditures to show that there are few changes in the structure between academic fields in Japanese universities, in Figure 4-2-5, and this same trends is also evident in data concerning the number of R&D scientists and engineers. Looking at changes over time in the number of R&D scientists and engineers by specialization (Figure 4-2-7), against an increase in the total number of R&D scientists and engineers, the structure by field is hardly changing at all. It is thought that in terms of specialization of R&D scientists and engineers, they often respond with the type of faculty of the university from which they graduated, so it was thought more persuasive to show the state of development of R&D scientists and engineers rather than showing the research areas at the time of the survey.

Figure 4-2-6 Trends in R&D expenditures per R&D scientists and engineer

(A) Total R&D expenditures

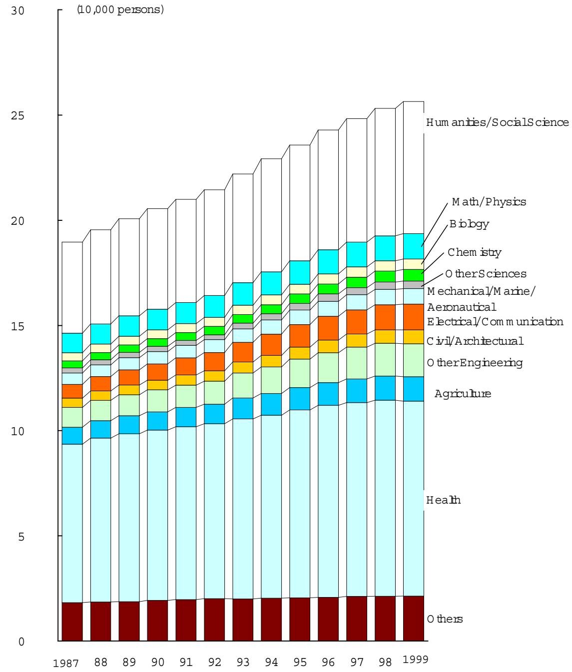


(B) R&D expenditures without labor cost



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

Figure 4-2-7 Trends in Number of R&D scientists and engineer by specialty



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

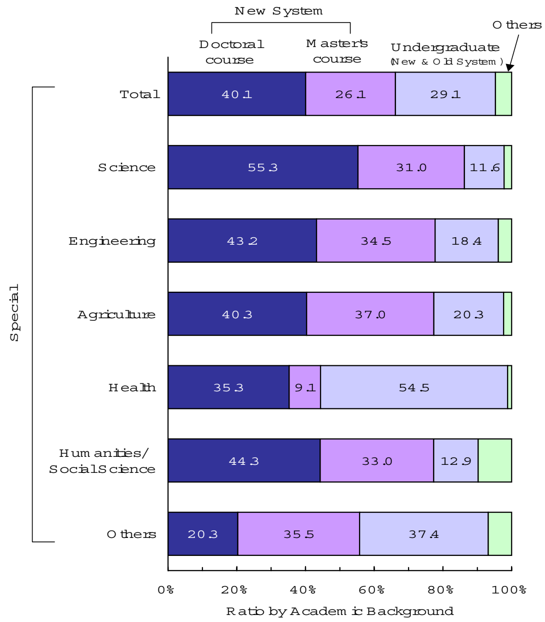
With regard to R&D scientists and engineers in the university sector, when making international comparisons, there are cases where the number of people with PhD's and the number of R&D scientists and engineers according to level of academic qualifications is necessary. For example, as mentioned earlier, in U.S. statistics only those R&D scientists and engineers with PhD's are included in the number of R&D scientists and engineers, and to compare this figure with the number of R&D scientists and engineers in Japan, data concerning the number of people with PhD's is required. In Japan's R&D statistics the number of people with PhD's is unclear, so using statistics concerning university teaching staffs, we will examine the number of teaching staffs according to the level of their academic achievement. These statistics apply to all university teaching staffs, and while they differ from R&D scientists and engineers in name, as already indicated in the description of Figure 4-1-4, almost all teaching staffs are included in statistics as R&D scientists and engineers, so it is possible to consider that effectively all of Japan's university R&D scientists and engineers are included (apart from postgraduate students and members of medical staff).

Figure 4-2-8 shows the classification of the number of university teaching staffs according to their highest level of academic achievement. In teaching staffs overall, the largest percentage (40.1%) have completed doctorate courses at universities under the new system, followed by 28.3% who have completed courses at universities under the new system (in the diagram these personnel are shown together with the 0.8% of people who have completed university courses under the old system). In addition, the percentage of people who have completed doctorate courses at universities under the new system is relatively high at 26.1%.

Looking at the level of achievement according to field of specialization, the area with the highest percentage of people who have completed postdoctorate PhD's under the new system is highest in science (55.3%) followed by human and social sciences (44.3%) and engineering (43.2%).

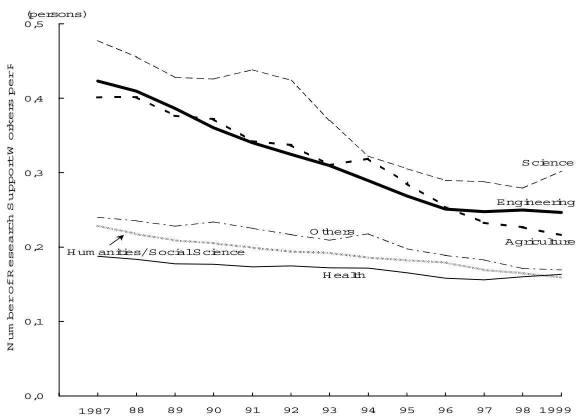
Next, Figure 4-2-9 shows the change over time in the number of research support staff per researcher in universities. The number of research support staff per R&D scientist and engineer in Japan is low in international terms, and it was mentioned in Chapter 3 that the number is particularly low in universities. Moreover, from the diagram shown here, the number of support staff is falling, with the drops most pronounced in those areas and faculties which in the past have had relatively high numbers of research support staff per R&D scientist/engineer.

Figure 4-2-8 Breakdown of number of universities/colleges regular faculty by academic background and specialty (FY1998)



Note: They are the number of teachers, such as a faculty, a graduate school, and attached hospital, and an arrangement research institute.
Source: Ministry of Education, "Report on the Survey of School Teachers Statistics (FY1998 edition)
See: appendix table 4-2-8

Figure 4-2-9 Trends in number of research support workers per R&D scientists/engineers in universities/colleges



Note: The classification of a learning field is based on the kind of organization of the faculty of a university etc.
Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 4-2-9

Bibliography

[1] Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development" (annual version)

[2] Ministry of Education, "Report on Basic Survey of Schools" 1999

[3] Ministry of Education, "Report on Survey of School Teachers Statistics" 1998

[4] FY1995 Report Comprehensive Research (A) under Scientific Research Expenses Subsidies, "Research Into the Living Hours of R&D Scientists and Engineers in Universities", (Research Representative Hiroshi Takuma)

Chapter 4
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Yumiko Kanda

Chapter 5　R&D in Industry

5.1 Comparison of Industrial Sectors of Selected Countries

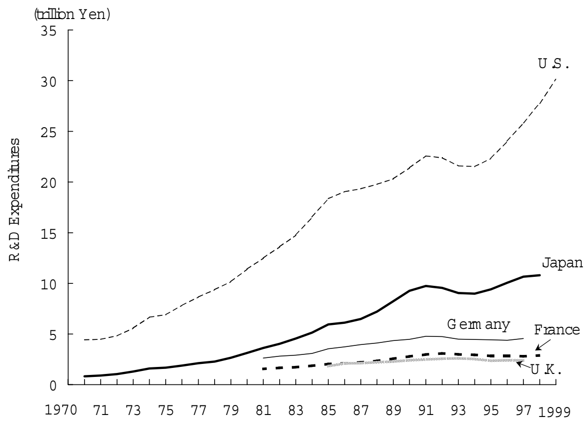
As already indicated in Chapter 3, in the major industrialized countries, industrial sectors are the largest sector in terms of both source and performer of R&D expenditures. Of these countries, Japan's R&D expenditures account for a particularly large position in the industrial sector.

Looking at the trends in the amount of R&D expenditures used in industry the five selected countries, including Japan (Fig. 5-1-1), after increasing in the 1980s, the figures stagnated in the early 1990s. In subsequent years, R&D expenditures increased in Japan and the U.S. from the late 1990s. This increasing tendency is not evident in the three European countries.

Japan's R&D expenditures in the industrial sector were 10.8 trillion in FY1998. Looking at the trends that have occurred up until now, the steady increase from the late 1970s became more gradual in FY1985, but continued to increase until FY1991. It changed to a decrease in FY1992, and reductions continued for three consecutive years until FY1994, but in FY1995 and subsequently, increases have been recorded for four consecutive years.

Comparing the number of R&D scientists and engineers in the industrial sector of the selected countries, even if the size of the population is taken into account, the U.S. has a large number, with 859,000 in 1996. Meanwhile, the number of R&D scientists and engineers in Japan's industrial sector was 429,000 in 1999. While Japan's figures are affected by the fact that statistical data does not convert the number of R&D scientists and engineers into full-time R&D scientists and engineers, these are relatively large figures.

Figure 5-1-1 Trends in industrial R&D expenditures in selected countries

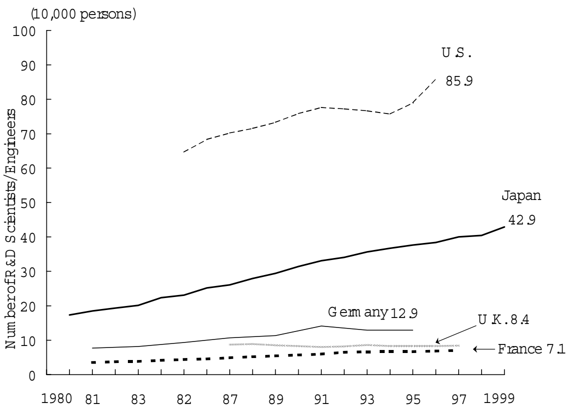


Note: 1) It converted in Japanese currency (Yen) using the purchasing power parity of OECD.
2) It is the sum total of natural science and humanities/social science with each country.
3) Japan will contain software business from the 1996 fiscal year.
4) Germany is Old Federal Republic of Germany till 1990, and is the Unified Germany in 1991 and afterwards.
5) The 1998 value of France is assumption value.
6) 1998, 1999 of the U.S. are numerical reserve value.

Source: Japan – Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
U.S. – NSF, "National Patterns R&D Resources 1990 Data Update".
Germany – BMBF, "Faktenbericht 1998".
France/U.K. – OCED, "Main S&T Indicators 1999/1" ("Basic Science and Technology Statistics "up to 1992)
Purchasing Power Parity – OCED, "Main S&T Indicators 1999/2", "National Accounts, 1999"

See: appendix table 5-1-1

Figure 5-1-2 Trends in number of R&D scientists/engineers in industry in selected countries



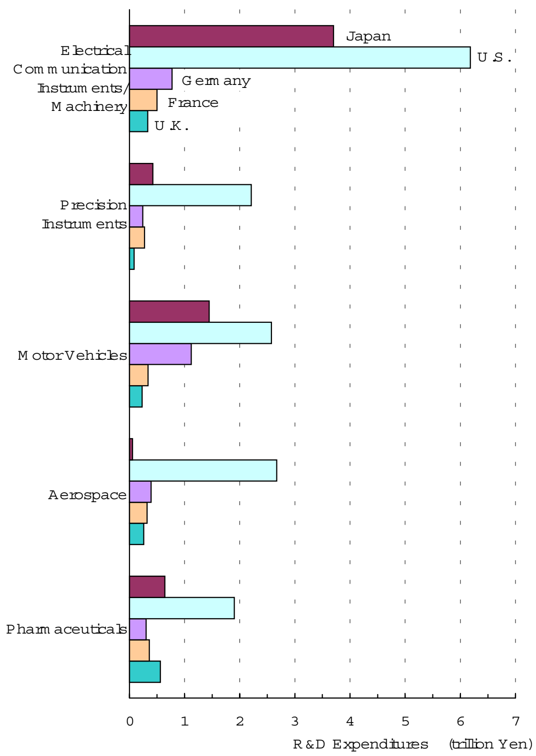
Note: 1) Japan R&D Scientists and Engineers are not used FTE. Data for Japan include software industry since 1997.
2) Other data same as figure 5-1-1
Source: Japan – Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"; U.S. – NSF, "National Patterns of R&D Resources 1998"; Germany – BMBF, "Bundesbericht Forschung 1996", "Faktenbericht 1998"; France – OECD, "Main S&T Indicators 1999/2" ("Basic Science and Technology Statistics" up to 1990); U.K. – OECD, "Main S&T Indicators 1999/2 ("Forward look" up to 1990)
See: appendix table 5-1-2

When comparing the number of R&D scientists and engineers in the selected countries in Chapter 3 (Fig. 3-1-6), an estimate was made attempting to convert the number of Japan's R&D scientists and engineers into full-time R&D scientists and engineers. In doing so, the number of R&D scientists and engineers in Japan's industrial sector were multiplied by a compensating factor of 0.7.

When multiplying by this compensating coefficient, the number of R&D scientists and engineers in Japan's industrial sector in 1999 was approximately 300,000. Using this value to make a comparison taking into account differences in population, Japan's number of R&D scientists and engineers is higher than that of the three European countries.

Next we will compare R&D expenditures in industry in the five selected countries according to major industries (Fig. 5-1-3). Industrial classifications in R&D statistics vary from country to country, so industrial classifications have been grouped together to some extent to enable comparison. In addition, to make a direct comparison of R&D expenditures, figures for countries other than Japan were converted to yen using the OECD's purchasing power parity.

Figure 5-1-3 Major industrial R&D expenditures in selected countries
(By the major industries; purchasing power parity; 1997)



Notes: 1) Other industries are included in "The electronic communication instruments/machinery" of Japan and the U.S. and "the motor vehicles" in the U.S.
2) Since the value by industry was unknown, "Aerospace of Japan added up the research and development cost about the airplane in "Machine industries for transportation other than the motor vehicles."
Source: OECD, "Basic Science and Technology Statistics 1998"
See: appendix table 5-1-3

The electrical communication instruments machinery industry is a major industry of both Japan and the U.S., and the sector that accounts for the largest portion of R&D expenditures in both countries. The U.S.'s R&D expenditures in this industry are 1.7 times greater than those of Japan.

On the other hand, in the precision instruments industry, the U.S.'s figure is far larger than that of other countries. Japan's R&D expenditures in this industry are slightly higher than those of Germany and France.

Japan's R&D expenditures in the motor vehicles industry are higher than those of Germany, France, and the U.K., but the U.S. uses 1.8 times the R&D expenditures of Japan.

Japan's R&D expenditures in the aerospace industry are extremely small compared to other major industrialized countries, while the U.S. invests a great deal of money in this area. While there are some countries where R&D in aerospace is carried out by the public sector, care needs to be taken of the fact that there are some R&D expenditures that do not appear here.

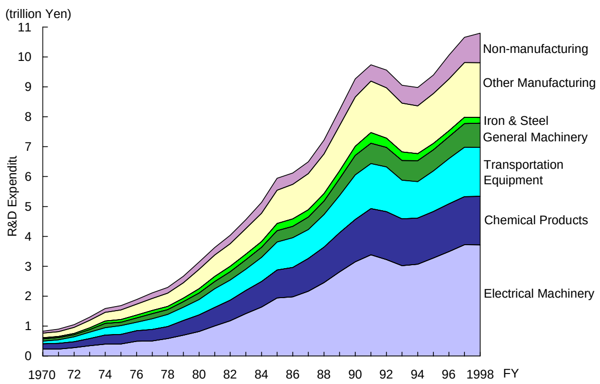
With regards to the pharmaceutical industry, while there is a great difference between Japan and the U.S., Japan still exceeds the figures of the other countries.

In addition to the above, although not displayed in the graph, the U.S. and the U.K. invest a large amount of R&D expenditures in the service industry sector. Of the service industry sectors of both countries, industries that account for a large percentage of R&D expenditures are finance, insurance, computer services, and R&D. In addition, statistics concerning R&D in the service industry sector vary greatly from country to country according to way the applicable industries are selected, and concepts and definitions of R&D in these industries is not clear, which makes an appropriate international comparison difficult under the current circumstances. In Japan's R&D statistics, industries deemed to be service industries are transport, communications, public service and software industries, but finance/insurance, retailing and wholesaling industries are not included.

5.2 Characteristics of R&D in Japan's Industry

Taking a look at a breakdown of R&D expenditures of Japan's industrial sector by key industries (Fig.5-2-1), the electrical machinery manufacturing industry has consistently accounted for the largest percentage, followed by the chemical products manufacturing industry and the transportation equipment industry. These three highest-rating industries alone account for some 64.6% (FY1998) of corporate R&D expenditures. They also account for 43.2% (FY1998) of Japan's total R&D expenditures. This proves that the electronics, motor vehicle, and chemical products manufacturing industry (including drugs and medicines) together account for a large portion of Japan's R&D.

Figure 5-2-1 Trends in industrial R&D expenditures in Japan

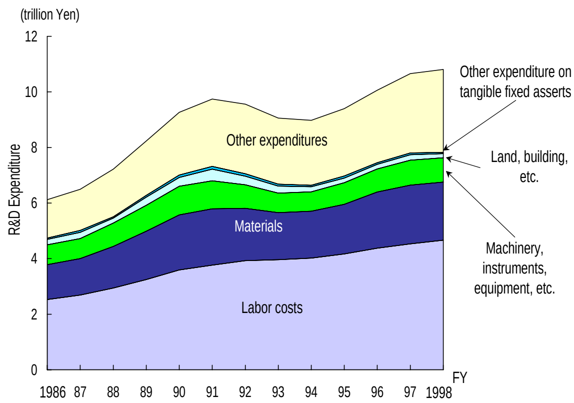


Note: Data are include software industry since FY1996
Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 5-2-1

Looking at trends in the percentage of R&D expenditures of all industry accounted for by these three industries, the electrical machinery manufacturing industry continued a general increase from FY1980 to FY1991, but from FY1992 it has moved sideways while undergoing repeated fluctuations. R&D expenditures in the chemical products manufacturing industry were in long-term decline until FY1990, but from FY1992 they have moved sideways. The transportation equipment industry continued to increase up until FY1978, but has been in long-term decline since FY1979.

R&D expenditures used internally by the industrial sector, when viewed according to expenditure items, show that labor costs are the highest, with labor costs in FY1998 amounting to 4.6654 trillion yen, accounting for 43.2% of the total amount of R&D expenditures used internally in that year (Fig.5-2-2). Looking at the trends up until this point in time, against a background of fluctuations in total R&D expenditures due to changes in economic conditions, the amount of labor costs has not undergone any great changes. The percentage of labor costs accounted for according to changes in R&D expenditures overall was less than 40% due to an increase in other expenditures in FY1989-FY1991, but in other years it has generally ranged from 40% to 45%.

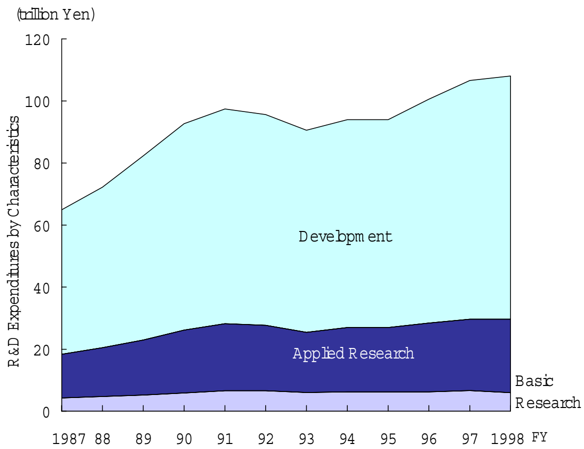
Figure 5-2-2 Trends in breakdown of industrial R&D expenditure by items



Note: Data are include software industry since FY1996
Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 5-2-2

In other expenditure items, the percentage accounted for by miscellaneous expenditures is increasing. Although details are unclear, this category may be regarded as including the expenditure incurred in obtaining and processing a variety of different types of information and data. Raw materials expenditures have remained at around 20% through the whole period. Land and buildings accounted for 4.3% of the total in FY1991, but by FY1998 this had fallen to 1.4%. In addition, the percentage accounted for by machinery, instruments and equipment has been in excess of 10% up until FY1991, but from around FY1995 it was between 8% and 9%.

Figure 5-2-3 Trends in industrial R&D expenditures by characteristics in Japan



Note: Data are include software industry since FY1996
Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 5-2-2

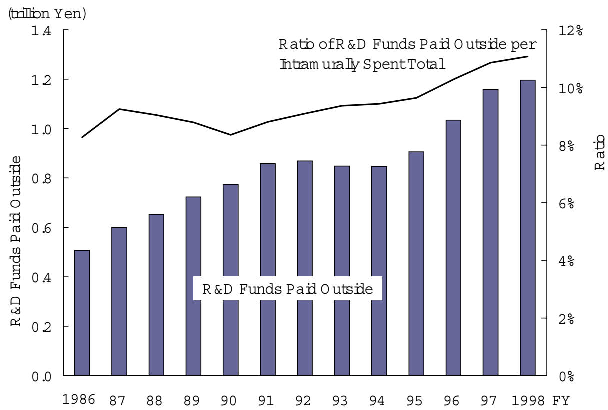
Looking at Japan's R&D expenditures in industry by nature (basic R&D expenditures, applied R&D expenditures, and development expenditures), in FY1998 development expenditures were high at 78.4%, followed by applied R&D expenditures with 23.6%, and basic R&D expenditures at 6.0% (Fig. 5-2-3). Looking at trends in these figures, basic R&D expenditures has few long-term fluctuations, while development expenses fluctuate greatly, having a great impact on fluctuations in R&D expenditures as a whole. Fluctuations in R&D expenditures of the industrial sector are linked to fluctuations in the economy, but it is clear that the main area of fluctuation is development expense.

Corporate R&D is not always carried out within one's own company; there are cases where it is commissioned to a party outside the company. In such situations, it is possible to gain a picture to some extent by looking at the R&D expenditures paid to outside parties.

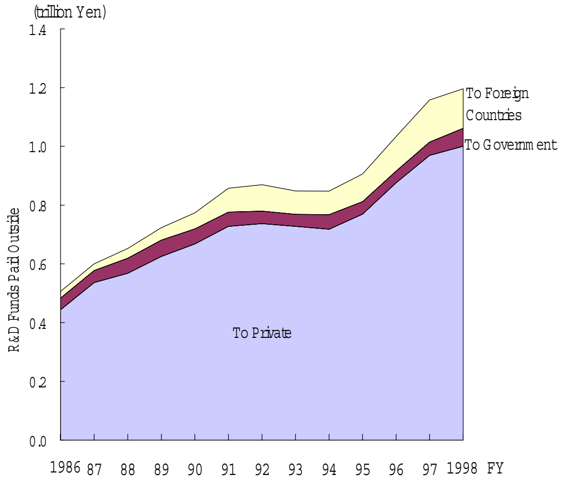
In FY1998 Japanese companies paid 1.1960 trillion yen in R&D expenditures to outside parties. This is equivalent to 11.1% of the total R&D expenditures used internally by companies during the same year (Fig. 5-2-4). Looking at trends in these figures, these figures fell in FY1993 and FY1994, after which they have been on the increase. In addition, the figures as a percentage of R&D expenditures used internally have also been continuing to increase each year since FY1991.

Figure 5-2-4 Trends in R&D funds paid by industry in Japan

(A) Ratio of total R&D expenditures per total amount



(B) Breakdown of the externally incurred R&D expenditures

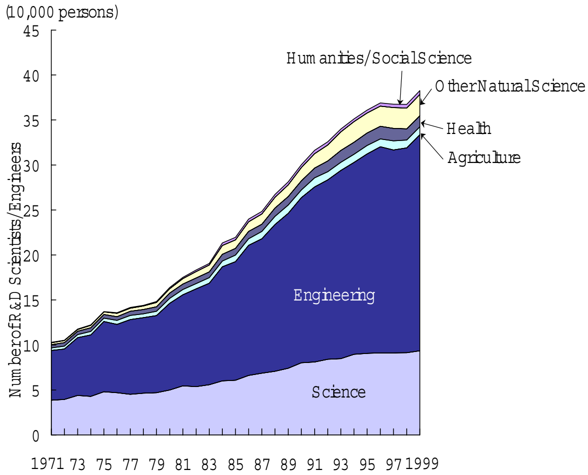


Note: Data are include software industry since FY1996
Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 5-2-4

Looking at a breakdown of the externally incurred R&D expenditures according to where payments were made (Fig. 5-2-4 (B)), payments to the domestic private sector accounted for the majority. In FY1998 the private sector accounted for 83.6% of such expenditures. Although the breakdown of payments to the government is unclear, the "government" referred to here includes national and public universities, and it is thought that this figure would be made up largely of payments to these universities.

With regard to the number of R&D scientists and engineers in the industrial sector, looking at the breakdown by specialization, engineering accounts for the largest percentage, followed by science (Fig. 5-2-5). With regard to the number of R&D scientists and engineers in FY1998, engineering and science together accounted for 87.2% of the total.

Figure 5-2-5 Trends in Number of R&D scientists/engineers in industry by specialty in Japan



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

5.3 Development of R&D Strategies in Japan's Industry

5.3.1 R&D Intensity

R&D intensity is an indicator that shows the level of effort corporations are devoting to R&D. The ratio of R&D expenditures to sales (intensity of R&D expenditures) and the ratio of R&D scientists and engineers to the total number of employees (intensity in the number of R&D scientists and engineers) will be used here as indicators of R&D intensity.

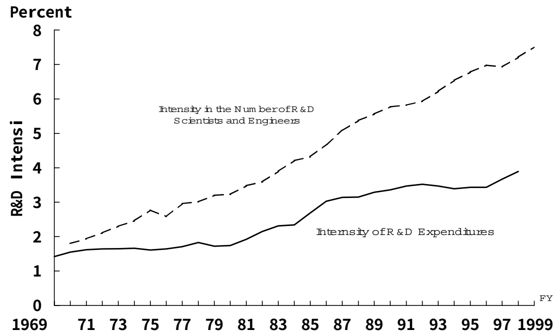
(1) Trends in R&D Intensity

The ratio of R&D expenditures to sales for industry as a whole in FY1998 was 3.14%, and that of manufacturing alone 3.89% [1]. The R&D intensity of the manufacturing industry in terms of R&D expenditures is 1.24 that of industry as a whole (comparing the R&D intensity of both). The ratio of R&D scientists and engineers to the total number of employees for industry overall was 5.55%, and that of manufacturing 7.21%. The R&D intensity of manufacturing in terms of personnel is 1.30 times that of industry as a whole, and this is slightly higher than when viewed from the perspective of R&D expenditures.

Taking a look at the change over time in these intensities for the manufacturing industry (Fig. 5-3-1), the R&D intensity of R&D expenditures remained fairly constant throughout the 1970s, but grew substantially during the 1980s, and that level was maintained into the 1990s. Intensity dropped off temporarily in the mid 1990s, but in FY1998 a record maximum of 3.89% was recorded.

Meanwhile, the intensity in the number of R&D scientists and engineers is increasing almost linearly over the long term. Intensity continued to increase even during the mid 1990s when there was a contraction in R&D expenditures, and the gap with intensity in R&D expenditures is widening.

Figure 5-3-1 Trends in R&D Intensity



Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 5-3-1

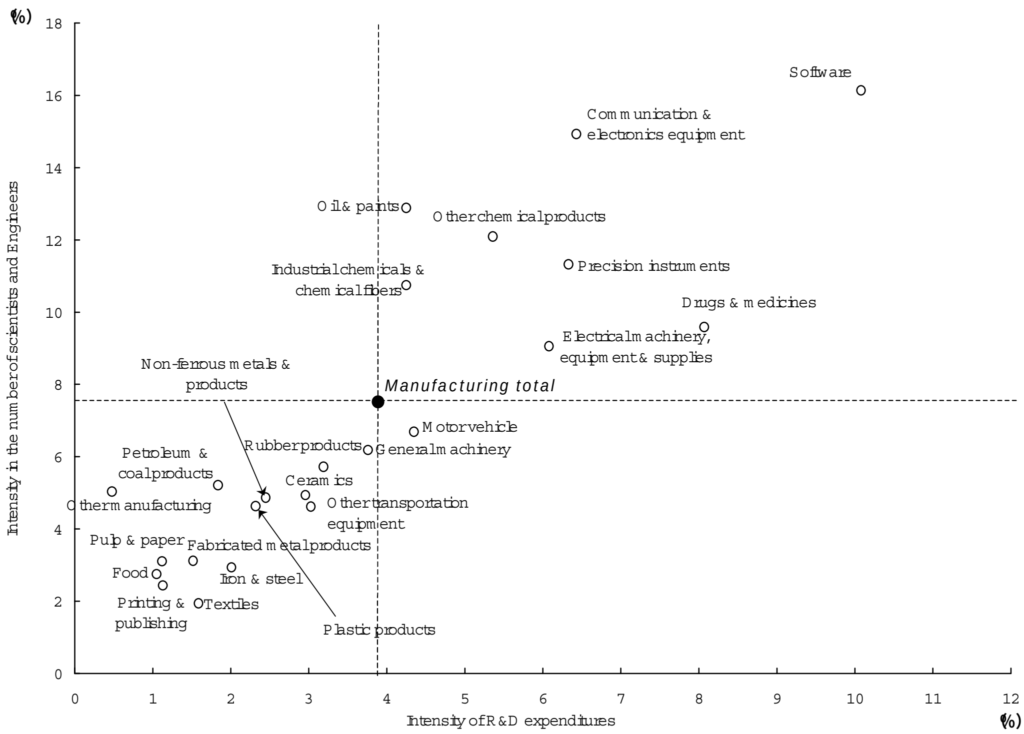
(2) Intensity by Industrial Category

Fig. 5-3-2 shows R&D intensity by industrial category. The horizontal axis shows R&D intensity for R&D expenditures while the vertical axis shows R&D intensity for the number of R&D scientists and engineers. These figures are plotted for each industrial category in FY1998.

The highest intensity in R&D expenditures was the 10.1% recorded by the software industry. This was followed by the drugs and medicines industry with 8.1% and the communication and electronics equipment industry with 6.4%, the precision instruments industry with 6.3% and the electrical machinery, equipment and supplies industry with 6.1%. One can see that R&D expenditures intensity is highest in high-tech industries. Next in line in intensity is the other chemical products manufacturing industry and other chemical products manufacturing industries.

[1] However, these are the value only about the company that is doing research and development.

Figure 5-3-2 R&D Intensity by industrial category



Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 5-3-2

The intensity in the number of R&D scientists and engineers is high in the software industry (16.1%), the communication and electronics equipment and electric gauges industry (14.9%), the oils and paints industry (12.9%), the other chemical products manufacturing industry (12.1%), and the precision instruments industry (11.3%). The order of intensity here is somewhat different to the order of intensity in R&D expenditures.

Intensity in R&D expenditures and intensity in R&D scientists and engineers, except for a number of industrial categories, are generally in a correlative relationship.

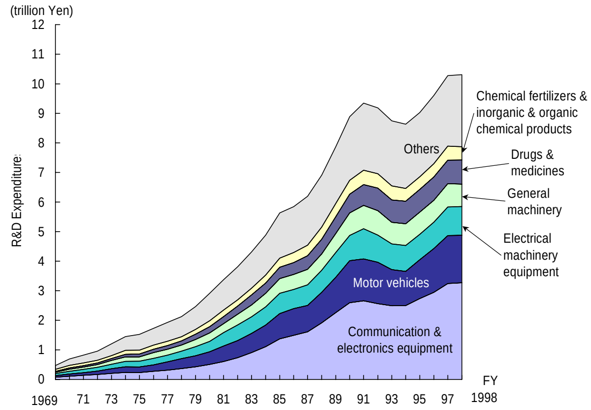
5.3.2 R&D Expenditures by Product Area

Here the areas in which R&D is being conducted by Japanese industry will be analyzed by dividing R&D expenditures according to product area. For example, in the case of motor vehicle companies conducting R&D in the area of electronic equipment, those R&D expenditures would not be classified as R&D expenditures for the motor vehicle industry but rather as R&D expenditures in the electronic equipment area. In other words, R&D is classified not by the industry conducting it but the area in which the R&D is conducted.

Fig. 5-3-3 shows the changes over time in industrial R&D expenditures by major product area. The area of communication and electronics equipment has consistently had the largest R&D expenditures of any area. It is followed by motor vehicles and electrical machinery equipment. R&D expenditures are also large in the areas of drugs and medicines, general machinery, industrial inorganic and organic chemicals, chemical fertilizers and chemical fibers. Growth in R&D expenditures for the drugs and medicines area has been greater in the 1990s compared to the 1980s, and from 1993 it has recorded slightly higher levels than the amount of R&D expenditures in general machinery.

The growth in R&D expenditures has since FY1980 been greatest in the area of communication and electronics equipment, and its share of the R&D expenditures of all areas is also rapidly increasing. This share did, however, drop from FY1992 to FY1994, but the percentage continues to increase, with the share of the R&D expenditures of all areas reaching 31.7% in FY1998. The share of R&D expenditures in the area of motor vehicles to those of all areas fell temporarily in the 1990s, but from FY1995 has been increasing, with a figure of 15.6% recorded in FY1998.

Figure 5-3-3 Trends in R&D expenditure By products fields



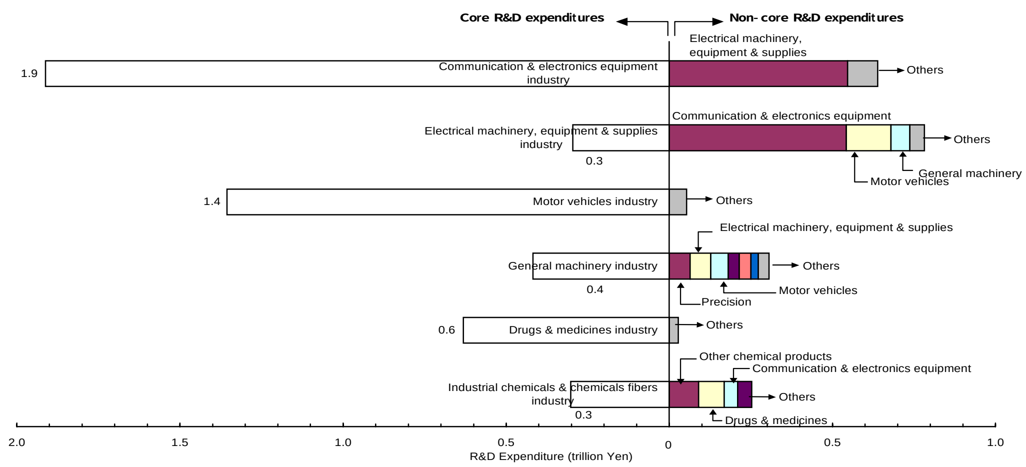
Note: It is aimed at the company etc. of the capital 100 million yen or more. "Electrical machinery" includes "Household electrical appliances"

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

See: appendix table 5-3-3

The following section analyzes the R&D expenditures by product area for key industries. Fig. 5-3-4 shows a breakdown of core R&D expenditures by industry on the left and non-core R&D expenditures on the right by industry for the six main industries that are users of R&D expenditures.

Figure 5-3-4 Major industrial R&D expenditures by product field



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

See: appendix table 5-3-4

In the communications and electronic equipment industry, R&D expenditures in the core business of communications and electronic equipment is high at 1.9125 trillion yen. R&D expenditures in the non-core business is 638.7 billion yen, but the majority of this is being directed to electrical machinery, equipment and supplies, a related sector.

In the electrical machinery, equipment and supplies industry, a large percentage of R&D expenditures are directed towards communications and electronic equipment, outside the core business. However, this is regarded as a non-core business under the current classification system, and it is also possible to refer to it as an area which is effectively close to its core business.

The motor vehicles industry, together with the drugs and medicines industry, directs almost all of its R&D expenditures to R&D in its core business. In both industries it is possible to make the observation that at least with regard to internal R&D, it is concentrated on core business products.

In the general machinery industry, in addition to the core business R&D expenditures of 417.9 billion yen, 306.1 billion yen is directed to non-core business product areas. This amount is spread across a relatively diverse range of sectors. This may be regarded as evidence of the breadth of applications of machinery technology.

The industrial chemicals and chemical fibers industry also has a large amount of R&D expenditures in its non-core business product areas. The amount can be broken down as follows: the other chemical products manufacturing industry and drugs and medicines and other closely-related areas account for large percentages of the total. These areas are effectively close to core business areas. However, some 7.4% of R&D expenditures are directed towards communications and electronics equipment.

Next, in order to clarify the changes over time in the nature of R&D, we analyzed the changes in R&D expenditures by product development area. In doing so we applied factor analysis to the data of R&D expenditures by product development area for each industry. Some 25-industry types were subjected to analysis, with data taken from FY1980 to FY1998. As a variable, instead of using R&D expenditures by product area as is, we use the ratios of R&D expenditures by product area. In addition, product areas were organized into industry categories, and the number of variables set at 24.

Having applied factor analysis, due to the large number of variables, no stand-out highly persuasive variables appeared, and even if the characteristic value was limited to 1 or over, some 11 variables were achieved. In this case, no general factor could explain everything with a small number, and each factor is responsible for its own specific information.

Looking at the results of factor analysis, the first factor has a particularly strong correlation with the communications and electronics equipment product area, and a relatively strong correlation with the electrical machinery equipment product area and the electricity and gas product area. It may therefore be interpreted as a factor concerned with R&D expenditures of the electronics area. The second factor has a strong correlation with the general machinery product area and the other transportation equipment product area, indicating that it is a machinery and process technology area factor.

Changes over time in the various industries will now be examined for each of these representative state-of-the-art technology areas. Fig. 5-3-5 shows movement over time in values (factor scores) for each industry for the electronics area and the machinery and process technology areas. It becomes complex if these trends are shown for all industries, so only key industries and characteristic industries have been plotted here. In these graphs, the larger the score for the industry, the more effort is being devoted to R&D in that area.

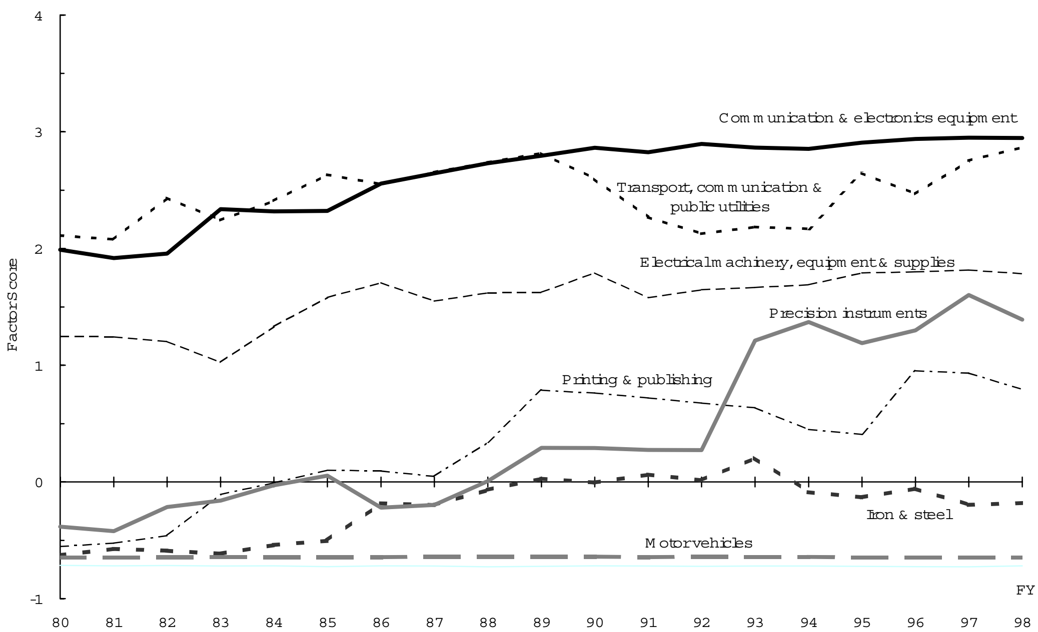
In the electronics area, values are highest for communications and electronic equipment and transport, communication and public utilities, followed by electrical machinery, equipment and supplies industry, which also scored highly. It goes without saying that these industries are the mainstays of electronics technology.

Looking at changes over time in the factor score, communications and electronics equipment industry and electrical machinery, equipment and supplies industry are clearly increasing over the long term, despite minor fluctuations. Transport, communication and public utilities were already increasing up until FY1989, but from FY1990 onwards figures have either fallen or moved sideways, increasing again from FY1995.

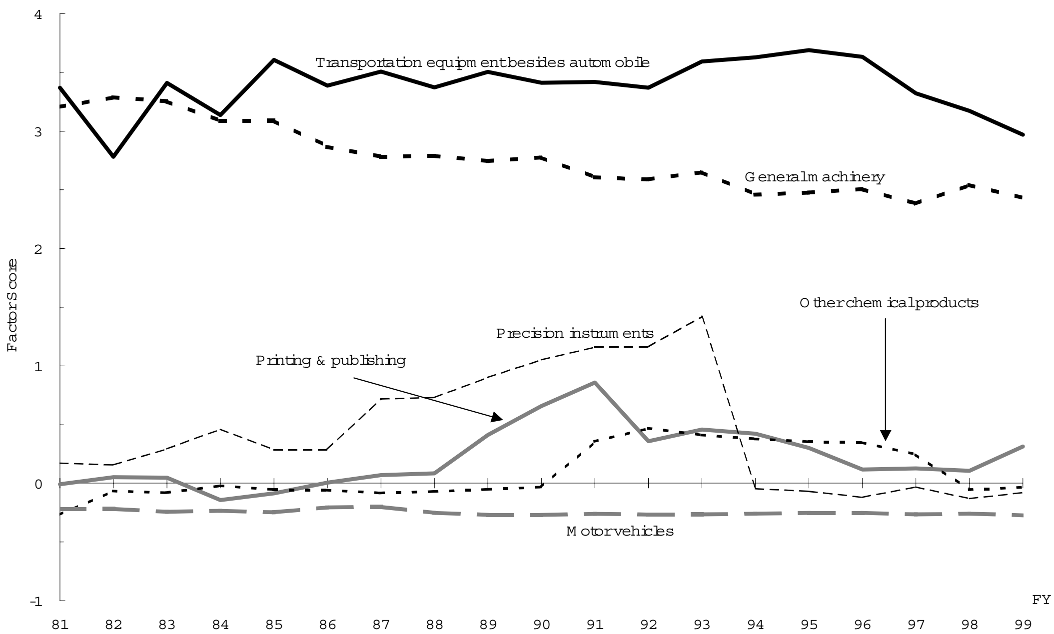
In other industries, precision instruments and printing and publishing show characteristic movements. There was a great increase in the precision instruments industry in FY1993, after which it has continued to maintain high levels. Printing and publishing recorded great increases in FY1988, FY1989 and FY1996. In these two industries, it is known that the changeover to electronic technology is taking place, and the results of analysis shown here seem to back this up.

Figure 5-3-5 R&D expenditures factor analysis result by product fields

(A) Electronic area



(B) Machinery and Process Technology area



Note: Based on the data of the Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development", the National Institute of Science and Technology Policy analyzed.
See: appendix table 5-3-5

With regard to the machinery and process technology area, other transportation equipment (transportation equipment other than motor vehicles) and general machinery recorded high values.

Precision instruments and printing and publishing also show characteristic movements in this area. The precision instruments industry recorded an increase in the factor score from the late 1980s until FY 1992, after which it recorded a great drop in FY 1994. It has remained at a low level ever since. The great change in the precision instrument industry with FY 1993 as a turning point must be considered in conjunction with the change in the values for the electronics area mentioned earlier. In this period, while the value for the machinery and process technology area continued to decline, the values in the electronics area increased, suggesting a change in the priorities of R & D. Meanwhile, in the printing and publishing industry, over several years from FY 1988, the figures for the electronics area and the machinery and process technology area both increased. In FY 1992, while the figure for the machinery and process technology area underwent a relatively large reduction, the value for the electronics area shows a gradual decrease from FY 1990. This is regarded as evidence of a change in product development areas.

In addition to the two industries mentioned above, a noteworthy feature is the increase in the machinery and process technology area from FY 1991 in the other chemical products manufacturing industry.

Japan's Venture Companies

In today's business situation, where the creation of new industry is regarded as an issue of importance for Japan, it is extremely important to gain a clear picture of the situation concerning so-called venture companies. However, there is inadequate data concerning venture companies and venture business in Japanese statistics, not only R&D statistics. Not only are the definition and scope of venture companies unclear, but there are many small companies, which are for the large part inadequately covered in statistical surveys.

The National Institute of Science and Technology Policy carried out a questionnaire survey by post in 1998 in order to obtain basic data concerning Japan's venture companies, and has published a report on the results of analysis (Reference [8]). The main analysis results are presented below in accordance with this report.

Companies Researched

In order to give as broad a scope as possible to venture companies, questionnaires were sent out to all companies listed in the Nikkei: Annual Corporation Reports of Venture Business (FY1998 Edition). The person responsible for managing the company (President) was asked to fill in the answers to the questionnaire. Questionnaires were mailed out in August 1998, with valid responses received from 1007 companies, giving a response rate of 42.2%.

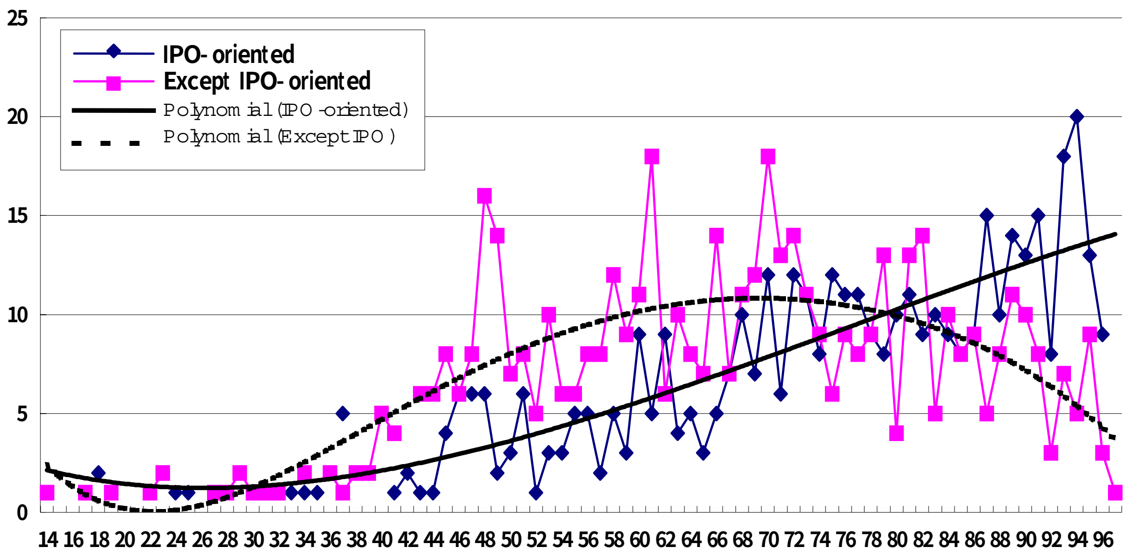
Some 639 companies that sent in valid responses belonged to the manufacturing industry (63.3%), 125 to the information industry (12.5%), and 240 companies in the service industry (23.9%), making for a structure in which there is no relative bias including any of the companies. The average number of employees of companies that responded to the survey was 112.7, while average capital was 202 million yen and average sales were 3.203 billion yen.

Key Survey Results

The most recent ratio of R&D expenditures to sales of companies that responded to the survey was 6.5% as an overall average, more than double the average of 2.85% for all of Japan's companies on the whole (Figures for FY 1997. See Fig. 5-3-1 and Table 5-3-1). Looking at the same figures according to the three industry categories, the figure for manufacturing was 6.4%, for the information industry the figure was 11.8%, and for the service industry the figure was 3.8%. Clearly the ratio of R&D expenditures to sales is highest in the information industry.

Looking at the year of establishment of the companies, a large number of companies were established in 1970 or later, but a large number were also established before 1970, giving a wide distribution. A recent trend, however, is the marked increase in the establishment of companies whose management is aiming for a listing on the stock exchange (companies whose management replied that they were "striving towards a public listing"), and a steady increase in the number of R&D-oriented companies (companies whose ratio of R&D expenditures to sales is at least 10%). Japan's venture business, which is often regarded as being low-key, does have aspects which may lead to future expectations (Fig. A).

Figure A Distribution of the year of establishment of the venture companies



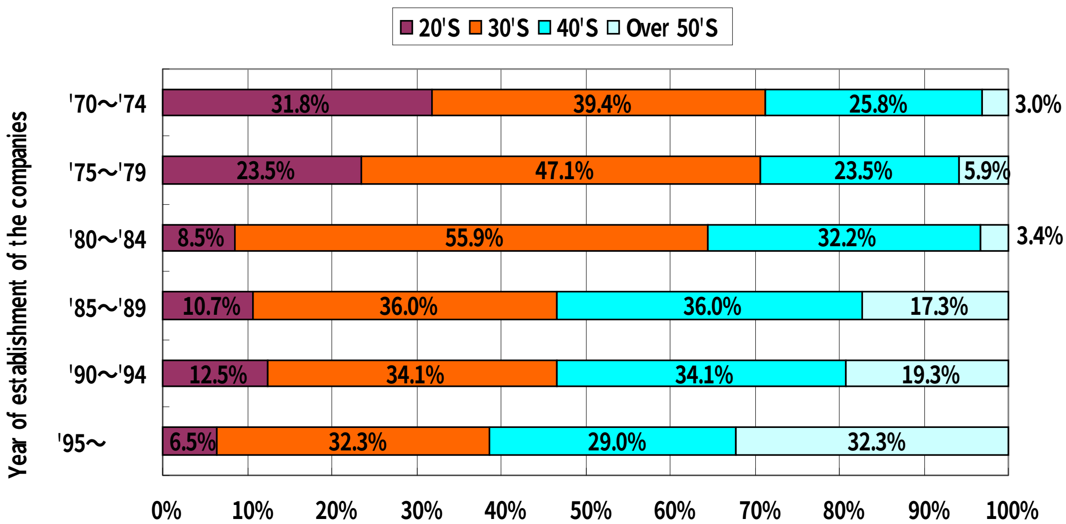
Note: IPO-oriented – Companies whose management replied that they were "striving towards Initial Public Offering (IPO)"
Source: Science and Technology Agency, National Institute of Science and Technology Policy, "Research into Japan's Venture Companies and Founders" (NISTEP Report No.61), (March 1999)

A feature of founding management (respondents who founded the company) was that their average age was 55.2 years old, indicating that the management of Japan's venture companies is generally quite old.

On the other hand, their age when they founded their companies was 37.4 years on average, which is not necessarily old, but the new companies created in the past 10 years have an average age of founders that is at least 5 years older than it was 10 years previously, indicating an increase in the age of at which founders start venture companies (Fig.B).

By looking further at data about founding managers, characteristics of Japan's technology venture companies become evident. Firstly, with regard to the age of the founder, making a comparison of R&D-oriented companies and other companies, the age for R&D-oriented companies tends to be somewhat older. This seems to suggest that R&D-oriented companies are based on the elements of skills based on many years of practical experience and knowledge gained through experience. Secondly, looking at the academic careers of the founding managers, some 6.4% have completed graduate school, and 57.6% have graduated from university, indicating that only a very small percentage of companies are founded based on high levels of academic advancement in the form of graduate school. A large percentage of the previous occupations of founding presidents is accounted for by engineers of large companies, engineers of small and medium-sized companies and managers of small and medium-sized companies. Taking into account these factors together, it is clear that there are few technical venture companies in Japan that are based directly on higher education.

Figure B Age of founder when founded venture companies



Source: Science and Technology Agency, National Institute of Science and Technology Policy, "Research into Japan's Venture Companies and Founders" (NISTEP Report No.61), (March 1999)

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Chapter 5
Hiroyuki Tomizawa
Yumiko Kanda

Chapter 6 R&D Achievements

6.1 Scientific Papers

As an indicator of science and technology achievements, the data related to scientific papers has become increasingly important in recent years. Despite the difficulty in directly measuring the achievements of R&D activities, particularly scientific research achievements, it is now possible to obtain a variety of data on scientific papers due to the completion of scientific literature databases. It is under these conditions that various data are being created throughout the world, from which a variety of indicators are being developed.

When creating such indicators, Science Citation Index (SCI) - a database of scientific and technological literature - is often used. The SCI is particularly useful because it covers all areas of science and technology. The SCI is particularly useful because it is a database from which it is possible to obtain data about the citations of papers, and it covers all areas of science and technology. Compared to other databases specializing in specific areas, however, the SCI database has only a small number of papers in each area and contains mainly papers in English. The indicators calculated for scientific and technological papers in this section are based on the NSI Database, which was in turn created based on the SCI.

6.1.1 International Comparison of Output of Papers

The R&D achievements of each country can be quantitatively examined by totaling the number of papers published by each country. Virtually the only method for calculating the totals for each country is based on the location of the facility to which an author belongs, and the data used in this book was obtained by this method. Papers authored by several people belonging to facilities with locations in different countries (known as internationally joint-authored papers) were double-counted as papers of the respective countries.

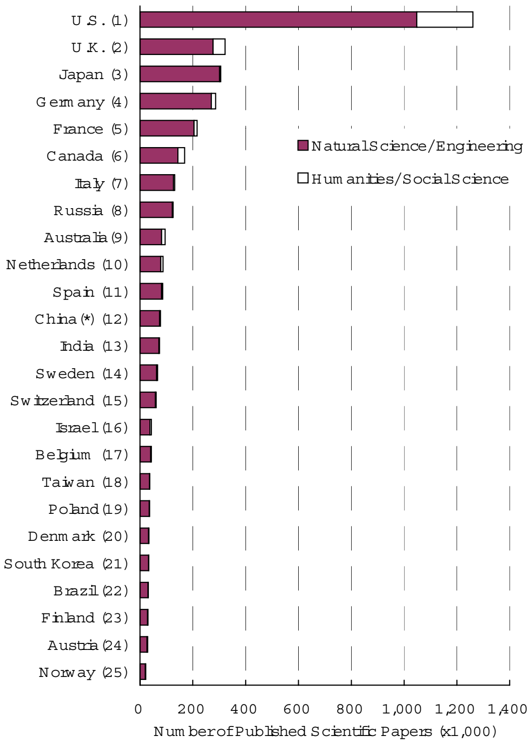
In the five year period up to 1998, the total number of papers recorded in the SCI database by country show the US with the majority, followed by the U.K., Japan, Germany and France, as seen in Figure 6-1-1. However, if we exclude the humanities and social sciences, and consider only the natural sciences and engineering, Japan and the U.K. switch positions, with Japan becoming the second most prolific publisher of literature in the world.

The breakdown by region shows that 15 of the top 25 countries are European. In Asia, the top 5 countries are China (12th), India (13th), Taiwan (18th) and Korea (21st), excluding Japan.

The R&D indicators dealt with in this book include both the natural sciences and engineering, as well as the humanities and social sciences, with the statistics shown in Figure 6-1-1 also including the literature for the humanities and social sciences. Due to many differences between the conditions for recording the natural sciences and engineering, and the humanities and social sciences in the SCI Database, however, the literature for the humanities and social sciences will be excluded after the figure below. In Figure 6-1-1, the countries which account for the highest ratios of literature in the humanities and social sciences are the English-speaking countries of the U.S., the U.K., Canada and

Australia. This is likely because of the inclination towards English literature in the collection of data for the humanities and social sciences. Although this inclination exists in the natural sciences and engineering as well, it seems far more prevalent in the humanities and social sciences.

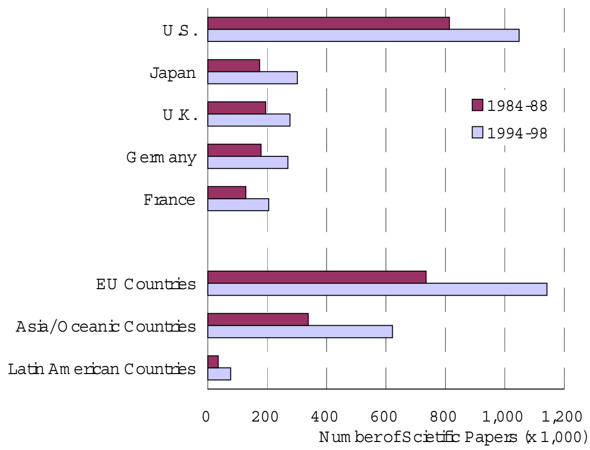
Figure 6-1-1 Number of published scientific papers by country: top 25 countries



Notes: 1) It is the sum total for five years for 1994-98 years.
2) The value by the country was counted in the whereabouts country of an author's affiliation organization.
3) Duplication appropriation of the international collaboration paper is carried out in each author's affiliation country.
4) The number of papers of Hong Kong is also included in China.
Data: Based on the data of the Institute for Scientific Information, and "National Science Indicators on Diskette, 1981-1998", the National Institute of Science and Technology Policy re-calculated.
See: appendix table 6-1-1

Next we examine the conditions surrounding the increase in the number of published papers by making a comparison between the five-year periods from 1994 to 1998 and 1984 to 1988 (see Figure 6-1-2). The SCI database as a whole (excluding the humanities and social sciences) increased by 36.7% during this period.

Figure 6-1-2 Change in number of published scientific papers by selected countries/nations (natural science and engineering)



Notes: 1) The paper of a humanities/social field was removed. (Refer to text).
2) EU countries are the sum total of the 15 nations of the present member nations. The countries in Asia Oceania contain Japan.
Data: Based on the data of Institute for Scientific Information, "National Science Indicators on Diskette, 1981-1998 (Deluxe version)", the National Institute of Science and Technology Policy totaled.
See: appendix table 6-1-2

The rate of increase by country was 28.9% for the U.S., 72.7% for Japan, 42.0% for the U.K., 50.9% for Germany and 60.6% for France. Japan had the largest increase of the five countries.

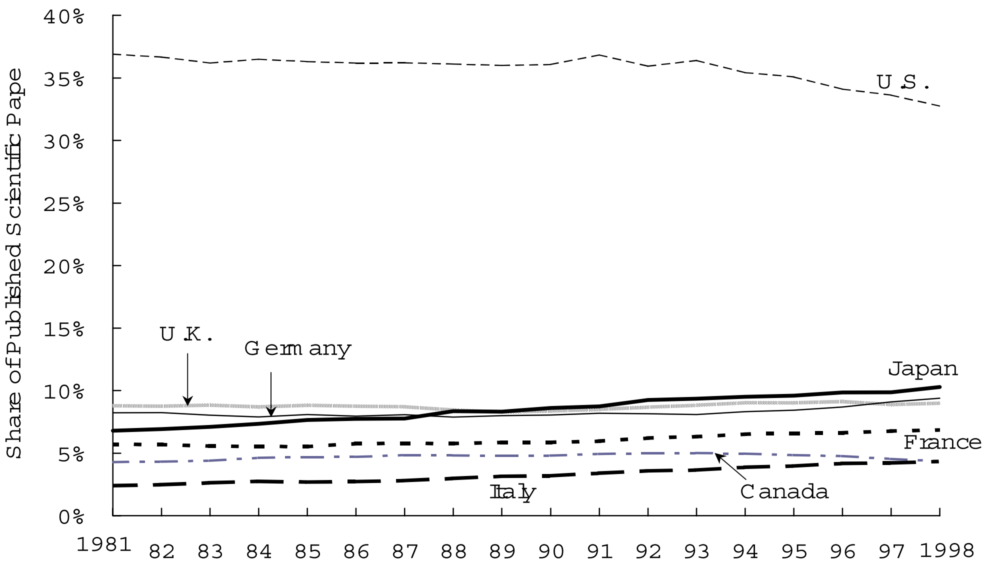
In the breakdown by region, those regions which traditionally had the fewest papers published had the largest increases in rates - among them, Latin America with 118.6% and Asia and Oceania with 83.8%. In contrast, the increase for the EU countries was 55.4%, representing an increase of around 410,000 publications, which is a remarkable increase nonetheless, given that it accounts for around half of the total increase in the SCI Database (around 820,000 publications). Compared to the total increase in the rates for the SCI, the increase in rates for countries and regions other than the U.S. is high, although these increases are partly accounted for by the international joint-authorship of papers.

To make an international comparison of the achievements of Japanese R&D activities, it is appropriate to base them on the world share. Figure 6-1-3 shows the trends in the shares of the output of papers by country. Since 1990, Japan has been second only to the U.S. in the output of publications in the natural sciences and engineering. In 1998, among the 643,000 papers in the SCI - excluding the humanities and social sciences - the U.S. accounted for 211,000 (32.8%), while Japan accounted for 66,000 (10.3%).

During the period shown in the figure, the U.S. consistently had an overwhelming share of over 30% of world output, despite a decline starting in the 1990s. The output itself has leveled off, but the reason for this decline in share is not so much because of a reduction in the output of papers in the U.S., as it is an increase in the output by other countries.

Among these other countries, the shares for Germany, France and Italy increased steadily in contrast to the leveling off or reduction in the shares for the U.K. and Canada from the mid-1990s. In comparison to the traditionally high output of English-speaking countries like the U.S., the U.K., Canada, and so on, there has been a noticeable increase in the number of papers from non-English speaking countries.

Figure 6-1-3 Trends in country share of published scientific papers (natural science and engineering)



Note: The paper of a humanities/social field was removed.
Data: Based on Institute for Scientific Information, "National Science Indicators on Diskette, 1981-1998 (Deluxe version)", the National Institute of Science and Technology Policy totaled.
See: appendix table 6-1-3

Because the SCI Database, used here for calculation purposes, contains predominantly English-language papers, it could be claimed that there is an underestimation in output for non-English speaking countries. Nonetheless, with the extraordinary development in the globalization of scientific and technological activities, English-language papers are becoming increasingly important, and in this sense, it can be argued that this indicator realistically shows the influence of papers from each country. Moreover, the increase in the share of papers from non-English speaking countries demonstrates an apparent increase in papers written in English in those countries.

Consideration must be given to the international joint authorship of papers in the analysis of the output of papers, since the increase in the international joint authorship of papers is one of the most extraordinary trends among those affecting the output of papers. According to a certain survey in which specific journals in the SCI are investigated, among all scientific papers, the number of papers increased by 20% in 1995 compared to 1981, while internationally joint-authored papers increased by three times (see Reference [1]).

In the same survey, the situation in each country was also examined, and showed that the proportion of internationally joint-authored papers was 25 to 40% of the total in the majority of countries around the world. The proportion in Japan, however, was a low 15%.

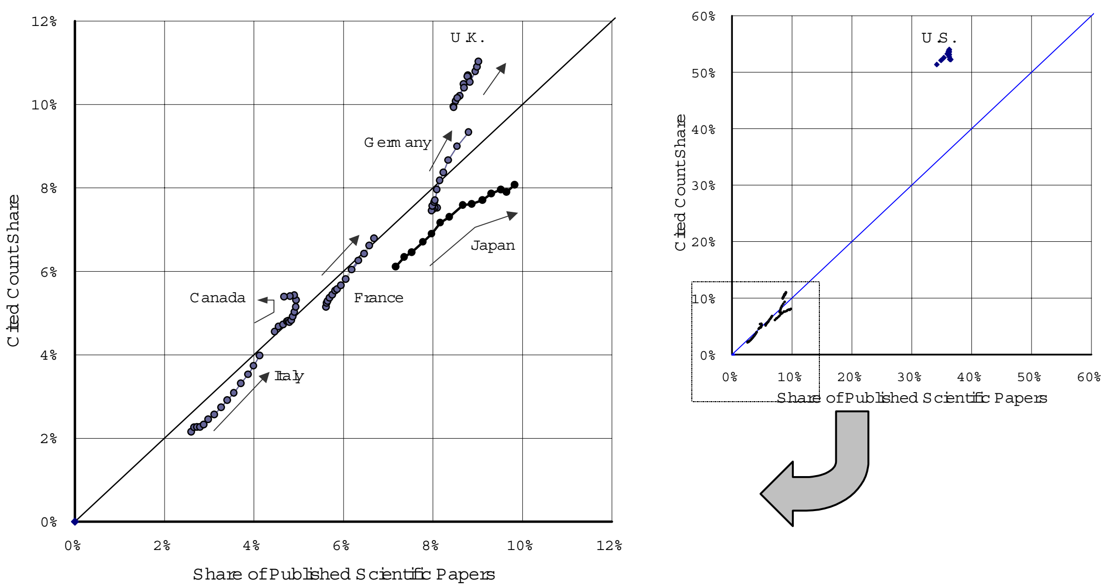
Next, we discuss the frequency of scientific paper citations as an indicator of the qualitative aspect of the output of papers. The frequency of scientific paper citations is the number of times a paper is cited by other papers, and can be considered to reflect its influence.

Figure 6-1-4 shows the relationship between two values: the share of papers on the horizontal axis, and the share of citations on the vertical axis. The straight line (slope = 1) in the figure shows equality between the share of published papers and the share of citations. Points on the line have a citation share equal to the world average; in other words, the number of paper citations matches the output of scientific papers. For points above this line, the citation share is higher than the paper share, meaning that the impact of the papers exceeds the world average.

The U.S. has the largest share of papers and its citation share is higher than its paper share, with almost half of the papers cited throughout the world being of U.S. origin. Thus once can see the enormous impact of U.S. papers. Following the U.S. in citation share is the U.K.. The U.K. also has a citation share higher than its paper share, and thus its papers can be considered to have a high impact. The trend for the U.K. citation share declined until 1988, but rose after 1989. Japan's citation share was ranked fourth in the world in 1994. However, its plot is below the straight line during the period shown in the graph, indicating that its citation share was small relative to its paper share, thus suggesting that the impact of Japan's papers is not very high. In addition, the growth of its share of citations has slowed. Despite almost no increase in the paper shares of Germany and France, their citation frequency shares have risen.

The fact that Japan's citation share is below the average for the leading western countries is partly due to the bias of the SCI Database towards English-speaking countries, as previously mentioned. However, this indicator reflects the fact that English-language publications are the mainstream of science and technology output, and in this sense, shows the actual impact of Japanese papers.

Figure 6-1-4 Trends in cited count share in selected countries (1981-1998)

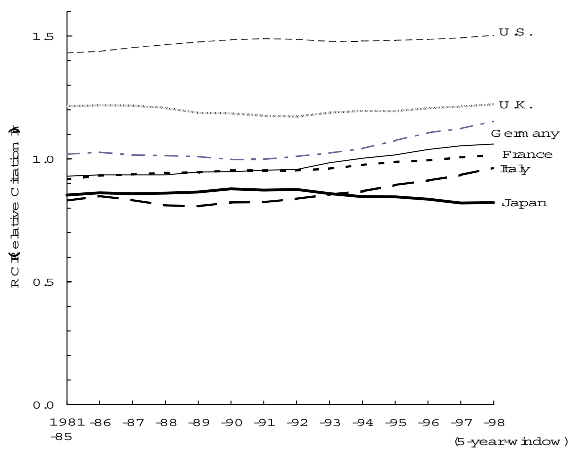


Notes: 1) It is the value of only natural science and engineering.
2) 5 overlapping-year was used as a "year".
Date: Based on the data of Institute for Scientific Information, "National Science Indicators on Diskette, 1981-1998 (Deluxe version)", the National Institute of Science and Technology Policy totaled.
Source: appendix table 6-1-4

The fact that Japan's citation share is below the international average is shown even more clearly by the relative citation index in Figure 6-1-5. The relative citation index is found by calculating the number of citations per paper for each country, and dividing this number by the international average. The international average for the frequency of citations is set at one.

The value for Japanese papers from 1994 to 1998 was 0.82, which was below the international average, and was even lower than the 0.88 from 1986 to 1990. Of the other countries, the values for the U.S. and the U.K., which had high relative citation indexes to start with, showed no increase, whereas the values for Germany, France, Italy and Canada show conspicuous increases from the beginning of the 1990s. The increase in the paper shares of Germany, France and Italy are also particularly noticeable.

Figure 6-1-5 Trends in RCI of scientific papers in selected countries



Note: 1) It is the value of only natural science and engineering.
2) 5 overlapping-year was used as a "year", and "-98" means for five years from 1994 to 1998.
Data: Based on the data of Institute for Scientific Information, "National Science Indicators on Diskette, 1981-1998 (Deluxe version)", the National Institute of Science and Technology Policy totaled.
See: appendix table 6-1-5

6-1-2 Number of Scientific Papers by Area of Research

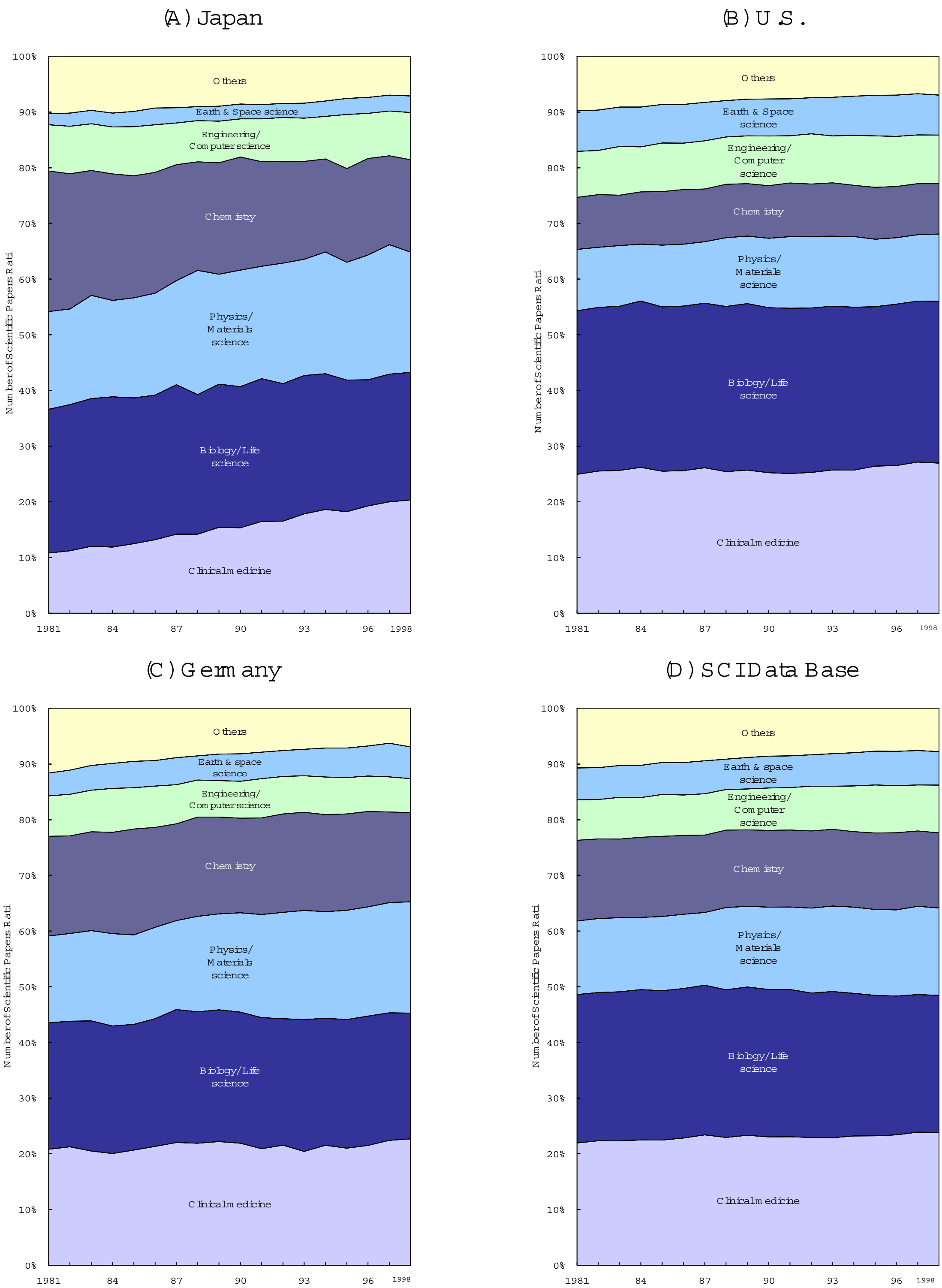
Indicators by area of research are extremely important in clarifying the R&D characteristics of each country; in particular, the number of papers by field is indispensable in compensating for the indicators concerning R&D resources that are difficult to classify by field. In addition, they are important in quantitatively expressing the achievements resulting from the organization of the R&D system of each country and the distribution of R&D resources.

Figure 6-1-6 shows the trends for the shares of scientific papers by area of research, excluding the humanities and social sciences, for Japan, the U.S., Germany and the whole SCI Database.

For Japan, the growth for clinical medicine is particularly striking. The shares for physics and material science also increased. Biology and life science accounted for a large share during the period displayed in the figure, and that share remained steady throughout. The share for chemistry, on the other hand, fell continually. The small shares for earth and space related a research field is also characteristic of Japanese research papers.

In the case of the U.S., the shares for biology/life science, and clinical medicine are particularly large, whereas the shares for physics and material science are small compared to other countries. In Germany, the shares in physics and material science increased, while the share for chemistry fell similarly to Japan. A slight increase can be seen in the trend for earth and space related fields.

Figure 6-1-6 Trends in number of papers by fields in selected countries



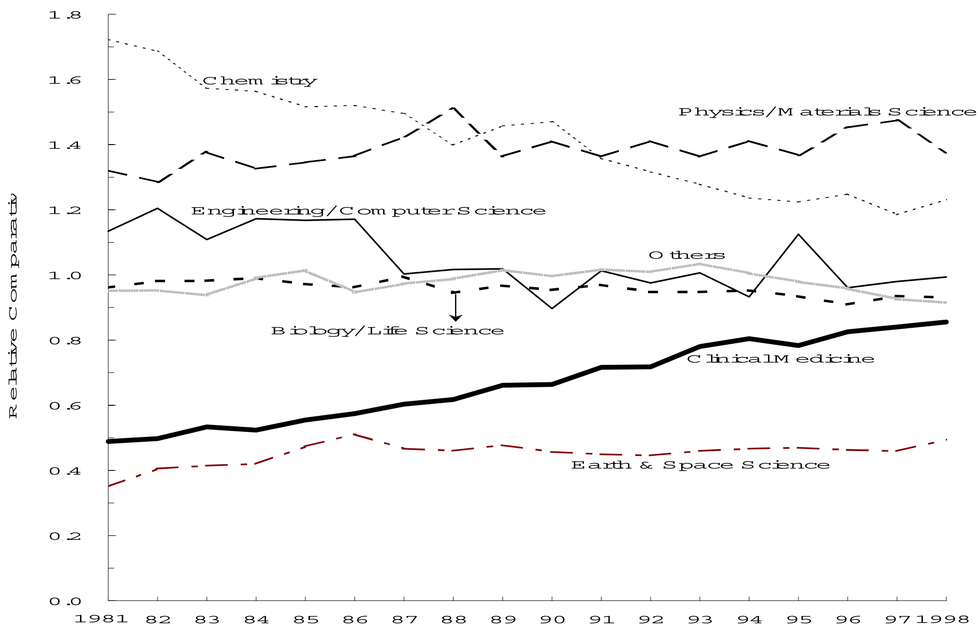
Data: Based on the data of Institute for Scientific Information, "National Science Indicators on Diskette, 1981-1998 (Deluxe version)", the National Institute of Science and Technology Policy totaled.
See: appendix table 6-1-6

In order to see the changes in the output of papers by area of research more clearly, an indicator called the Relative Comparative Advantage (RCA) indicator can be used. This value is the share of papers in each field for each country divided by the worldwide share in each field. For example, clinical medicine accounted for a share of 22.2% of Japanese papers in 1997. The worldwide share for clinical medicine was 26.4%. Dividing the 22.2% share by the worldwide share of 26.4% yields an RCA indicator of 0.841 in this case. A value of one indicates a level equal to the worldwide standard in that field.

The RCA has been found to be associated with the national core competence of a country, and is useful in considering which fields Japan has core competence in.

Figure 6-1-7 shows the changes in the RCA indicator for Japanese scientific papers. The large number of papers in chemistry, and physics and material science has traditionally been above the world standard. However, the values for chemistry have decreased significantly, while the values for physics and material science have remained virtually unchanged or increased gradually over the long term. In contrast, despite the conspicuous growth in the values for clinical medicine, the RCA did not reach 1 even in 1997.

Figure 6-1-7 Trends in RCA of scientific papers by field in Japan



Data: Based on the data of Institute for Science Information, "National Science Indicators on Diskette, 1981-1998 (Deluxe version)", the National Institute of Science and Technology Policy totaled.
See: appendix table 6-1-7

6.2 Patents

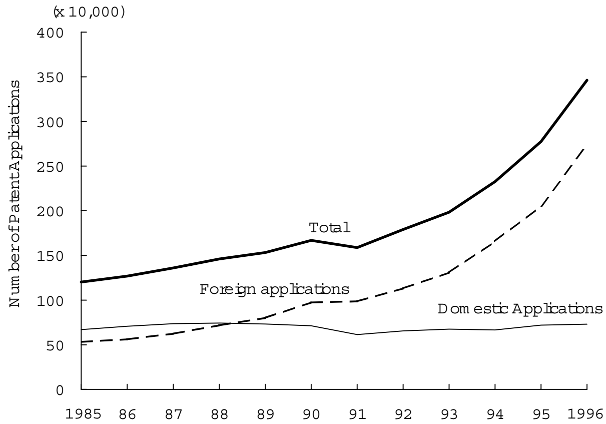
Data concerning patents is an indispensable indicator in understanding the current development of science and technology as related to industry. While the data on patents provides a variety of information on new technical knowledge, it does not cover all inventions and technical knowledge, and is best thought of as showing one aspect of science and technology. Because of significant differences in the value of patents according to the industry and the area of technology, there are differences in the importance of the data. Moreover, it is difficult to make international comparisons due to significant differences in the patent systems between countries, and even within the system of a single country, there are problems in the continuity of time-series data because of the impact of changes to the system, changes in the fees charged to applicants, and so on. When interpreting data concerning patents, it is important to take the above points into consideration, and to acknowledge their characteristics and limitations.

6.2.1 The Internationalization of Patents

Although the data for patents has been totaled based on the institution in charge of patents in each country, as an indicator of R&D achievements, it is more appropriate to total the data based on the country to which the applicant or the patent right holder belongs (or nationality, in some cases). In principle, it is this kind of data that has been used below.

In the 1990s, there was a considerable increase in the number of patent applications worldwide. The greatest contribution to this increase was an increase in the number of applications coming from foreign countries, as opposed to domestic applications. Though the increase of applications from foreign countries is partly due to the internationalization of patent application systems, the greater influence is the result of the double counting of applications made to several countries for a single invention, and this does not signify a quantitative expansion of technological achievements. Nevertheless, there has been definite progress in the rights for technology that cross national boundaries, and in this sense, there has been a rapid development of the globalization of science and technology. (Figure 6-2-1)

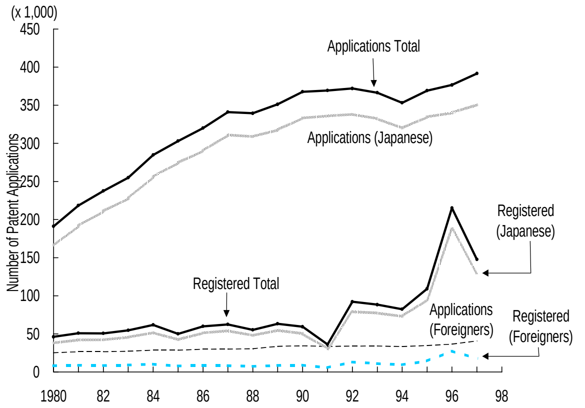
Figure 6-2-1 Trends in number of patent applications in the world



Source: Data of Japan Patent Office and WIPO data
See: appendix table 6-2-1

Figure 6-2-2 shows the changes over time in the number of applications received by the Japan Patent Office. Following the rapid increase in applications up until the late 1980s, the number leveled off in the mid-1990s. The trend began to rise once again from 1996. The majority of applications made to the Japan Patent Office (90% in 1998) were by Japanese nationals, with relatively few made by foreigners.

Figure 6-2-2 Trends in number of patent in Japan



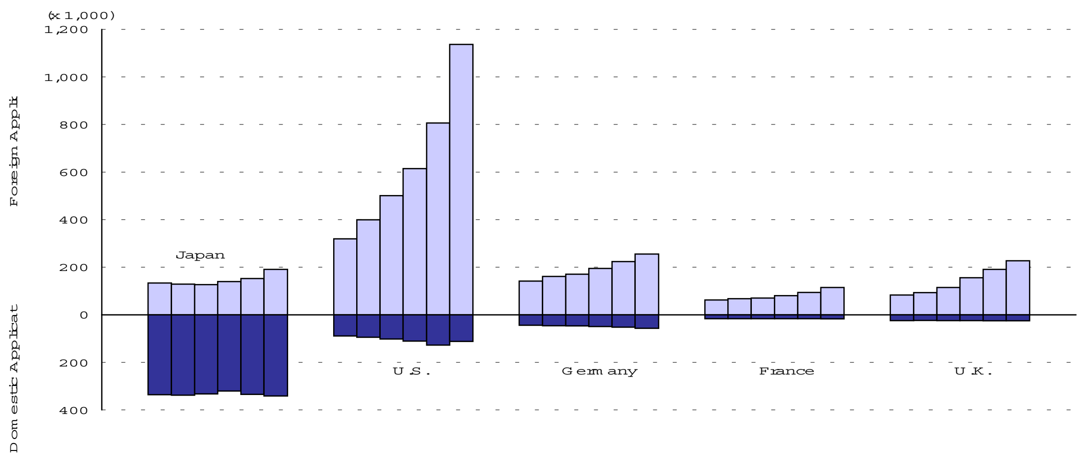
Source: Patent Agency, "Patent Agency Annual Report"
See: appendix table 6-2-2

Although there has traditionally been a large gap between the number of applications and the number of patents granted, that gap diminished in the late 1990s. Moreover, there were large fluctuations in the number of patents granted because of changes to the system. The rapid increase in 1992 was a result of the impact of the introduction of an electronic application system, while the surge in 1996 was a result of a change to the system enabling formal objections to patents after their registration.

Figure 6-2-3 shows the state of patent applications in the selected countries. For the U.S., Germany, France and the U.K., the number of applications from foreign countries exceeds the number for domestic applications. Japan is the only country in which the number of domestic applicants exceeds the number of foreign applicants, indicating an enormous domestic bias. However, there has also been an increase in the number of applications made to foreign countries by Japan.

The increase in the number of external patent applications is a trend that is not only apparent in Japan, but is common throughout the five countries. This is especially true for the U.S., which has shown a striking increase in the number of applications made to other countries. This increase in the number of external applications by the U.S. was the result of an increase in the use of the PCT application system designated by a number of countries. In Europe, the use of the European patent system has contributed to the increase in the number of applications made to foreign countries.

Figure 6-2-3 Trends in number of domestic and foreign applications in selected countries (1991 to 1996)

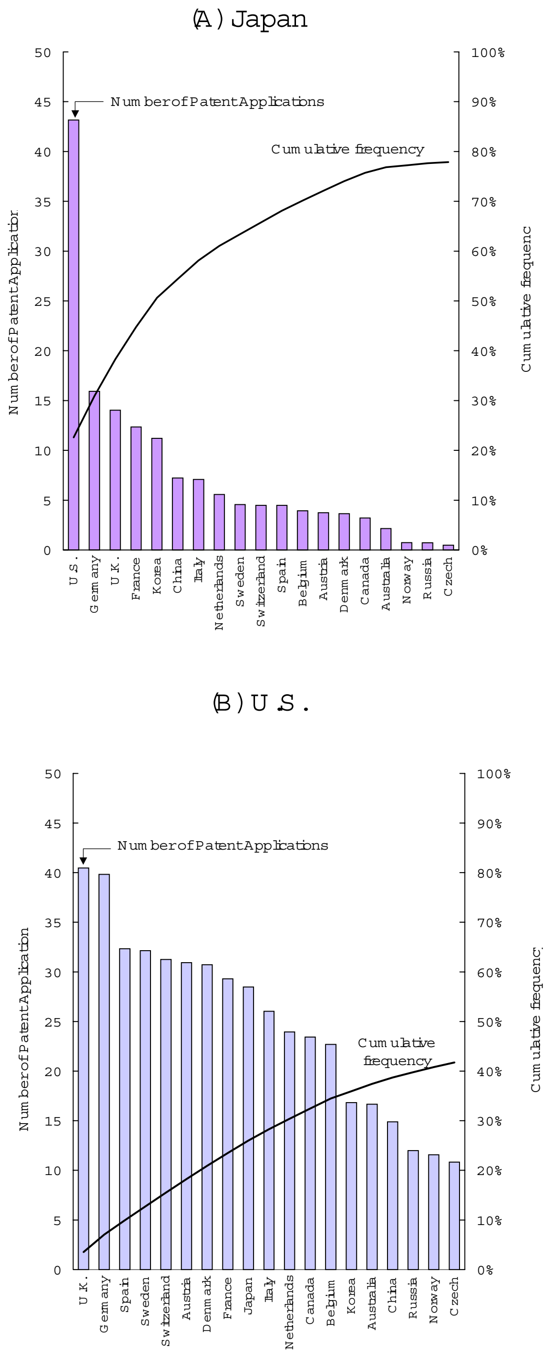


Note: The data of graph is the value in 1991 to 1996 sequentially from the left with each country.
Source: Patent Agency, "Patent Agency Annual Report".
See: appendix table 6-2-3

Next we make a detailed examination of the overseas patent applications for Japanese and American inventions. Figure 6-2-4 shows a breakdown of the number of Japanese and American foreign patent applications by country for the top 19 countries in 1996. The majority of applications by Japan were made in the U.S., accounting for 22.6% of the total. Next is Germany with only 8.3% of the total. The total number of applications made in the top 19 countries was 77.9% of the total number of foreign applications.

In comparison, for the U.S., the largest proportion of patent applications went to the U.K.; however, this amounted to only 3.6% of the total and shows the diversity of countries to which the U.S. makes applications. A majority of the countries - 14 of the top 19 - were European, with Japan ranking only ninth. A conspicuous feature of the foreign applications made by the U.S. is that they were made to a variety of countries, rather than to a particular country. This is further illustrated by the fact that the total number of applications made to the top 19 countries accounts for only 41.8% of the worldwide total. It is obvious that U.S. applicants are making progress in obtaining the rights to technology in countries worldwide.

Figure 6-2-4 Number of applications to foreign countries from Japan and U.S. (1996)



Source: Patent Agency, "Patent Agency Annual Report"
See: appendix table 6-2-4

Next, we look at the breakdown of the share of patent applications by nationality of the inventor for each of the five selected countries in Figure 6-2-5. The figure also includes the breakdown of shares for the European Patent Office.

Among the countries shown in the figure, the U.S., Germany and Japan, have the greatest shares of domestic applications. Of the three, Japan has the highest share of domestic applicants with over 80% of the applications received by the Patent Office coming from within Japan, which is very high even from a global standpoint.

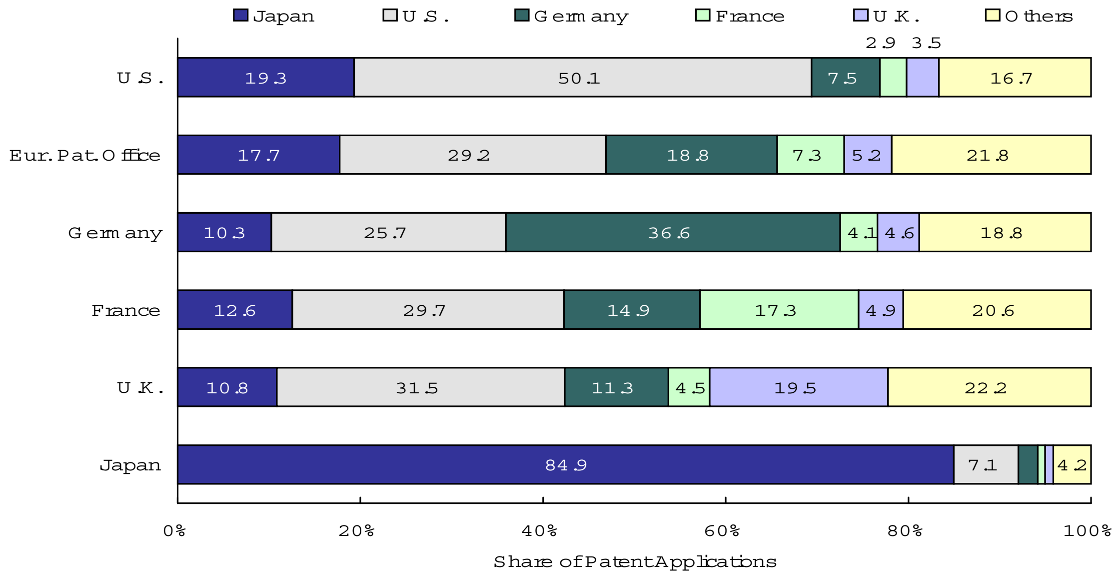
Looking at Japan's share of applications in foreign countries, we see that the share for the U.S. is 19.3%, which is the highest of all countries, excluding the U.S. itself. The share for the European Patent Office is 17.7%, which is the third highest after the U.S. and Germany. For Germany, France and the U.K., the number of applications from Japan is a healthy 10% for each country.

Applications from the U.S. account for a large share in each of the recipient countries, especially France and the U.K., where the U.S. share is surpassed only by domestic applications. Germany also accounts for a large share of the applications received by the European Patent Office, France and the U.K., showing the strength of the position of its patents in Europe.

Although the numbers of patents granted are not shown in any graphs, the share for each country is roughly equal to its share of applications.

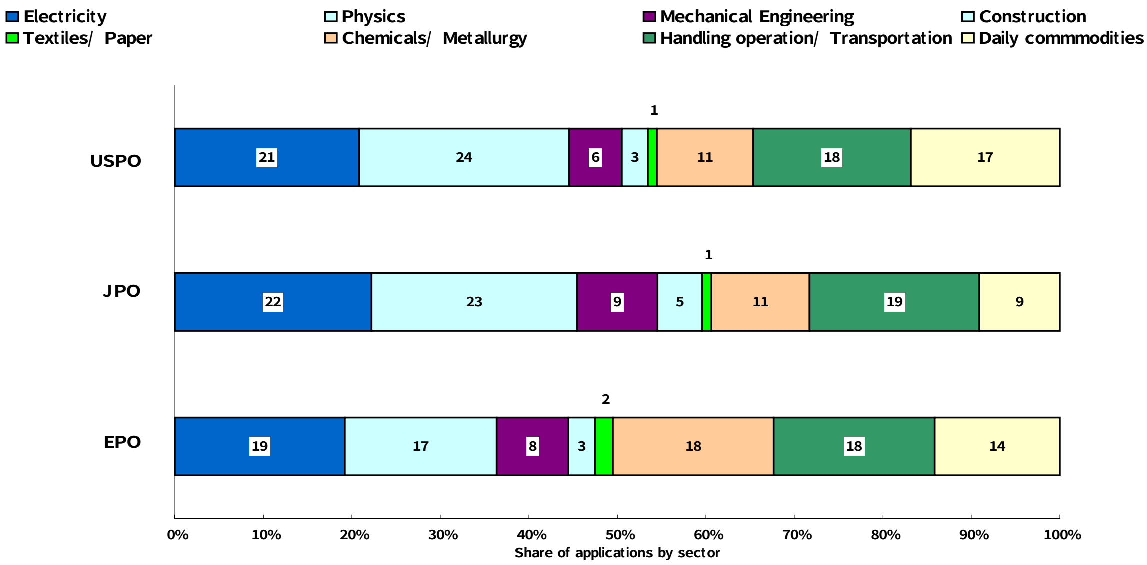
A comparison of the share of patent applications by field was made between the patent offices of Japan, the U.S. and Europe (referred to as the "three regions" below). It was found that there were no significant differences between the three regions in the shares for each field. A more detailed look shows that in the U.S., daily commodities and physics had the highest shares; in Japan, electrical and physics patents had relatively high shares. In the European Patent Office, chemicals and metallurgy had high shares.

Figure 6-2-5 Number of patents by Nationality of inventor in selected countries and region (1996)



Source: Patent Agency, "Patent Agency Annual Report"
See: appendix table 6-2-5

Figure 6-2-6 Number of patent applications by sector in Japan, U.S. and Europe (1998)



Source: Patent Agency, "Patent Agency Annual Report"
See: appendix table 6-2-6

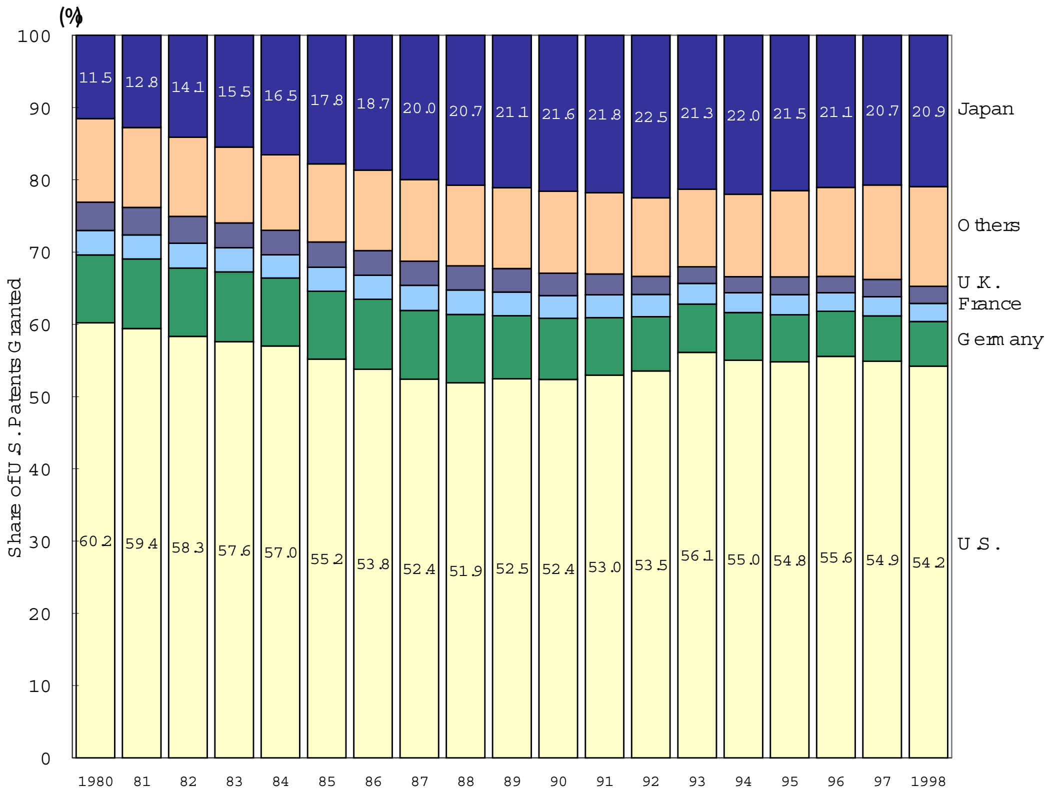
6.2.2 Comparison of Technical Strengths According to Data on U.S. Patents

In this section we carry out a slightly more detailed analysis using data on U.S. patents. The data for U.S. patents is used here for the following reasons: First, there is no alternative to the data on U.S. patents, with its source of patent citations and scientific literature citations, that generates the same level of interest. Second, applications from abroad for patents in Japan are relatively small, making it impossible to gain a clear picture of Japanese R&D achievements from an international perspective. For this reason, U.S. patents are more appropriate in most cases. The fact that the majority of important Japanese inventions have had applications made for them in the U.S. can also be raised as a reason.

Figure 6-2-7 shows the share of applicants for U.S. patents by nationality. The share of Japanese patents increased dramatically in the 1980s. This growth slowed in the late 1980s, however, and actually fell in the late 1990s. Nonetheless, Japan maintained its second place position next to the U.S..

The U.S. share continued to fall until around 1988, and after that rose until 1993. It then fell once again, with the exception of 1996. The German share showed a long-term decline, leveling off after the mid-1990s.

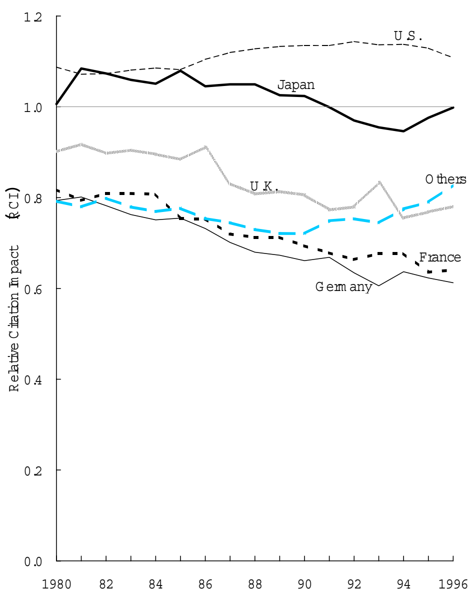
Figure 6-2-7 Trends in number of U.S. patents granted by selected countries



Source: CHI Research Inc., "National Technological Indicators Database"
See: appendix table 6-2-7

Next, we discuss the citation index for U.S. patents. In order to show the details of an invention as objectively as possible for U.S. patents, a patent examiner must carry out citations on a variety of literature and previous patents as determined by the law. Using this data on citations, the number of citations by succeeding patents is totaled, making it possible to calculate a relative citation index, as in the case for literature. In the case of patents, the purpose of carrying out citations is to support or prove the originality or the level of innovation of a patented invention on the citation side. In many cases, the value of patents being sited can be thought to be neutral. However, patents being cited can be thought of as being relatively more important(1).

Figure 6-2-8 Trends in relative citation impact of U.S. patents



Source: CHI Research Inc., "National Technology Indicators Database."
See: appendix table

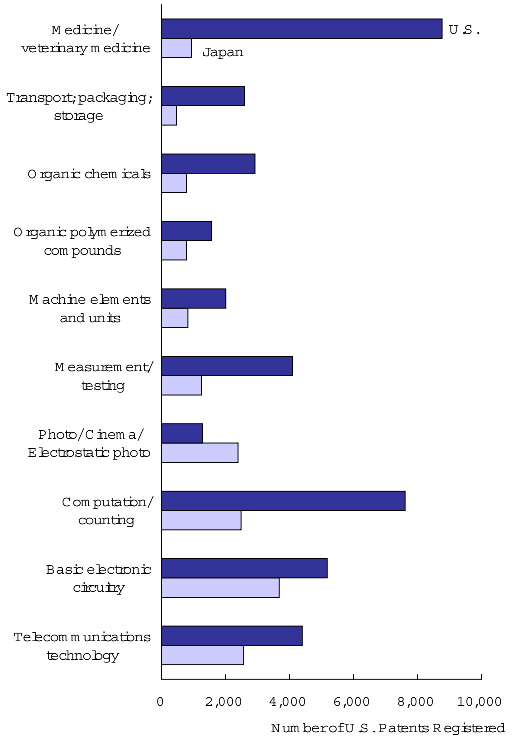
A look at the relative citation index by nationality of inventors shows Japan being above one in the early 1980s, on par with the U.S.. In the late 1980s, however, there was a downward trend, which resulted in Japan falling below one (Figure 6-2-8). A slight increase can be seen in 1995 and 1996. However, if a certain number of years have not elapsed in the data for patent citations, the data lacks stability, which casts doubt on the reliability of the trend.

The values for the U.S. show an increase in the 1990s compared to the 1980s, becoming stable. The values for other countries are well below those of Japan and the U.S..

We will also touch on the breakdown of U.S. patents by classification. Figure 6-2-9 shows the 1998 comparison between the U.S. and Japan in the top ten classifications of the 118 (3-figured classifications) specified in the International Patent Classifications (IPC). The U.S. surpassed Japan in nine of the classifications. There is a particularly big gap in the number of U.S. and Japanese patents in the "medicine and veterinary medicine" field. Japan, on the other hand, surpassed the U.S. in the "photo/cinema" field, and was relatively close to the U.S. in "basic electronic circuitry" and telecommunications technology".

(1) An empirical test was carried out to discover whether the citation index for patents reflects their technical value. A number of researchers agreed that specialists regard frequently cited patents as important (see References [2] and [3]).

Figure 6-2-9 Number of U.S. patents by international patent classification (Japan, U.S. and total: 1998)

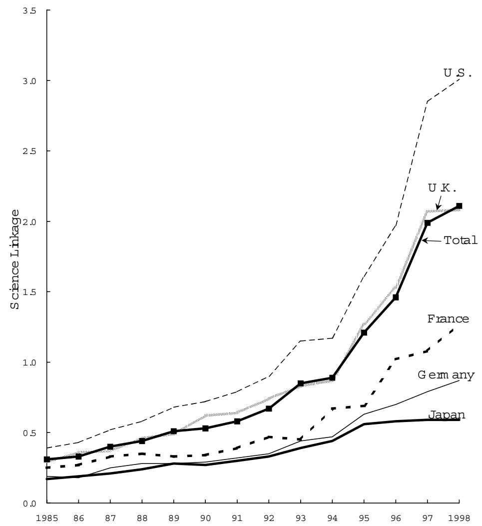


Note: The long thing uses the abbreviated name among the names of the six-abovementioned fields. It is table 6-2-9 reference correctly.
Source: CHI Research Inc., "National Technology Indicators Database"
See: appendix table 6-2-9

Next, we discuss the "Science Linkage" indicator which shows the strength of the relationship between patents and scientific papers. The science linkage shows the number of citations per scientific paper in the U.S. Patents Examination Report. As described previously, citations of previously existing patents and of a variety of literature are attached to the U.S. Patents Examination Report in order to clarify the details of the relevant patents. The science linkage indicator was developed with attention to the number of scientific papers within this report. Because the scientific paper citations for patents can be thought of as showing a relationship between technology (patents) and the science it depends on, the strength of the science linkage can be interpreted as showing the strength of its relationship to science. Moreover, since the citations are made by the examiners rather than by the applicants, their objectivity is relatively high.

Figure 6-2-10 shows the trends for the science linkage of U.S. patents by nationality of the applicant. All of the values are rising, which seems to indicate a strong relationship between patents and scientific papers. Examining the trends by country, we see that the U.S. values are the highest, increasing remarkably. The values for Japan, meanwhile, are the lowest of the five countries shown on the graph, and the disparity with the other countries widened in the late 1990s.

Figure 6-2-10 Trends in the Science Linkage of U.S. patent in selected countries



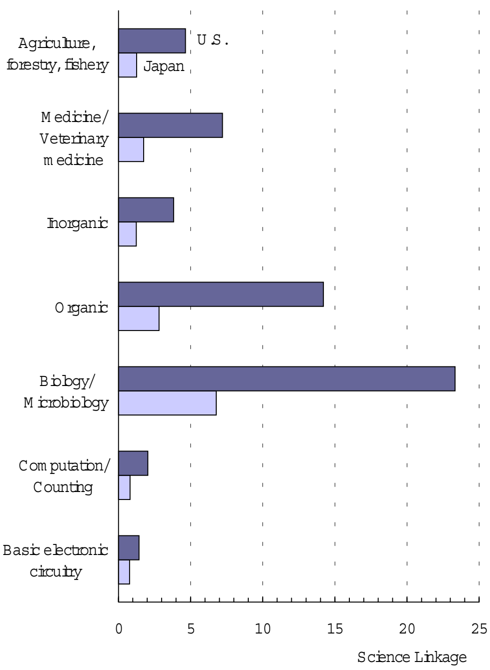
Note: Science linkage is the science paper quotation number of cases per U.S. patent.
Source: CHI Research Inc., "National Technology Indicators Database"
See: appendix table 6-2-10

The science linkage values differ considerably from field to field, and are fairly low in all fields. There are several life science related fields with high values. Figure 6-2-11 shows the trends for the science linkage values of Japan and the U.S. for the top three fields - "biochemistry and microbiology", "organic chemistry" and "medicine and veterinary medicine" - in addition to the other fields with the highest total number of citations in scientific literature. The citations for these six fields account for 60% of the total citations in the scientific literature with regard to U.S. patents.

The U.S. science linkage values exceed those of Japan in all six fields, and is extremely large in "biochemistry and microbiology" with a value of 23.3 (in 1998). The majority of genetic engineering-related patents have been included in this field, enabling us to see the close relationship between the scientific papers and patents in this field.

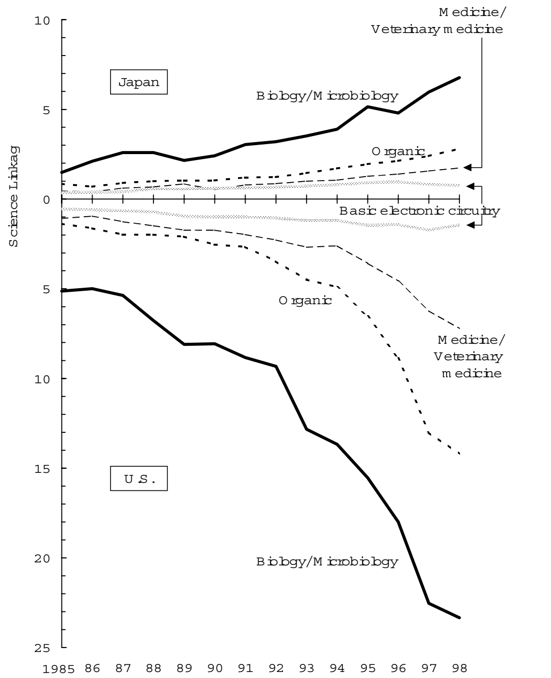
The science linkage trends in the top four fields - "biology and microbiology", "organic", "medicine and veterinary medicine", etc. - are shown in Figure 6-2-12 for the past ten years, for Japan and the U.S.. The values for the U.S. show remarkable increases in contrast to the values for Japan, which despite showing an increase, are comparatively small. The speed of growth in the "basic electrical circuitry" field is slow compared to the other three fields, but accounts for a major position among the fields, and displays steady increases.

Figure 6-2-11 The Science Linkage by major fields in Japan and U.S. (1998)



Note: Science linkage is the science paper quotation number of cases per U.S. patent.
Source: CHI Research Inc., "National Technology Indicators Database"
See: appendix table 6-2-11

Figure: 6-2-12 Trends in Science Linkage by major field in Japan and U.S.



Note: The long thing uses the abbreviated name among the names of the six-abovementioned fields. It is table 6-2-11 reference correctly.
Source: CHI Research Inc., "National Technology Indicators Database"
See: appendix table 6-2-11

6.3 Trade in Technology

Generally, granting the rights to use a certain technology[2] to a foreign resident company or individual for some pay is known as technology export. Conversely, paying a foreign resident company or individual for the rights to use a technology is known as technology import (or technology introduction). The two of these together are known as technology trade, whose data is an important measure of the technological level of a country on an international basis. A comparison between the value of technology exports (amount received) and the value of technology import (amount paid) can be used as an indicator to reflect the technological strength of a country by showing a comparison between technology trade income and expenditures. The data for technology trade is also important in showing the international movements of technical knowledge.

As a result of the globalization of business in recent years, the technology trade between affiliated companies based overseas, and so on, and technology transfers within business groups have surfaced as trade between countries and must also be taken into consideration.

In Japan, the representative statistics concerning technology trade are those of the Bank of Japan, and the Management and Coordination Agency. In this chapter, we use the statistics from the Management and Coordination Agency in Sections 6.3.1 (those concerning Japan), 6.3.2 and 6.3.3. The statistics from the Bank of Japan are used in Section 6.3.5. In addition to the above, an analysis of the details of technology imports is made using the National Institute of Science and Technology Policy's "An Analysis of the Trends in Foreign Technology Imports" in Section 6.3.4.

[2] These include intellectual property rights, as well as rights for designs, blueprints, and so-called "know-how", etc., which are granted based on the laws for patent rights, utility model rights, trademark rights, design rights, literary rights, and so on.

6.3.1 International Comparison of Technology Trade

The data for the technology trade of the five major industrialized countries can be seen in Figure 6-3-1. The upper part of the graph shows the value of technology exports, while the lower part shows the value of technology imports. Once again, the figures have been converted into yen using the OECD's purchasing power parity, enabling a direct comparison of the value of technology trade for each country.

It can be seen that value of both technology imports and exports for Japan are small on an absolute scale. However, a simple comparison of countries is not possible due to geographical differences. Instead, we would like to highlight the relative relationship between values of technology exports and imports, as well as the annual trends.

Looking at each country in detail, we see that there was considerable growth in Japan's technology exports in the 1990s, with technology exports exceeding the imports from 1993. The technology exports in 1998 amounted to 916.1 billion yen, while imports were 430.1 billion yen.

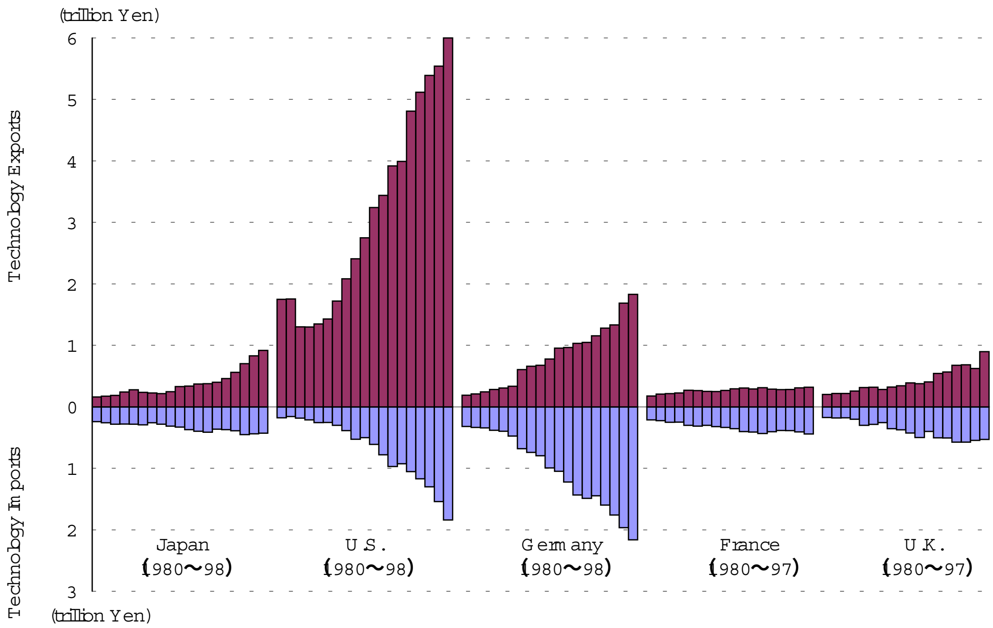
U.S. technology exports are overwhelmingly high, with an amount 8 times higher than that of Japan in 1997. The trends show a prominent increase from the late 1980s, and although the technology imports increase on an annual basis, they are small relative to the value of exports, leading to substantial gaps in the technology trade incomes and expenditures. The ratio of technology exports to imports is 3.58 in 1997, which is exceptionally large among the countries shown in the figure, and shows the strong influence of U.S. technology. Nonetheless, this ratio shows a long-term decline.

The values for both technology imports and exports for Germany exceed those of Japan. Both values increased almost every year, although there was an excess of technology imports over exports during all of the years shown in the graph (from 1980 to 1997).

Among the countries shown on the graph, the values of technology imports and exports for France were small, on par with those of Japan. This figure has not increased over time, and there was a slight decline in the trend for technology exports, while the trend for technology imports moved sideways. As with Germany, there is an excess of technology imports over exports during the years shown in the graph (from 1980 to 1996).

Although the trends in the values of technology exports and imports for the U.K. show an overall increase, they fluctuate from year to year. Despite an excess of technology trade expenditures over incomes in the late 1980s, the opposite was true for most of the period before and after this. Technology exports in 1996, however, fell in comparison to the previous year, resulting in an excess of imports over exports.

Figure 6-3-1 Trends in technology trade in selected countries



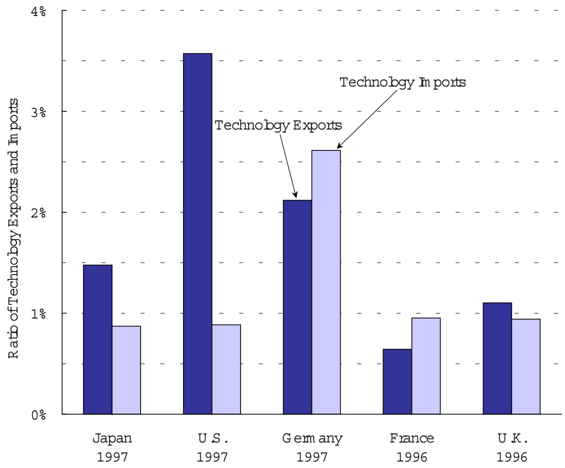
Note: Technology trade costs other than Japan were converted into Japanese currency (Yen) using the purchasing power parity of OECD.
Source: Japan-Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development".
U.S. Germany, France and U.K. - OECD, "Main Science and Technology Indicators, 1999/1"
See: appendix table 6-3-1

We must also consider the influence of the geographical and historical conditions of each country, as well as international relations, and so on, on the technology trade. Figure 6-3-2 shows the level of trade in technology relative to the total trade in goods and services. Below, we refer to the ratio of technology exports to total exports as the "technology export ratio", and for the ratio of technology imports to total imports as the "technology import ratio".

The technology export ratio for the U.S. is the highest at 3.6%, followed by Germany at 2.1%, and Japan at 1.5%. Meanwhile, the technology import ratio was particularly high for Germany at 2.6%, while the other countries were roughly on par with each other at 0.9% to 1%. Only Germany and France had a technology import ratio exceeding the technology export ratio.

Overall, the values for Japan are lower than those for the U.S. and Germany, though the differences are not as pronounced as in Figure 6-3-1. The absolute values for Japanese imports and exports are smaller than those of both the U.S. and Germany, which partially explains the small technology trade figures for Japan. Despite this fact, Japan's technology trade figures are not particularly large compared to the U.S. and Germany.

Figure 6-3-2 Ratio of All trades and technology trade in selected countries



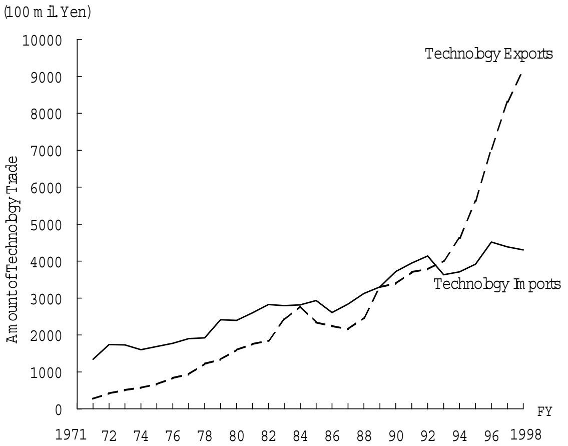
Source: OECD, "National Accounts, Main Aggregates: 1999"
OECD, "Basic Science and Technology Statistics 1998"
See: appendix table 6-3-2

6.3.2 Technology Trade by Industry in Japan

In this section, we discuss the technology trade conditions in Japan. The discussion of the technology trade statistics, which are broken down by industry and region, is based on the Management and Coordination Agency's "Report on the Survey of Research and Development".

Figure 6-3-3 shows the trends in values of technology trade exports and imports for all industries in Japan.

Figure 6-3-3 Trend in technology export and import in Japan (all industries and major industries)



Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 6-3-3

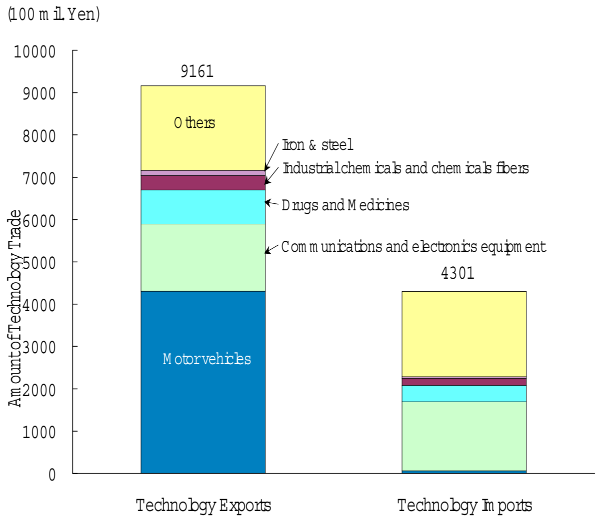
The value of technology exports rose dramatically around the mid-1990s, with particularly significant growth in FY1997 and FY1998. In contrast, despite an increase in the value of technology imports from FY1994 to FY1996, there were consecutive decreases in FY1997 and FY1998.

The total value of technology exports for all industries in Japan was 916.1 billion yen in 1998, while the total value of imports was 430.1 billion yen, meaning an excess of 486 billion yen in technology exports over imports (see Figure 6-3-4).

The industries with the largest technology values of exports were the "Motor vehicles industry" (430.8 billion yen - 47.0% of the total for all industries), and the "Communications and electronics equipment industry" (158.6 billion yen - 17.3% of the total), together accounting for 64.3% of the total export amount. Next was the "Drugs and medicines industry" with 80.5 billion yen, or 8.8% of the total.

The industry with the largest amount of technology imports was the "Communication and electronics equipment industry" (163 billion yen - 37.9% of the total for all industries), the "Drugs and medicines industry" (38.5 billion yen - 8.9% of the total), and the "Industrial chemicals and chemical fibers" (16.4 billion yen - 3.8% of the total). Moreover, despite being at the top for technology exports, the technology imports for the "Motor vehicles industry" amounted to only 6.2 billion yen.

Figure 6-3-4 Technology trade by major industries in Japan (FY1998)

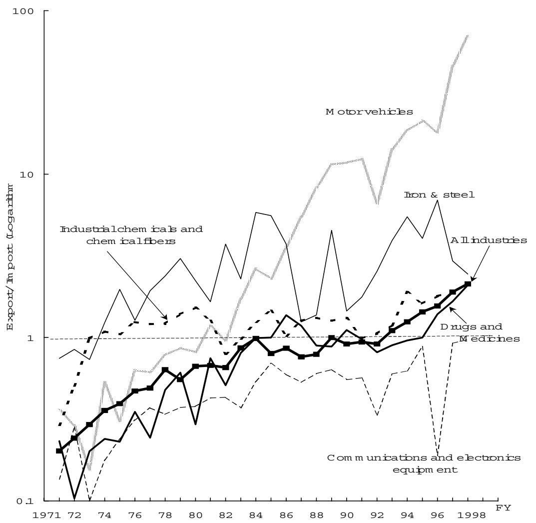


Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 6-3-4

Next, we look at the trends in the ratios for technology trade incomes and expenditures (i.e. logarithmic expressions for the ratio of value of exports to imports) of the five leading industries, as shown in Figure 6-3-5.

In Japan, the growth rate in technology exports has been high compared to the rate for technology imports in recent years, with the result that the ratio for incomes and expenditures in technology trade has increased yearly. The ratio exceeded 1 for the first time in FY1993 for all industries together, and continued to grow after that, reaching 2.13 in FY1998. The trend shows that the income/expenditure ratio remained close to 1 from the mid-1980s to the beginning of the 1990s. This was a result of an increase in the technology imports to Japan during this period, despite an increase in the amount of technology exports by Japanese industry. It can be seen from the graph that the income/expenditure ratio finally rose in the late 1990s.

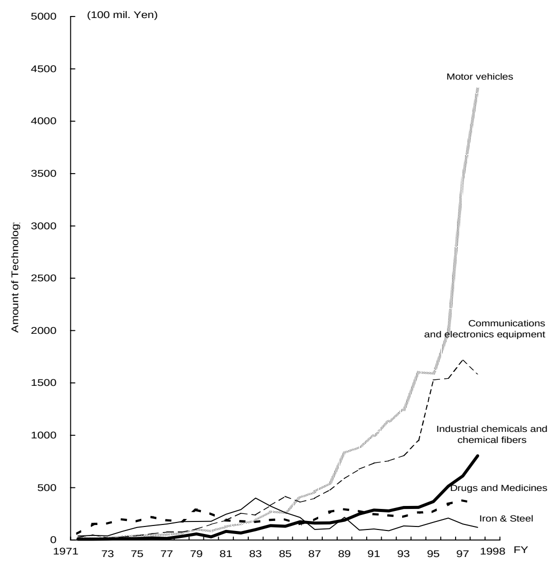
Figure 6-3-5 Trends in Japan's technology trade balance



Note: Software business is also included after the 1996 fiscal year of Japan.
Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 6-3-5

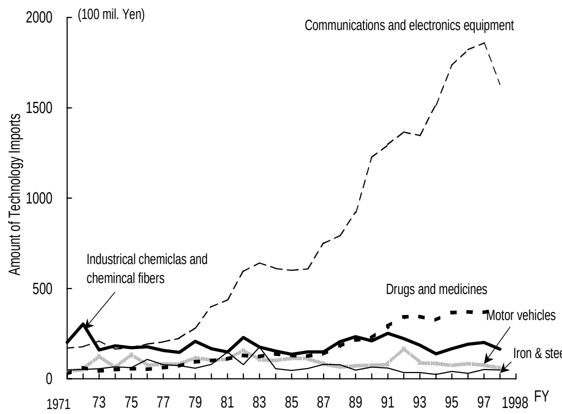
Figure 6-3-6 shows the trends in the technology exports for the five leading industries, while Figure 6-3-7 shows the trends for technology imports. Examining the technology trends together with those shown in Figure 6-3-5, we see the following characteristics for each of the industries.

Figure 6-3-6 Trends in Japan's technology exports by major industries



Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 6-3-6

Figure 6-3-7 Trends in Japan's technology import by major industries



Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 6-3-7

The "Industrial chemicals and chemical fibers" shows low growth rates in the values of both technology exports and imports compared to the average for all industries. Technology exports were around 20 billion yen from the end of the 1970s to the mid-1990s, but passed the 30 billion yen mark in 1996. Technology imports, on the other hand, fluctuated on an annual basis, with long-term movements in the range of 15 and 20 billion yen from the 1970s onwards. From FY1973 until the present, these industries experienced a trade income/expenditure ratio above one (i.e. an excess of exports over imports), except in the fiscal years 1982, 1983 and 1991, and in 1998 the ratio went above two.

The value of imports for the "Drug and medicine industry" exceeded those for exports from the 1970s to the mid-1980s. The trade income and expenditure ratio was roughly the same as the average for all industries over a ten-year period starting in the mid-1980s. In 1996 the ratio exceeded one, and increased even further after that, going above two in 1998.

The technology exports for the "Iron and steel industry" passed the 10 billion yen mark in FY1975 and continued to rise after that until the mid-1980s. In 1983, the industry reached 40.2 billion yen, but began a fluctuating downward trend after that, falling to 11.9 billion yen in FY1998. Meanwhile, technology imports moved between a relatively low ranges of two to eight billion yen from around the mid-1980s. As a result, the trade income and expenditure ratio for the "Iron and steel industry" was well above one from FY1974 onwards, thus indicating a surplus in technology exports from early on.

The technology exports for the "Communications and electronics equipment industry" were second only to those of the "Motor vehicles industry," and the technology imports were extremely large. The income/expenditure ratio was consistently lower than the average ratio for all "Manufacturing industries," and showed an excess of imports over exports during the period shown in the graph. Nonetheless, the ratio displayed a long-term increase that reached 0.97 in FY1998.

The "Motor vehicles industry" had a technology export surplus starting in FY1981, with a rising income/expenditure ratio from that time. In FY1998, the export amount exceeded the import amount by a staggering 70 times. Examining the trend of the trade income and expenditure ratio, we see that it rose remarkably from the 1980s, and even while the ratio for other industries hovered around one, the Motor vehicles industry was the only one to continue past one. The industry did, however, show a temporary decrease in 1992, but continued to rise again after that.

6.3.3 International Technology Trading Partners of Japan

An examination of the breakdown of technology trade statistics by region enables us to clarify the technology relationship between Japan and the other countries, and gives us a picture of the actual conditions of Japanese industrial technology. It is from this perspective that we will view the breakdown of technology trade statistics by region and industry.

In the statistics found in the Management and Coordination Agency's "The Value and Volume of Technology Exchange by Region and Industry" in the "Report on the Survey of Research and Development", "new contracts" and "continuing contracts" are not recorded separately. Consequently, all of the trade figures discussed for these items are aggregates of the two.

(1) Technology Exports

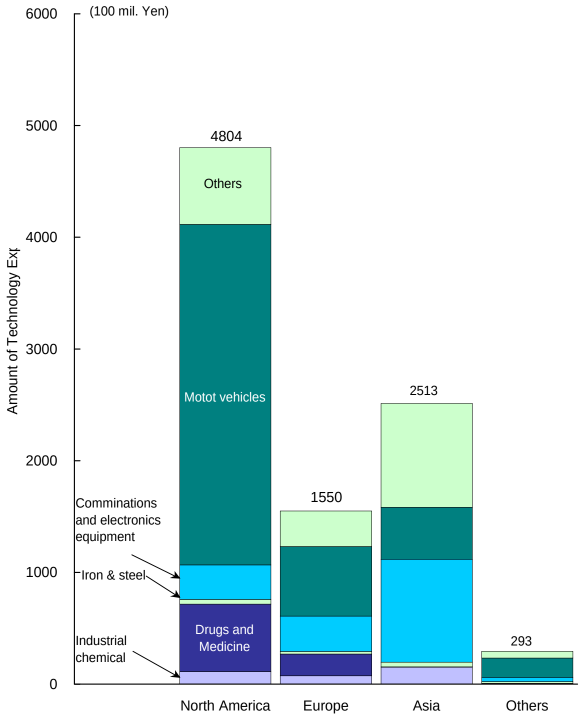
Figure 6-3-8 shows a breakdown of the export amount by region in the five leading industries in FY1998. Of the total technology exports of 916.1 billion yen for all industries, exports to North America accounted for

480.4 billion yen, which was 52.4% of the total. This was followed by 251.3 billion yen (27.4%) to Asia (excluding western Asia, which will be the case for the rest of this section), and 155 billion yen (16.9%) to Europe.

Within the technology exports to North America, the "Motor vehicles industry" accounted for the largest share at 63.4%. The "Motor vehicles industry" also accounted for the majority of technology exports to Europe with a 40.1% share. On the other hand, the "Communications and electronics equipment industry" had the strongest technology exports to Asia, with a 36.6% share.

A breakdown of technology exports by region for each industry indicates that North America was the heaviest buyer of technology from the "Motor vehicles industry" with 70.7% of the share, whereas Asia was the largest export region for technology for the "Communications and electronics equipment industry." (58.1%) For the "Industrial chemicals and chemical fibers", Asia accounted for 44.0% of the technology exports, followed by North America with 32.3%, and Europe by 21.5%. For the "Drug and medicine industry," North America accounted for 75.0% of the total, in contrast to Asia, which accounted for a mere 0.5%. North American share of technology exports from the "Iron and steel industry" was 36.1%, surpassing the Asian share of 34.1% for the first time.

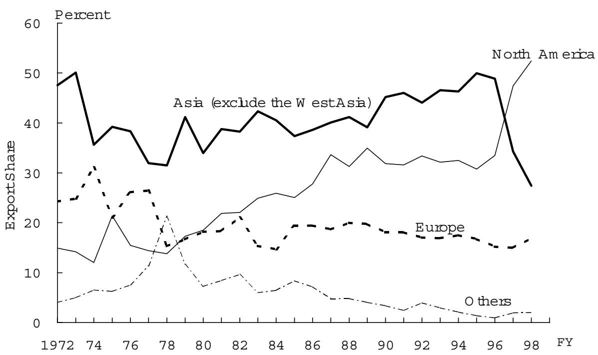
Figure 6-3-8 Breakdown of Japan's technology exports by region and major industries (FY1998)



Note: Asia (exclude the West Asia)
Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 6-3-8

A survey of the current trends in the breakdown of technology exports by region is shown in Figure 6-3-9. The region in the top position changed for the first time in FY1997 when a sharp decline in technology exports to Asia (285.1 billion yen, 34% in 1997), which was in economic turmoil, was supplanted by a sudden increase in exports to North America (394.5 billion yen 34% in 1997). Despite a downward trend in the European share, there was a slight increase in 1998 for the first time in 4 years.

Figure 6-3-9 Trends in Japan's technology exports by region



Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 6-3-6

(2) Technology Imports

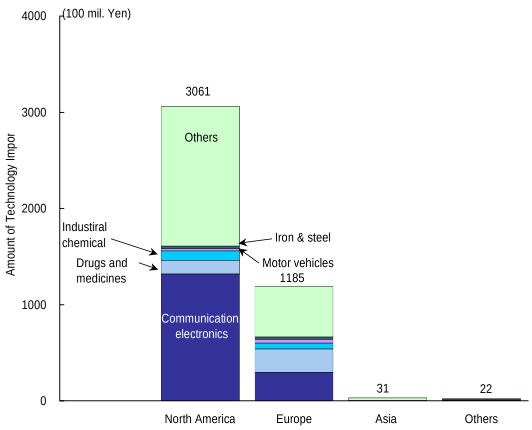
Technology imports for FY1998

Figure 6-3-10 shows a breakdown of technology imports by region for all industries. The total amount of technology imports was 430.1 billion yen, 306.1 billion (71.2%) of which came from North America, and 118.5 billion yen (27.56%) from Europe - together accounting for 98.8% of the total.

The current trends in technology imports for all industries show that Europe and North America consistently account for the largest proportion. The North American share ranges from 60 to 70%, while the European share is from 30 to 40%, with very little change. Imports from the other regions are around 1%. Obviously, the technology imports from Asia are extremely small, though they have been rising since FY1991.

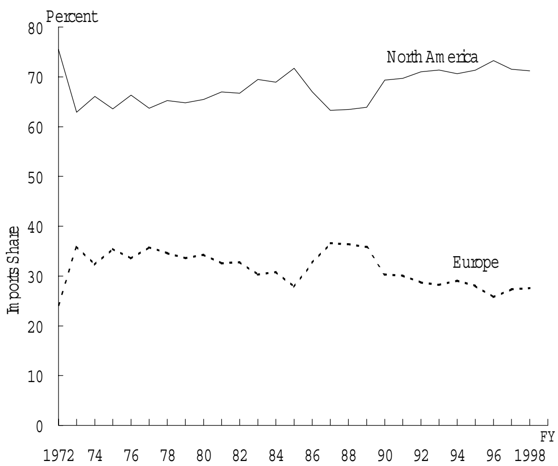
As mentioned previously, Japan's partners in technology trade are mostly concentrated in the North American, European and Asian regions for imports and the North American and European regions for exports. The trade income and expenditure ratio for all industries together has continued to grow year by year since FY1992. North America and Europe, which had an excess of imports over exports until recently, began having an export surplus for the first time in FY1997. Despite a decrease in the value of technology exports to Asia, the large export surplus remains unchanged.

Figure 6-3-10 Breakdown of Japan's technology imports by region and major industries (FY1998)



Note: Asia (exclude the West Asia)
Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 6-3-10

Figure 6-3-11 Trends in Japan's technology imports by region



Note: The amount of money cannot display an area except the above small.
Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 6-3-10

A comparison of the value of technology exports (Figure 6-3-8) and imports (Figure 6-3-10) shows a trade income and expenditure ratio of 1.57 for North America, 1.31 for Europe and 71.5 for Asia in FY 1998.

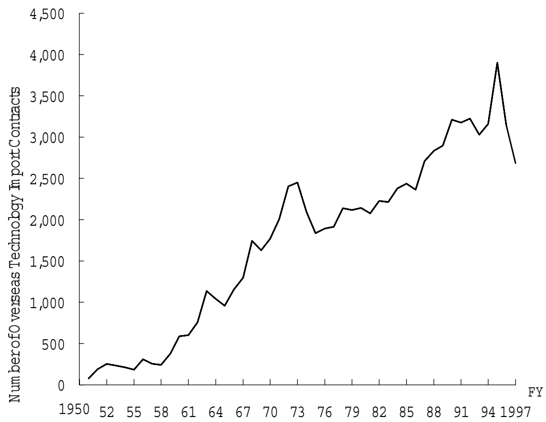
6.3.4 Number of Technology Imports by Field

One of the sets of the statistics related to technology trade for Japan is from "Analysis of Trend in Technology Import" by the National Institute of Science and Technology Policy[3]. Although these statistics are limited to technology imports, it is a category of data that is unavailable from the Management and Coordination Agency or the Bank of Japan, and is useful in clarifying the technology fields with the greatest number of imports. Following is an overview of technology imports by field.

(1) General Trends in Technology Imports

To get a clear picture of the significant flows of technology imports from overseas, we will examine the trends for the total number of new technology imports shown in Figure 6-3-12. Amid the continual fluctuations, the trend rose in the long term, hitting a peak of 3,901 in FY 1995[4], and declining after that. In FY 1997, the number of new technology imports was 2,685, a decrease of 15% compared to a previous fiscal year previous, and equal to the same level as previous ten years.

Figure 6-3-12 Trends in the number of overseas technology import contracts



Source: The Science and Technology Agency, National Institute of Science and Technology Policy, "Trends in Technology Exports from Japan - FY 1994-" and "Analysis of Trends in the import of Foreign Technology from Japan -FY 1993 to 1997-"
See: appendix table 6-3-12

(2) Breakdown of Technology by Field

Looking at the number of imports by field, we see that there were 2,685 imports of new technology in FY 1997, the majority of which were for the electronics field with 1,735 imports (64.6% of the total), followed by machinery at 254 (9.5%), then chemical at 184 (6.9%), metals at 35 (1.3%) and others at 477 (17.8%). The trends in the composition of the technology fields are shown in Figure 6-3-13. The electronics field continued to grow until FY 1993, but showed no change after that except for in FY 1995.

In the "Electronics field," 1,349 of the imports were for practical devices (1,290 of which were electrical computational devices), which accounted for the majority. This was followed by 169 imports for electronic components/devices, and 168 imports for communication equipment. In the "Chemical field," 67 imports were for pharmaceuticals, while in "Other" there were 237 imports for clothing and textiles.

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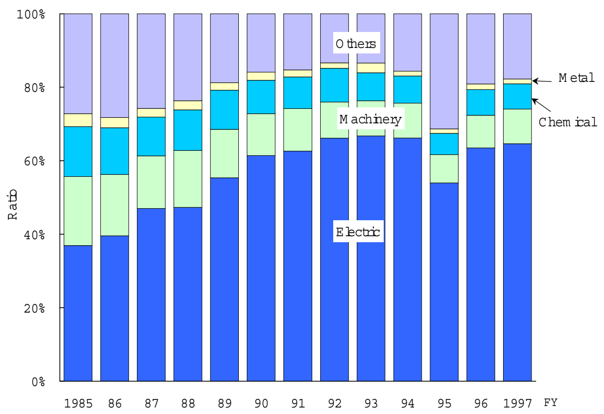
(3) The survey by the National Institute of Science and Technology Policy was carried out based on reports which must be submitted to the Bank of Japan at the time of the conclusion of a technology import contract, as based on "Laws Concerning the Management of Foreign Exchange and Foreign Trade". The details of the tabulation are the number of contracts for importing technology.

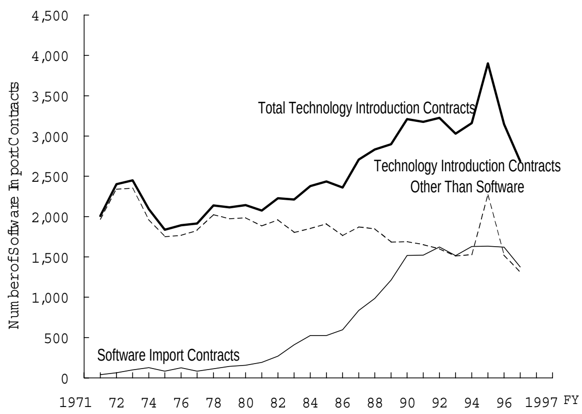
(4) This was largely influenced by special circumstances after 1986, in which all contracts for fiber-related trademarks imported from the U.K. up until the end of April 1995 were rescinded.

Figure 6-3-13 Trends in breakdown of overseas technology import contracts by technological field



Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 6-3-13

Figure 6-3-14 Trends in number of software import contracts relative to total technology introduction contracts



Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development".
See: appendix table 6-3-14

(3) Technology Imports for Software

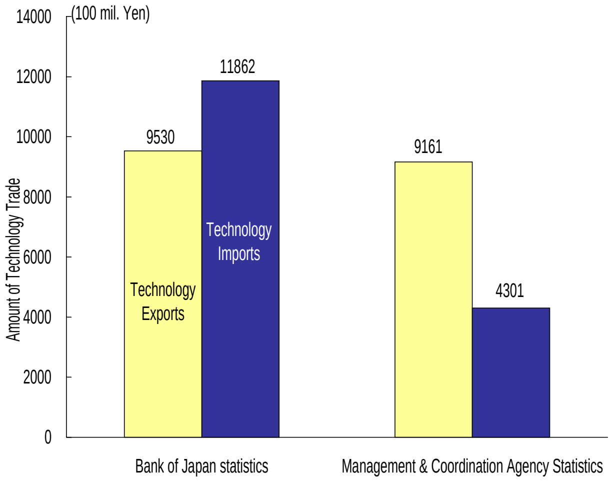
As mentioned above, the number of imports in the electronics field accounted for a large proportion of the total at 55.2% (in FY1997). The large number of imports in the electronics field, in comparison to the other fields, is a primary factor in the large number of imports in computer software, at 1,376. The share of technology imports in software has increased year after year, and has surpassed the number of software-excluded technology imports since FY1993, other than in FY1995. However, there was a 15% decline in FY1997 compared to a previous year.

6.3.5 Technology Trade Statistics for Japan

The representative technology trade statistics for Japan are those of the Bank of Japan and the Management and Coordination Agency. However, while both organizations deal with technology trade, there are significant disparities between their data, particularly in the data for value of technology imports (see Figure 6-3-15).

As a result, there are big differences in the technology trade income and expenditure ratio (i.e. technology import amount/technology export amount) derived from each set of data. For example, in FY1998, the Management and Coordination Agency's statistics show a ratio of 2.13, indicating an export surplus. In the statistics for the Bank of Japan, on the other hand, the ratio is 0.8, indicating an excess of imports over exports. However, these disparities are explained by the differences in the purposes, methods and ranges of the surveys by the two: The Bank of Japan's chief purpose is the management of foreign currencies, while the Management and Coordination Agency's chief purpose is to grasp the actual conditions for R&D activities in Japan.

Figure 6-3-15 Trends in Japan's technology trade (FY1998)



Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development". The Bank of Japan, "Balance of Payments Monthly Report"
See: appendix table 6-3-14

There are three main reasons for the disparities between the statistics for the Bank of Japan and the Management and Coordination Agency:

1) The statistics for the Management and Coordination Agency exclude a number of industries, such as wholesale, retail, food and beverage, finance and insurance, real estate, and the service industry. The industries targeted under technology trade are not limited to the manufacturing industries, and must include all industries.

2) The statistics for the Bank of Japan exclude know-how accompanying factory exports, as well as the value of technology consulting for industry. However, technology consulting, and so on, which occurs with the export of factories, etc. must be included as part of technology trade.

3) Since the value of establishing transference and usage rights for trademarks is included in the statistics for the Bank of Japan, these must be subtracted. Even if there are industrial ownership rights, strong claims to non-technical elements such as trademarks must be removed from technology trade.

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[1] National Science Board, Science and Technology Indicators – 1998, Arlington, VA: National Science Foundation, 1998 (NSB 98-1)

[2] Worcester Polytechnic Institute, "Analysis of Highly Cited Patents: Are They Important?", Report prepared for the U.S. Patent Office, 16 December 1988.

[3] Albert, M.B., Avery, D., Narin, F. and McAllister, P., "Direct Validation of Citation Counts as Indicators of Industrially Important Patents", Research Policy, Vol. 20, No. 3, June, 1991, pp. 251-259

[4] Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"

[5] Science and Technology Agency, National Institute of Science and Technology Policy, "Trends in Technology Exports from Japan - FY1994" and "Analysis of Trends in the Import of Foreign Technology from Japan - FY1993 to FY1997-"

[6] The Bank of Japan, "Monthly Report on International Income and Expenditures"

[7] OECD, "Main Science and Technology Indicators, 1999/2"

[8] OECD, "Basic Science and Technology Statistics, 1999"

[9] OECD, "National Accounts, Main Aggregates: 1999"

Chapter 6
Hiroyuki Tomizawa
Yumiko Kanda

Chapter 7 Social Contribution of Science and Technology

This chapter will examine the impact that science and technology activities have on Japan's economy and society. Section 1 will present technological progress and improvements in productivity, Section 2 will present innovations in new product development, Section 3 will deal with the effect that information and communications technology has on society and the economy, and Section 4 will present the contribution of life sciences. Relevant indicators will also be presented in each section.

7.1 Technological Progress and Improved Productivity

Progress in science and technology has an impact on our society and economy through a variety of routes. For example, the appearance of new products makes our lives more comfortable, and the reduction in working hours brought about by the introduction of new processes may provide people with more leisure time. In this way, the impact that progress in science and technology has on society and the economy is complex and diverse, and for some time now attempts have been made in a variety of forms to create a general indicator of these effects.

This section will examine the impact that science and technology has on our society and economy from the perspective of improvements in productivity. Productivity refers to the volume of output per unit of factors input into production activities, and there is a possibility that technical knowledge, one of the outcomes of science and technology activities, may improve this productivity by being embodied in new products and new processes. Accordingly, it is possible to grasp the economic contribution of technological progress using the rate of growth in productivity as an indicator.

Although there are a variety of different forms of indicators of productivity,[1] this section will focus on two indicators of productivity in particular: labor productivity of added value and total factor productivity. As will be mentioned later, these indicators have their limitations, but they are regarded as useful as a primary border to gain a picture of the impact of technological progress on society and the economy.

7.1.1 Raising Labor Productivity of Added Value

In this paragraph firstly we will deal with labor productivity of added value (real GDP per capita) and look at long-term trends while drawing international comparisons.

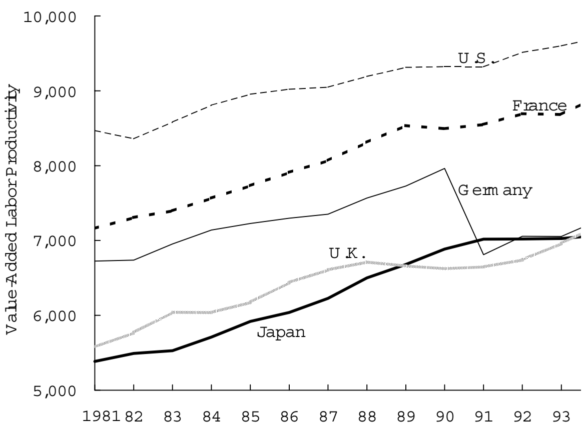
[1] The following types of classification are generally used as indicators of productivity. Indexes which measure output as physical output are called physical output, and indexes which measure the value of output are called value of output. An index that measures the factors input by capital (stock) is called capital productivity, and an indicator which measures it in terms of labor (number of persons employed or total working hours) is called labor productivity. Physical productivity is restricted to cases where it is possible to assess production in terms of physical volume, so it cannot be applied to measuring productivity of all economic activities incorporating the service industry. Therefore, as a macroeconomic indicator, productivity of added value is used, which takes as its numerator Gross National Product (GNP) or Gross Domestic Product (GDP) calculated as the total value added by a country.

Fig. 7-1-1 shows an international comparison of changes over time in labor productivity of added value (real GDP per capita) on the basis of actual figures in the five major industrialized countries.[2] The labor productivity of added value of the four countries apart from Germany, which experienced an integration of East and West in 1990, have generally been rising from FY1981 to FY1996. Comparing the five countries from the perspective of absolute levels of labor productivity of added value, the superiority of the U.S. remains unchanged, with the figure rising from 8.46 million yen to 9.90 million yen over the 16 years from FY1981 to FY1996. Additionally, France has secured the position behind the U.S., with labor productivity of added value over this 16-year period increasing from 7.16 million yen to 9.14 million yen.

In contrast, the relative positions of Japan, the U.K. and Germany have fluctuated somewhat. In these fluctuations, Japan's labor productivity in FY1981 was 5.38 million yen, lowest of the five nations, but in FY1989 it rose above that of the U.K., and in FY1991 it rose above that of Germany to reach the third position among the five countries. However, growth in labor productivity slowed from the mid-1990s, with Japan falling to become the lowest-ranked country again in 1994 and subsequent years. The low growth from FY1994 is regarded as reflecting the impact of economic recession.

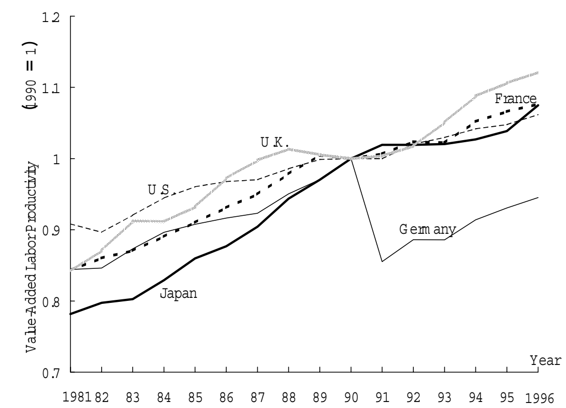
[2] Real GDP per member of the labor force (see Table 7-1-1) is calculated by multiplying the actual figures for real GDP per capita of each country (figures in 1,000 yen, 1990 prices) which appears in the International Comparison of Labor Productivity (1998 edition) published by the Productivity Research Institute of the Japan Productivity Center for Socio-Economic Development (see Table 7-1-1) by the total population of each country, then dividing the result by total employment (see Table 7-1-4). Figures for total population and total employment were taken from OECD Labor Force Statistics 1977-1997 (1998 edition).

Figure 7-1-1 International comparison of value-added labor productivity



Source: Japan Productivity Center for Socio-Economic Development, "International Comparison of Labor Productivity" (FY1998 edition)
See: appendix table 7-1-1

Figure 7-1-2 Trends in value-added labor productivity index in selected countries



Note: A currency conversion will be based on the purchasing power parity of price in 1990.
Source: Based on Japan Productivity Center for Socio-Economic Development, "International Comparison of Labor Productivity" (FY1998 edition)
What excluded added value labor productivity of each country and each fiscal year with the value in the 1990 fiscal year with the added value labor productivity index.
See: appendix table 7-1-2

In order to further clarify the changes over time in labor productivity of added value in the various countries, Fig. 7-1-2 has been devised to compare how the labor productivity of added value of each country in each fiscal year to the level of labor productivity of added value in FY1990 (hereinafter "the labor productivity of added value of each fiscal year/labor productivity of added value in FY1990") is referred to as "the labor productivity index of added value").

Looking at the labor productivity index of added value, Japan's labor productivity of added value improved dramatically in the 1980s, and while it leveled off somewhat in the early 1990s, it started to rise again in 1995. The other four countries also experienced rises in productivity across the board in the 1980s, but the increases were of a lesser magnitude than those experienced by Japan.

Looking at the change in labor productivity of added value over the whole period (1981-1996) relative to the average annual growth rate, Japan recorded the highest growth rate at 2.15%, followed by the U.K. (1.93%), France (1.64%), the U.S. (1.05%) and Germany (0.76%).[3]

Next, let's make an international comparison of the changes over time in the average annual growth rate in labor productivity of added value, dividing the whole period up into the 1980s and the 1990s. In the 1980s Japan's superiority remained unchanged, and the average annual growth rate of 2.74% was a high level. This figure was much higher than that of the U.K. (2.26%) and France (2.22%). Upon entering the 1990s, however, the growth rate slowed dramatically, dropping to 1.48%, but maintaining the second position among the five countries. A similar phenomenon was also observed in France, with the growth rate of 2.22% in the 1980s dropping dramatically to 0.99% in the 1990s. In contrast, the U.K. managed to retain a similar level of growth in both the 1980s and 1990s, with the figure of 2.26% in the 1980s only dropping to 1.94% in the 1990s. Finally, the labor productivity of added value in the U.S. is highest of the five countries when viewed as an absolute level, but its average growth rate was 1.05% (FY1981 to FY1996), half of that of Japan.

The differential between labor productivity in Japan and other countries is narrowing as the years go by. For example, the differential with the U.S. was 57.3 points in 1981, but this fell to 33.8 points in FY1996. The differential with France was 33.0 points in 1981, but this fell to 23.6 points in 1996. In addition, the differential with the labor productivity of added value of the U.K. and Germany was almost cancelled out in FY1996.[4] Because labor productivity of added value is an indicator defined as the real GDP per member of the labor force, it is greatly affected by the employment rate (defined as the labor force/whole population) in the country in question. Therefore, if labor productivity of added value is improved by reducing the employment rate, this change cannot be interpreted as being directly linked to an improvement in the standard of living in that country. This point needs to be taken into account when making comparisons.[5]

[3] See Table 7-1-2 and Table 7-1-3.

[4] In each fiscal year, the labor productivity of added value for each country has been divided by Japan's labor productivity of added value before comparison.

[5] For example, France's labor productivity of added value is next after that of the US (see Fig. 7-1-1), but when comparing the countries in terms of GDP per capita, in FY1990 and subsequent years France is lower than Japan (see Fig. 7-1-11). This can be attributed to France's low employment rate compared to the other four countries (see Table 7-1-5).

7.1.2 Technological Progress and Changes in Total Factor Productivity

In the previous paragraph we looked at the changes over time in labor productivity of added value of the five major industrialized countries, and an international comparison was made with Japan's figures. Incidentally, labor productivity of added value is an index of productivity which takes labor as the only factor of production, but in today's economy, machinery and other capital equipment other than labor are also input as factors of production. It is therefore desirable that Total Factor Productivity (TFP) – the ratio of total added value for all factors of production (labor and capital) - be examined in order to gain an overall picture of the efficiency of a country's production activities.

Total factor productivity represents the amount of added value per unit of all factors input, and may be interpreted as indicating the efficiency of production technology in a country's economy. Therefore, growth in total factor productivity may be regarded as an improvement in the efficiency of production technology or technological progress. This can be understood by considering it in the following way. If the input of total factors of production is doubled in the current fiscal year, and the total added value of the following fiscal year is double that of the current fiscal year, then the increase in total added value can be explained totally by an increase in the factors of production, indicating that the efficiency of production technology has not changed. However, if the total added value of the following fiscal year more than doubles, then this means that an improvement in efficiency (technological progress) has occurred which cannot be explained by the growth in factors of production. Therefore, in cases where a growth in output that exceeds the growth in the factors input between two points in time, then this means that during this period an improvement in efficiency of production technology has occurred, i.e. technological progress has occurred.

Fig. 7-1-3 shows changes over time in the total factor productivity index (calculated by dividing the total factor productivity for each fiscal year by the total factor productivity for FY 1990) in the five major industrialized countries that appear in the 1998 edition of the OECD International Sectoral Data Base.(6)

The total factor productivity index of the five selected countries(7) fluctuates slightly, but generally rises over time. This means that during this period, all of the five selected countries experienced continued technological progress. Taking an overview of the changes over time in the total factor productivity index by country, Japan's index increased consistently up until 1990, but in 1992 a level lower than 1990's level was recorded. In subsequent years the index has moved sideways. The U.K. recorded its peak in 1988, after which its figures have been falling. In contrast, the U.S., France and Germany, despite minor fluctuations, have con-

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(6) The total factor productivity indices for the major five industrialized countries have been extracted from the Total Factor Productivity Index in all of the industries that appears in the International Sectoral Data Base 1998 Edition (OECD). The total factor productivity index referred to here is the value arrived at by standardizing the total factor productivity for each fiscal year, assuming the Cobb-Douglas production function below, with the total factor productivity for FY 1990.

It is defined as:

$TFP = [VA/(ET^{W} \times GCS^{(1-W)})]/TFP_{1990}$

Where TFP = total factor productivity

VA = gross value added

ET = total number of employed persons

GCS = gross capital stock

W = labor share

TFP_{1990} = total factor productivity for FY 1990

Labor share W is defined as W = [COMP x (ET/EE)]/VA

Where COMP = amount paid to employees

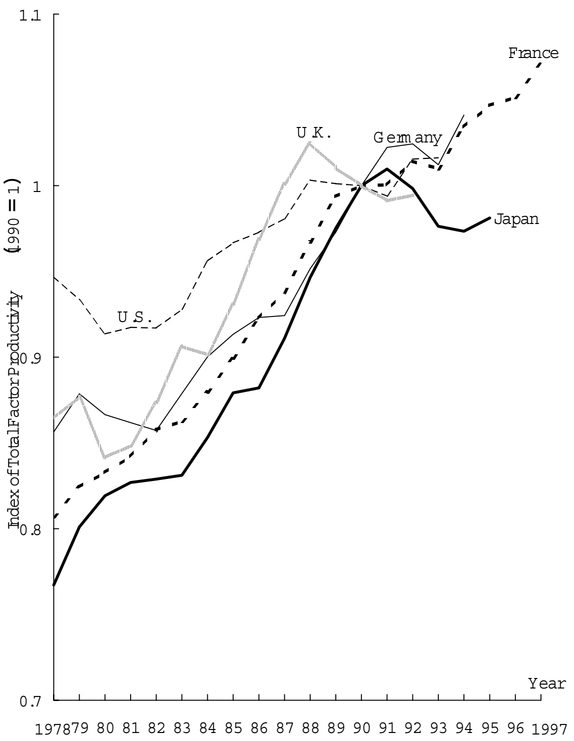
EE = total number of persons employed

By multiplying the number of persons employed by the total ratio of persons in gainful employment, the income of self-employed people is also taken into account.

(7) The figure for Germany's total factor productivity index uses the total factor productivity index for West Germany.

tinued to show rising figures even after 1990, the reference year. In France in particular, the figure for 1997 is some 7% higher than the figure for 1990.

Figure 7-1-3 Trend in total factor productivity Index in selected countries



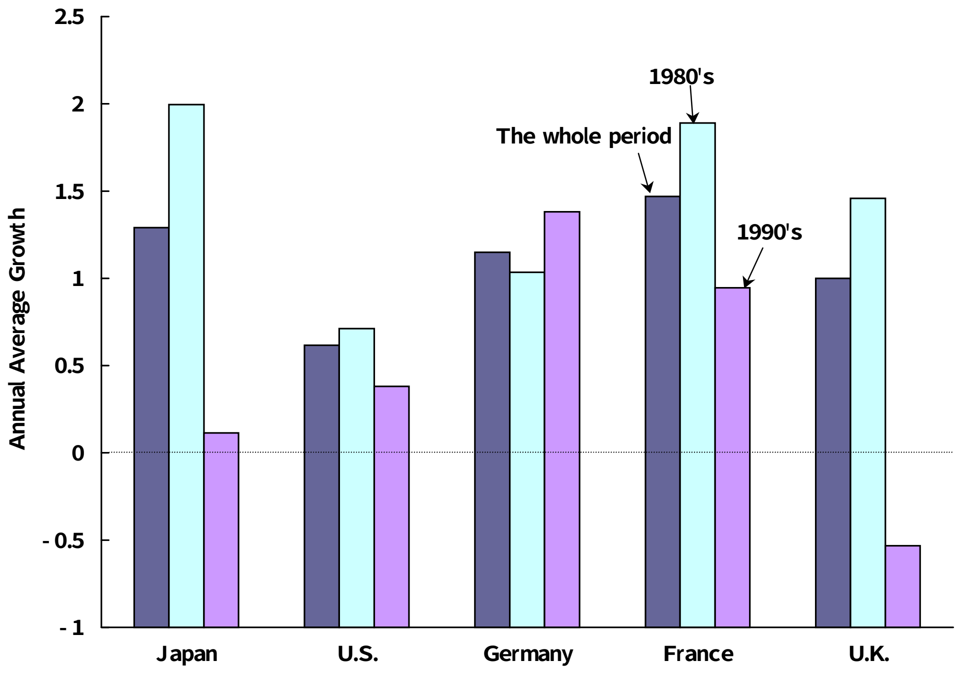
Source: OECD International Sectoral Data Base (FY1998 Edition)
See: appendix table 7-1-9

Differences between countries in the changes over time in the total factor of production index become clearer when the average annual growth in total factor productivity (Fig. 7-1-4) has been arranged. Firstly, when making a comparison of the annual average growth in total factor productivity for the whole period, France has recorded the highest figure at 1.47%, followed by Japan with 1.29%, Germany (1.15%), the U.K. (1.00%) and the U.S. (0.62%). Taking a look at trends in technological progress by dividing the period observed up into the 1980s and the 1990s, in the same way as in the previous paragraph, during the 1980s Japan showed the highest rate of technological progress (2.00%), followed by France (1.89%) and the U.K. (1.46%). Upon entering the 1990s, however, the growth in total factor productivity slowed in all countries, and the slowing was most pronounced in Japan and the U.K.[8].

However, the growth in total factor productivity measured in this way contains all of the residual increases in total added value which cannot be explained by the expansion of volume of input of factors of production such as capital and labor. Improvements in production efficiency can be achieved by efforts to improve management, introducing new industrial organizations, or by economies of scale, and may not necessarily accompany technological progress. One must be aware, therefore, that there are limitations in that in using growth in total factor productivity as an indicator of technological progress, factors other than technology are also included.

[8] It is possible to obtain the total factor productivity index for each country from OECD data, but not the actual figures for total factor productivity for each fiscal year. It is therefore impossible to make an international comparison between countries.

Figure 7-1-4 Growth rate of total factor productivity index in selected countries



Source: Based on OECD International Sectoral Data Base (FY1998 Edition).
The growth rate was calculated as "(value of this term - value of the first half)/value of the first half".
See: appendix table 7-1-10

7.2 Innovations in New Product Development

7.2.1 Objectives and Meaning of Indicators

This section will deal with innovations in new product development as one of the aspects that represents how science and technology contributes to society and the economy. Knowledge obtained through science and research is reflected in some form of technology or in the form of knowledge in products and processes. Without restricting oneself to the narrow definition of technology, it is reflected in the broad definition of technology concerning economic and social mechanisms, information, products, processes and services, etc. Society and economy that are regarded in this way are generally referred to as a knowledge-based economy or a knowledge-based society, and the process of creating new products, processes, services and mechanisms is referred to as innovation.

Of all of the goods that are created as products, we will focus here on the products that are provided to consumers in the form of final consumer goods, and observe one aspect of innovation through trends in products released onto the market. Trends in products reflect not only the state of technological innovations such as product innovations and process innovations on products developed, but also non-technological innovations relating to distribution and so forth.

Science and technology alone is not the only factor that contributes expressly to the development of new products. It is undeniable, however, the fruits of science and technology have an impact on the diverse process of innovation. For example, it is easy to acknowledge that the fruits of science and technology are utilized in household appliances, but in processed food, the results of science and technology are also used in functional food and so forth. In terms of processes, too, improvements to manufacturing methods and packaging technology have been made based on the results of science and technology, and new products are being created. In this sense, in today's society where science and technology is being expected to contribute to society and the economy, it is highly significant that we can analyze the state of innovation through products, as final consumer goods, as one aspect.

In analyzing the state of new product development, we will be focusing on products as final consumer goods. This has been made possible by the computerization of distribution that has occurred in recent years. Almost all products currently distributed in the selected countries of the world are affixed with a product code in accordance with a worldwide system displayed in the form of a symbol called a barcode. In Japan this product code is referred to as a JAN code, and JICFS has been developed as a database of products that can be used by both wholesalers and retailers. In this section we will perform analysis using statistics concerning JICFS, the database of products to which this JAN code has been affixed. JAN Code and JICFS has been provided as a column to give an overview of these two topics.

With regard to statistics concerning patents, while there are limitations in terms of differences caused by the quality of individual patents and differences in fields, it is regarded as meaningful to observe the activity concerning technological development as a whole by quantitatively assessing and comparing them. In this regard, analysis using patents is discussed in Chapter 6 of this report. It is possible to regard products in the same way, and while there are limitations in terms of differences in the quality of individual products, differences in the way they are regarded as units, and differences in sector, it is extremely important to measure the state of new product development quantitatively and in aggregate terms. Up until now, the main focus of analysis of innovations has been on the process. There are few surveys, however, that focus on products as the fruits of innovation, and exhaustive data concerning products has not be observed from the perspective of innovation. Further, in the future, it will also become possible to observe the contribution of technology to product development more directly by matching technological fields with products. Additionally, by utilizing information concerning products to which JAN codes other than those included in the JICFS database (EAN codes, UPC, etc.) have been assigned, it will become possible to gain a clear picture of the distribution of product lives and clarify a wide range of trends in new product development of consumer goods in terms of distribution. In addition, because EAN codes (as indicated above, JAN codes is the name for EAN codes in Japan) are the same throughout the world (there are plans to integrate them for the U.S. and Canada), international comparisons of activity in product innovation will become possible through indicators utilizing these codes. The indicators referred to in this section have these possibilities, and in this edition we will present trial initiatives and the situation in Japan.

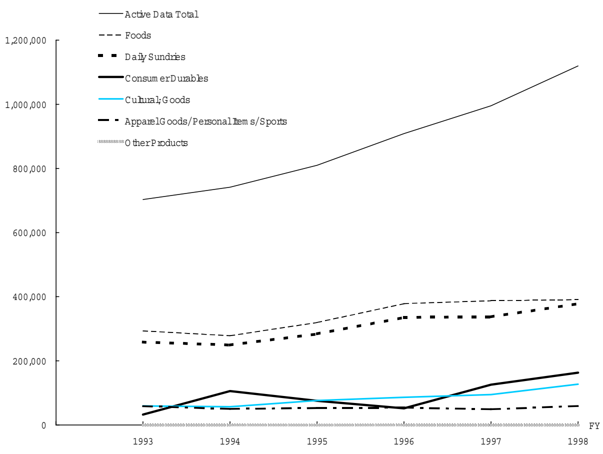
JAN codes themselves are not restricted to final consumer goods, but are affixed to many consumer goods. Some 99% of goods handled in supermarkets and convenience stores have JAN codes affixed to them. Of the products to which JAN codes have been affixed, some 85% to 90% of those in supermarkets are included in JICFS, and more than 95% of those in convenience stores are included in JICFS. From existing surveys, it is suggested that products to which JAN codes have been affixed but which are not registered in JICFS are products to which JAN codes have been affixed by individual stores, or products which are distributed only to a particularly area. Examples of merchandise categories which are consumer goods but to which JAN codes have not been affixed are motor vehicle parts (excluding car accessories), motor vehicles themselves, housing-related products (excluding products available at home improvement centers), and fresh food (processed food has JAN codes assigned to it). This suggests that by using JICFS it is possible to analyze products which are final consumer goods distributed in Japan. JAN codes are also affixed to books and magazines, but they have a separate system, and are managed on a separate database, so these are not included in the analysis.

7.2.2 Trends in Number of Products and Average Product Life

This section contains the results of observation using JICFS and the points suggested by those results. In performing the analysis, firstly it is necessary to take into account whether the data is reflecting the state of the market or reflecting the characteristics of the database. If the data reflects the state of the market, the values may be stationary or fluctuating. Particularly if they are fluctuating, care needs to be taken in interpreting whether they are reflecting the results of technological innovations brought about by the results of new product development or whether they are reflecting the results of non-technological innovations such as deregulation or reform in distribution mechanisms. In addition, with regard to database characteristics, one needs to take into account the fact that the database has only been in operation for a short period of time, and that there processes whereby new data is incorporated into the database in a concentrated manner by approaching industry sectors and business categories.

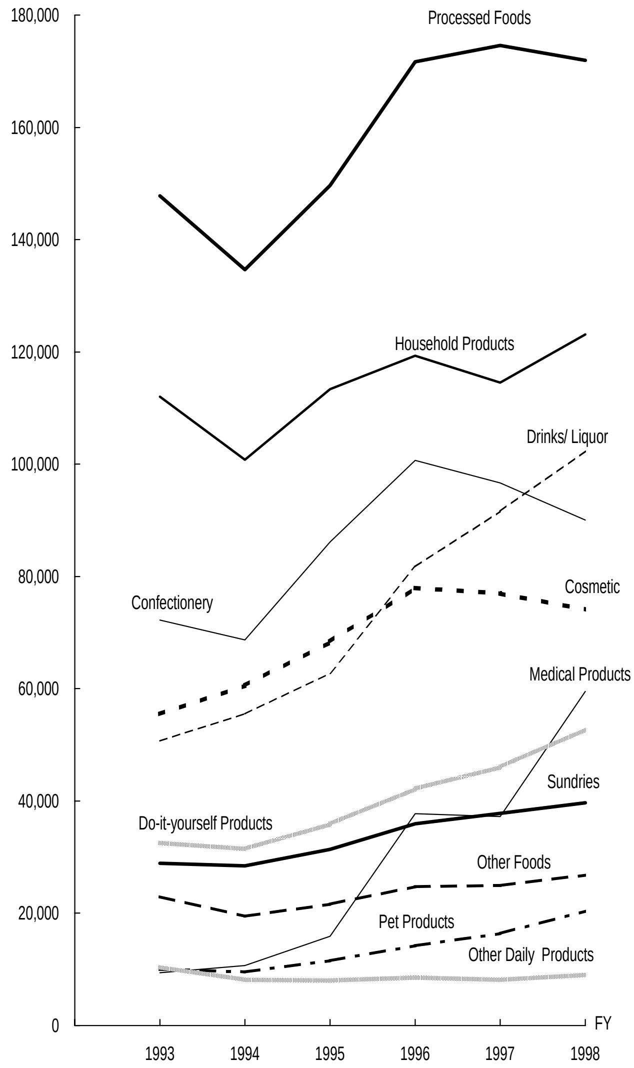
Fig. 7-2-1 shows changes over time in the active data registered in JICFS as a whole, separated into Divisions. Overall, the number of cases is increasing. Looking at the figures by category, however, "Foods" has remained stationary at less than 400,000, while "Daily-use Goods" are increasing gradually. In contrast, "Consumer Durables" and "Recreation and Miscellaneous Goods" are increasing, with "Consumer Durables" in particular subject to great fluctuations from year to year. Fig. 7-2-2 shows the change over time by Major groups for "Foods" and "Daily-use Goods." In this graph, categories experiencing great increases "Beverages and Alcohol" and "Drugs," and these increases are step-by-step. Categories that are increasing consistently are "DIY (Do-It-Yourself) Products" and "Pet Accessories." "Daily-use Accessories" and "Other Foods" are increasing gradually, while "Processed Foods," "Confectionery," "Household Goods" and "Cosmetics" are either constant or decreasing gradually.

Figure 7-2-1 Trend in number of items registered with JICFS (Divisions)



Data: Distribution Code Center, Distribution Systems Research Institute, "A Guide to JICFS (JAN Code Information Database) Registration-". Tokyo: Distribution Code Center, Distribution Systems Research Institute
Based on the above-mentioned data, the National Institute of Science and Technology Policy estimated.
See: appendix table 7-2-3

Figure 7-2-2 Trend in number of items registered with JICFS (Major groups of "Foods" and "Daily-use Goods")

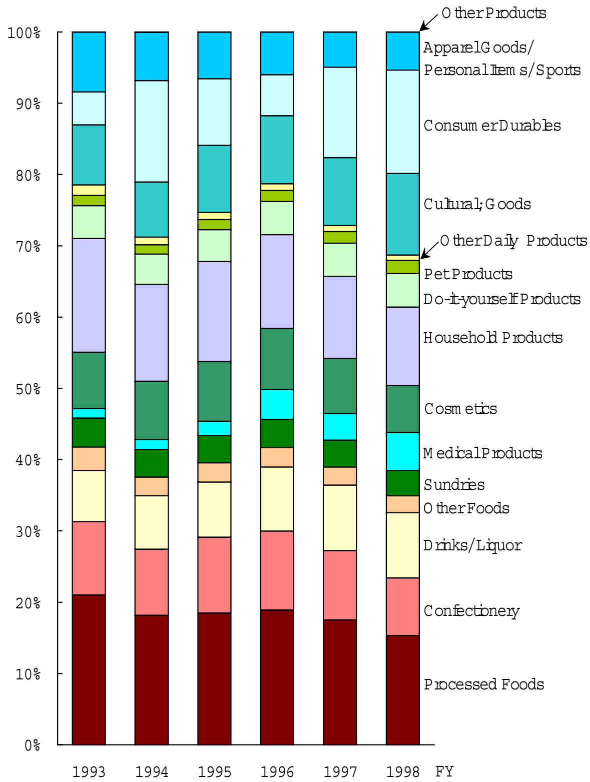


Data: Distribution Code Center, Distribution Systems Research Institute, "A Guide to JICFS (JAN Code Information Database) Registration-", Tokyo: Distribution Code Center, Distribution Systems Research Institute
Based on the above-mentioned data, the National Institute of Science and Technology Policy estimated.
See: appendix table 7-2-3

With regard to "Foods" and "Daily-use Goods," those products distributed virtually across the whole country are registered in JICFS, and it is suggested that their sizes are generally constant (just under 400,000 items for "Foods" and just under 400,000 for "Daily-use Goods"). As sub-categories of these categories, however, "Beverages and Alcohol" and "Drugs" are increasing step-by-step, suggesting that non-technological innovations have occurred during this period. These points will be examined in more detail below. Meanwhile, with regard to "Consumer Durables," the fluctuations by year are great, strongly indicating the need to look at the characteristics of the database when carrying out analysis. It is possible that a maximum of 160,000 items are being distributed.

Fig. 7-2-3 shows the change over time in the percentage of items registered with JICFS by sector. Taking a look at the characteristic movements within this graph, firstly "Processed Foods" is gradually increasing. In contrast, "Drugs" is increasing rapidly. Fluctuations from year to year are severe in "Consumer Durables."

Figure 7-2-3 Change over time in the percentage of items registered with JICFS

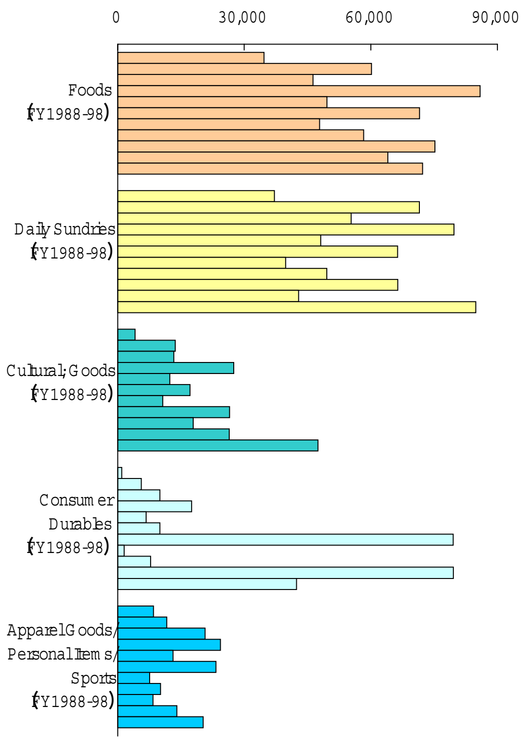


Data: Distribution Code Center, Distribution Systems Research Institute, "A Guide to JICFS (JAN Code Information Database) Registration-", Tokyo: Distribution Code Center, Distribution Systems Research Institute,
Based on the above-mentioned data, the National Institute of Science and Technology Policy estimated.
See: appendix table 7-2-4

Fig. 7-2-4 shows trends in the number of items registered with JICFS for the first time each fiscal year by Divisions. According to this graph, the fluctuations from year are quite considerable. Even looking at the past five years alone, the number of items for "Foods" has ranged from approximately 50,000 to 80,000, for "Daily-use Goods" it has ranged from approximately 40,000 to 90,000 items, and for "Recreation and Miscellaneous Goods" it has ranged from approximately 10,000 to 50,000 items. Fig. 7-2-5 shows figures for Major groups of

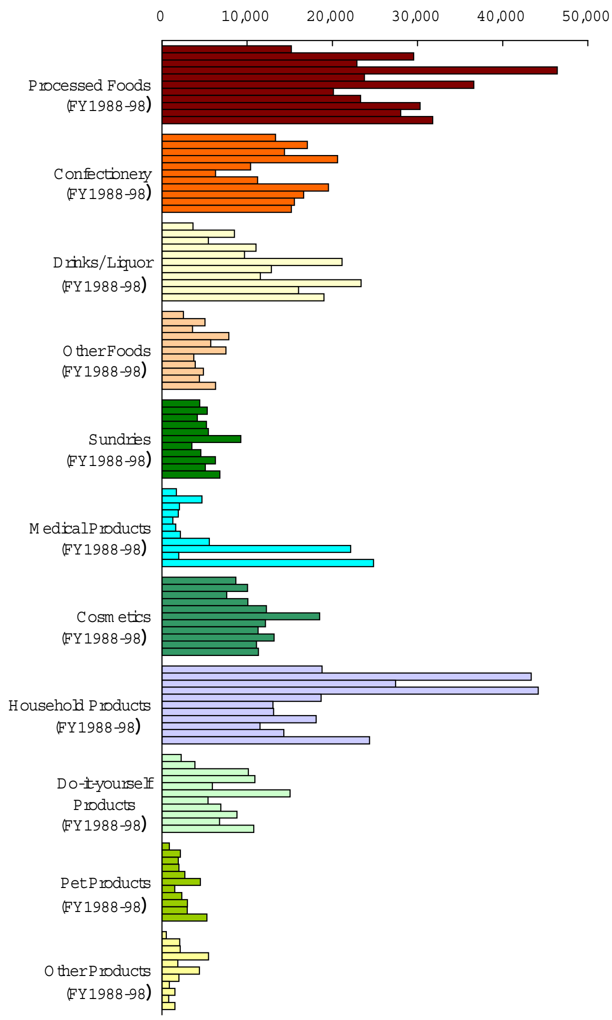
"Foods" and "Daily-use Goods." Even breaking down figures into Major groups like this, there are still considerable fluctuations from year to year. Fluctuations still occur from year to year in categories like "Processed Foods," where a considerable percentage of items are regarded as already having been registered. Care needs to be taken about the fact that "Beverages and Alcohol" experienced a noteworthy rise in the number of items registered for the first time in FY1996, while the same can be said for "Drugs" in FY1996 and FY1998.

Figure 7-2-4 Trend in number of new registration to JICFS (Divisions)



Data: Distribution Code Center, Distribution Systems Research Institute, "A Guide to JICFS (JAN Codes Information Database) Registration-", Tokyo: Distribution Code Center, Distribution Systems Research Institute.
Based on the above-mentioned data, the National Institute of Science and Technology Policy estimated.
See: appendix table 7-2-5

Figure 7-2-5 Trend in number of new registration to JICFS (major groups of "Foods" and "Daily-use Goods")



Data: Distribution Code Center, Distribution Systems Research Institute, "A Guide to JICFS (JAN Codes Information Database) Registration-", Tokyo: Distribution Code Center, Distribution Systems Research Institute.
Based on the above-mentioned data, the National Institute of Science and Technology Policy estimated.
See: appendix table 7-2-5

Firstly, fluctuations from year to year in the number of items registered for the first time are evident even in subcategories of "Foods" and some subcategories of "Daily-use Goods" categories whose registrations to the database are regarded as stable and which are deemed to represent a state which is close to that of the actual state of product development. Although definitive statements cannot be made from this analysis, it seems that it is necessary to gain a more detailed picture of the relationships with movements in technological development and movements in the market. It is also clear that marked increases have occurred in FY 1996 and FY 1998 for items registered for the first time under "Beverages and Alcohol" and "Drugs." We are looking at the number of products registered with JICFS, so it is difficult to ascertain whether new increases in these figures are completely due to new product development, or whether data concerning existing products to which JAN codes are affixed has been newly added to JICFS. According to the Distribution Systems Research Institute, uploading of data for "Drugs" was carried out over a number of occasions due to requests from users and in the industry itself. However, considering that a need has arisen to share data through JICFS for products which are distributed nationwide, these fluctuations can be attributed to some form of innovation concerning products. In fact, products classified as alcohol and drugs have experienced non-technological innovations during this period, such as changes in the type of retailers and changes in the way goods are sold, resulting from deregulation. This is regarded as having resulted in a quantitative increase in the number of new products. With regard to "Consumer Durables," although the fluctuations from year to year are quite severe, according to the database, assuming that most recently nearly all products are captured on the database, it suggests that at least 40,000 new products are created each year.

For each category, from the number of new registrations to JICFS, the number of shunting and the number of items registered, we calculated the average length of time that data concerning the products on JICFS exists as active data. This period has been provisionally names the "Average Product Life" here. Fig. 7-2-6 shows the average product life of each category. If analysis were carried out using data concerning the number of new registrations and shunting for each individual product, then in addition to making it possible to gain a more accurate picture, it would also be possible to ascertain the distribution of product lives.

Figure 7-2-6 Average Product Life of each category

Data: Distribution Code Center, Distribution Systems Research Institute, "A Guide to JICFS (JAN Codes Information Database) Registration-", Tokyo: Distribution Code Center, Distribution Systems Research Institute.
Based on the above-mentioned data, the National Institute of Science and Technology Policy estimated.
See: appendix table 7-2-6

In this case, due to restrictions in terms of using data, we have made an overall analysis for each category, and made rough estimates for the case where the number of new registrations is used, and the case where the number of items shunting is used. In a stationary situation where the number of new items and the number of items shunting is about the same, the results achieved from both calculations would be about the same, and disregarding the existence of a time lag caused by the fact that shunting is carried out roughly once a year, it may be regarded as a rough representation of the actual situation.

According to the analysis, while there are differences for each Major group, the product life for "Foods (overall)" is approximately 6 to 7 years, for "Daily-use Goods (overall)" it is approximately 6 to 9 years. In particular, the life for "Processed Foods," "Confectionery" and "Cosmetics" is approximately 6 to 7 years. In contrast, the life of "Consumer Durables" is approximately 3 to 7 years, a product life that is shorter than the other Division. The fact that the product life of "Consumer Durables" is shorter than that of "Foods" and "Daily-use Goods" is easily imagined if one considers the daily lives of people in Japan, and is quite interesting when looked at from the durability that consumers expect of "Consumer Durables." With regard to Major groups of "Drugs," "Pet Accessories," "Beverages and Alcohol" and "Do-It-Yourself Products," registration of products has yet to reach a stationary state, so some range is evident in the estimated results.

By carrying out continued and detailed analysis of data, it is deemed possible to gain a clear picture of the actual state of innovations in new product development.

JAN Codes and JICFS Codes

In 1997 the EAN (European Article Number) code was systematized as a common product code for the whole world (excluding the U.S. and Canada), and the name for this system in Japan is the JAN (Japan Article Number) code. The JAN code is a common product code for the whole of Japan, which forms the basis of distribution information systems. This code is displayed on products as a barcode, and is used in POS (point of sale) systems, ordering systems, stocktaking and inventory management systems. In the U.S. and Canada, the UPC (Universal Product Code) was systematized in 1973 and is being used as a common product code. Countries and regions affiliated with EAN have the compatibility of being able to read UPC. With a view to creating a global standard, moves are being made to have UPC match the EAN system by 2005. In Japan, the Distribution Code Center (DCC) of the Distribution Systems Research Institute (DSRI) is affiliated with EAN International.

In addition to the common product code used in many product fields, the JAN code includes the common magazine code which is a code framework for magazines, the book JAN code which is a code framework for books, as well as the JAN code for coupons and the JAN code for fee payment forms.

The common product code is comprised of 13 digits (standard type) or 8 digits (shortened type). With the standard type, the first 7 digits of the 13 (the first 9 digits for companies registered for the first time in January 2001 or later) (the first 2 digits of the 7 or 9 digits are the country code for Japan – 49 or 45) are the product manufacturer code; the next 5 digits (3 digits for companies registered for the first time in January 2001 or later) are the product item code, and the last digit is a check digit to prevent misreading. Usually, in addition to the numbers that display this code, the JAN symbol is displayed on packaged products together with a display called a barcode. The JAN symbol is normally read by a POS terminal. Product manufacturer codes are managed in a centralized manner by the Distribution Systems Research Institute, with companies applying for registration to the Distribution Systems Research Institute, which then assigns codes. Product item codes are set, in accordance with given setting criteria, independently by companies to which a product manufacturer code has been assigned, to units that can be managed in the retail industry at a single unit level. In reusing product item codes that have already been assigned once, which will be mentioned later, normally a minimum of four years are left after suspension of shipping, and each company is requested to confirm that there is no distribution inventory at wholesalers or retailers.

In response to movements in Europe, in Japan the JAN code was made a Japan Industrial Standard (JIS) as a barcode symbol for common product codes (JIS X 0501) in April 1978. Then in December 1978 the Distribution Code Center in the Distribution Systems Research Institute started receiving registrations for the product manufacturer code. As at the end of March 1999, 85,673 companies had registered JAN product manufacturer codes (excluding some 10,000 codes assigned for book and magazine codes).

In addition, the following have been established by EAN International as common worldwide codes for distribution: Global Location Number (GLN) established to coincide with the development of distribution EDI (Electronic Data Interchange – an online data interchange system linking companies in accordance with the Standard Agreement Concerning Data Interchange for Commercial Transactions); EAN-14 (in Japan this code is called product code ITF (interleaved two of five) for collective packaging, and it was established as JIS X 0502) which is a product code framework for collective packaging; and EAN-128 (established in Japan as JIS X 0504) which is a code framework for product-related information and transaction information between companies.

Currently JAN codes are being assigned not only to consumer goods, which were the original subject of source marking, but are also being assigned increasingly to production goods. The following items are examples of products which are consumer goods, but to which JAN codes have not been source marked.

- Motor vehicle parts (excluding car accessories)
- Motor vehicles themselves
- Housing-related products (excluding products available at home improvement centers)
- Fresh food (processed food has JAN codes assigned to it)

At any rate, codes have been assigned to the majority of products that are consumer goods.

Meanwhile, JICFS is an abbreviation for JAN Item Code File Service, a database of JAN code product information, and as a service system for the database that centrally manages JAN codes and the related product information. JICFS commenced operation in 1988, and in FY1992, with the guidance and support of the Small and Medium Enterprise Agency of the Ministry of International Trade and Industry, the further strengthening and promotion of its use are being tackled. JICFS is being operated mainly by the Distribution Code Center. JICFS mainly collects items that can be used by the distribution industry as a whole. The data items collected include the JAN code (EAN code, UPC code), JICFS product classification code, official (kanji) product names, kana product names, content volume and weight, and single unit size. Registration is carried out mainly by product manufacturers. According to recent surveys, the percentage of product (item) information handled by stores which relies on JICFS (referred to as the hit rate) in foods and daily-use products, which make up the core of JICFS, is some 85% to 90% of products handled by general supermarkets, and exceeds 95% for convenience stores.

With regard to the structure of the JICFS database, explanation will provided especially with regards the registration of data. The relationship between "new registration," "abolition" and "shunting" is represented in Fig.7-2-7.

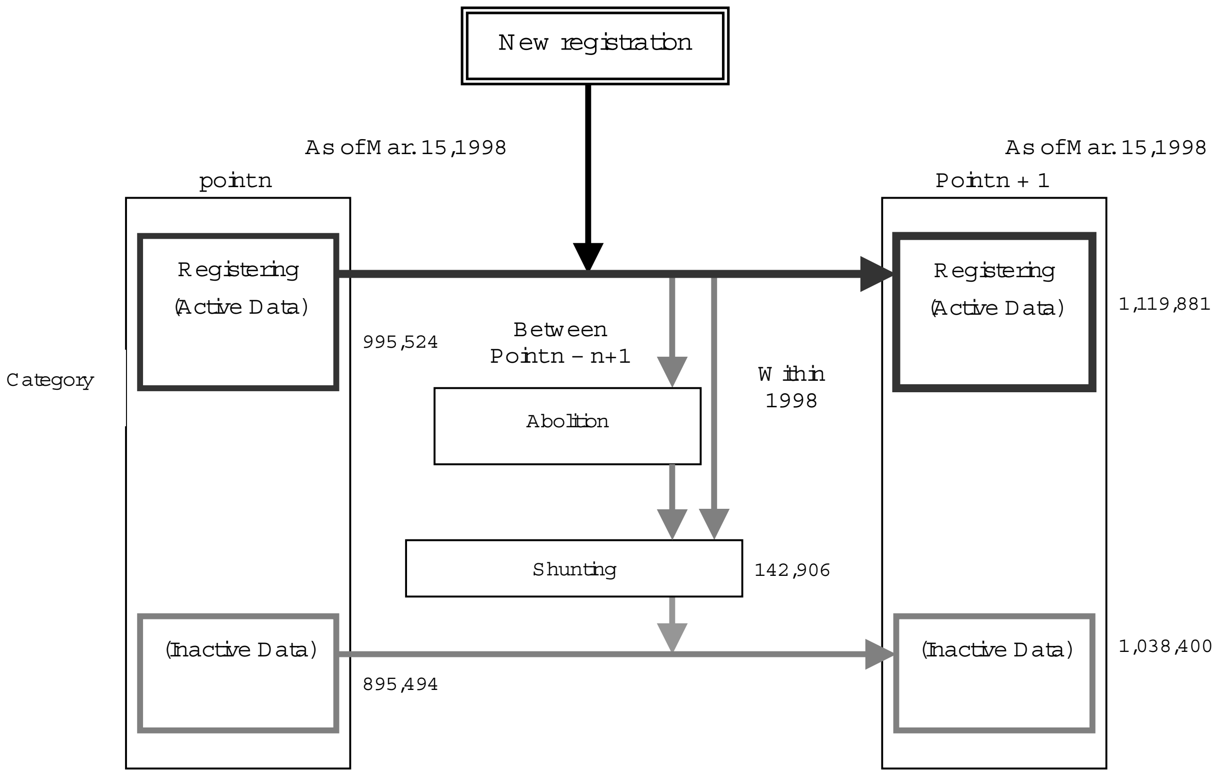
As data concerning products that is registered in JICFS, with the JAN code as a unit, there is active data which is being used at that point in time, and inactive data which is no longer used. Active data and inactive data are managed in separate databases. In the diagrams shown in this section, unless stated otherwise, it is active data that is being analyzed as JICFS registered data. New data is being registered to the active data database virtually on a daily basis. Meanwhile, due to the increase in data not utilized in JICFS as a whole, a database for inactive data was created in FY1993. Generally once each year since FY1993 data that satisfies any one of the following conditions is shunting from the active data database to the inactive data database.

- If POS data has not been recorded for the past year in the some 500 stores (as at September 1999) of the some 130 companies participating in RDS (distribution POS data service: a POS data service run by the Distribution Systems Development Institute with the support of the Ministry of Trade and Industry) (mainly medium-sized retailers and daily-use good stores).
- If a notification is received from the manufacturer that the item is no longer sold (abolition of the applicable product item code).
- If there has been no movement in the form of additions or renewals of items over the period of two years since its registration with JICFS.

- The following rules have been displayed for source marking of product item codes by manufacturers:
- JAN codes which have been source marked once shall not be reused on other products for a period of at least four years from the suspension of shipping of the product by the manufacturer.
- When reusing product codes, care shall be taken to ensure that codes are only used after concluding that distribution inventory does not remain at wholesalers and retailers.

In this way, mechanisms adopted avoid the duplication of the inflow and outflow of data concerning the same product, as well as the mixing of data concerning different products.

Figure 7-2-7 The conceptual figure of data processing in JICFS



Incidentally, it is conceivable that product data that was in inactive data may be re-registered in active data. In this case, products with the same JAN code are registered for the first time as active data. There are the following two reasons why this kind of situation may occur.

- The product was in fact still "alive," and being distributed in the market.
- The same JAN code has been source marked to a different product (in this case it is necessary to observe the general principle that recommends that a code not be source marked to another product for a period of four years after the shipping to the market of the previous product has ceased).

At the Distribution Systems Research Institute, a quantitative assessment is not made of JAN codes that were inactive data which appear again as active data in this way. Nevertheless, making an actual comparison of the number of shunting and the number of inactive data, it becomes clear that there is a considerable quantity of data with the same JAN code which has returned from inactive data to active data. In this section the number of shunting and the number of inactive data are compared, and an analysis made of the number of JAN codes which have actually ceased to be used.

Incidentally, in a survey concerning POS source marking rate targeting companies participating in RDS mentioned earlier, of all of the 600,000 products to which JAN codes have been source marked, approximately 300,000 have also been registered with JICFS, while the remaining 300,000 have not been registered. Meanwhile, in stores and companies, approximately 70% to 80% of companies register hits on JICFS. That is to say, the data concerning that product is contained in JICFS. Normally medium-sized stores are said to carry approximately 20,000 different products, of which approximately 16,000 products register hits on JICFS. In other words, there are approximately 4,000 products to which JAN codes have been source marked but which are not registered in JICFS. These two survey results suggest that products to which JAN codes have been source marked but which are not registered in JICFS are not stocked by other companies and stores. This refers to products which are unique to a particular store and have not been source marked a JAN code, and products which are distributed only in a particular region. Types of these products to which JAN codes have been source marked but which are not registered in JICFS include products delivered on the day, prepared food, and tofu.

7.3 Contribution of Telecommunications Technology to Society and Economy

Thanks to telecommunications technology which has developed to a sophisticated state, Japan's economy and society are entering a period of great reform. The rapid take-up of cellular phones, personal computers and other telecommunications equipment and services, together with the rapid take-up of the Internet, are making a great contribution to the development of Japan's economy, providing a new level of convenience, and making dramatic changes to the way we live and the way we do business. In this section we look at the effect and impact of these factors on economy and society, centering on the developments in information networks brought about by telecommunications technology.

7.3.1 Progress in Telecommunications Technology

With regard to telecommunications technology, the invention of letters as a means of recording and paper as a recording media, the invention of type printing, the creation of the postal system and the invention of the telephone, which were all inventions of technology or establishment of systems which were revolutionary for their respective eras, have had great impacts both socially and culturally. In recent years, the progress in science and technology, and especially telecommunications technology, is having a great new impact on economy and society.

The speed of communication of information by humans has increased from the movement of people from the beginning of time (walking and using horses), the communication of information to remote locations using smoke signals (speed is fast but the quantity of information is limited), and in transporting media such as paper, the speed has increased with the adoption of new means of transport such as ships, railways, cars and lastly aircraft, and finally with electronic communications the speed has increased to approach the speed of light. In addition, the quantity of information communicated has moved gradually to higher frequencies from ancient means of communicating information such as smoke signals and Morse code, and the development of wider-band communication routes with the development of optical fiber, in conjunction with the development of sophisticated telecommunications technology, has made it possible to process and transmit large quantities of information in a short time.

Table 7-3-1 (A) shows the processing capacity of typical electronic computers in each generation, and price per unit of processing power. This graph shows that personal computers of today have surpassed the supercomputers of the past, and that over a period of 20 years it is has become possible to obtain the same processing power for approximately one-three hundredth of the price. Table 7-3-1 (B) shows changes over time in the shipping price per computer main units in recent years in Japan. While the performance of computers is increasing as the years go by, the price of computers is falling. This increasing performance and falling prices of computers is acting as the driving force for the broad-based market penetration of sophisticated telecommunications equipment.

Figure 7-3-1 (A) Trends in computing price relative to speed

Year	Device	MIPS	Price per MIPS ($)
1975	IBM Mainframe	10	1,000,000
1976	Cray 1	160	125,000
1979	DEC VAX	1	200,000
1981	IBM PC	0.25	12,000
1984	Sun 2	1	10,000
1994	Intel Pentium Micro	66	3,000

Note: MIPS (million instructions per second)
Source: National Science Board, Science and Engineering Indicators-1998, Chapter 8, p.8-6
Quotation: J. Warnke, "Computer Manufacturing Change and Competition", Monthly Labor Review (August 1996): 18-30

Figure 7-3-1 (B) Trends in unit price of shipment of personal computer main frame in Japan

	Unit price of shipment (unit: 1,000yen)		
Year	Total	Desktop/Server	Portable
1995	244	235	266
1996	243	234	260
1997	241	234	250
1998	217	207	227
1999	199	177	226

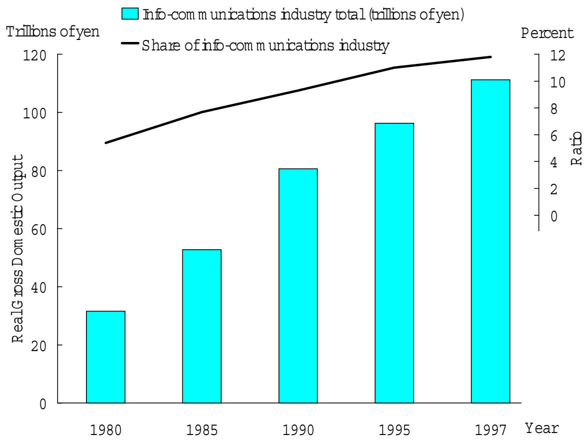
Note: the numerical value in the 1999 fiscal year is the numerical value of the third quarter in the 1999 fiscal year.
Source: Edited by Japan Electronic Industry Development Association "Electronic industrial monthly report" 1999.12 No.446, P35, and news of the same month 2000.3 No.449 and P30.

7.3.2 Growth in the Telecommunications Industry

Telecommunications, which have achieved great technological growth, are evoking great demand due to the convenience that they provide, and they are growing rapidly as an industry.

Fig. 7-3-2 shows the changes over time in the real value of domestic production for the telecommunications industry. The real value of domestic production for the telecommunications industry was 31.6 trillion yen in 1980, but this has grown rapidly to reach 111.2 trillion yen in 1997, and the percentage of all industry accounted for by telecommunications has increased dramatically from 5.4% to 11.8%.

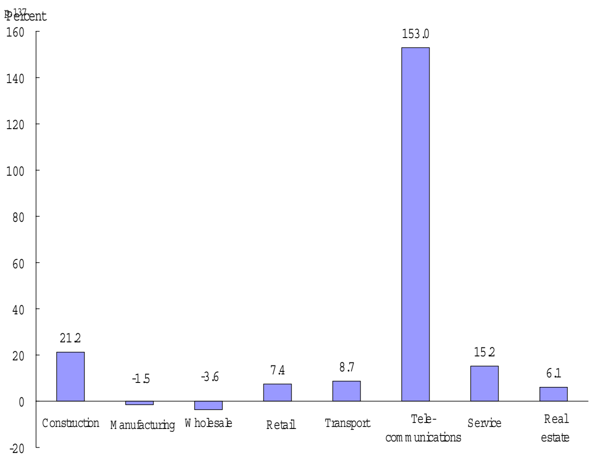
Figure 7-3-2 Trends in real gross domestic output of the info-communications industry



Note: In communication white paper, "info-com industry" is defined as what collected, ① mail, ② communications, ③ broadcast, ④ information software, ⑤ information related, ⑥ information communication apparatus manufacture, ⑦ information communication apparatus lease, ⑧ electricity communication institution construction, and ⑨ research among my domestic business section classifications.
Quotation: The Ministry of Posts and Telecommunications data the Management and Coordination Agency an "inter-industry-relations table" and the Ministry of International Trade and Industry "Inter-industry-relations table (extended table)"
See: appendix table 7-3-2

Fig. 7-3-3 shows the rate of increase in the number of companies by industry from 1991 to 1996 [(number of companies in 1996 – number of companies in 1991) ÷ number of companies in 1991]. This graph shows that the growth rate for telecommunications far exceeds that of other industries.

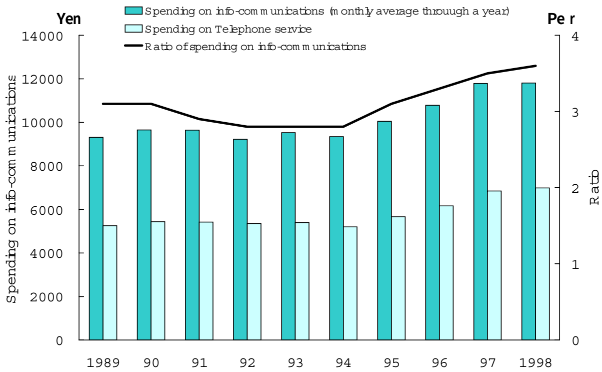
Figure 7-3-3 Rate of increase in the number of new companies by industry



Source: Ministry of Posts and Telecommunications, "White paper on Telecommunications" (FY1999 Edition)
Quotation: Management and Coordination Agency, Statistics Bureau, "Annual Report on the Family Income and Expenditure survey" and "Report on the Survey of Family Income and Expenditure"
See: appendix table 7-3-3

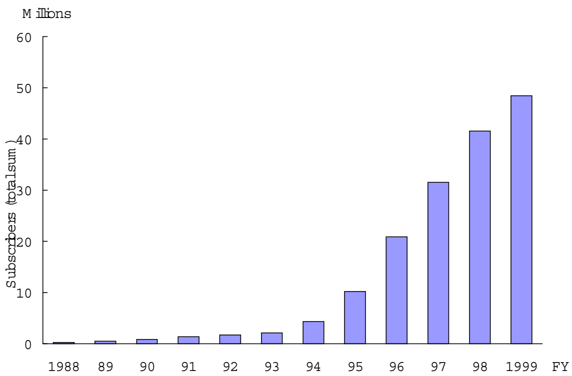
Now we will take a look at the growth in telecommunications from a consumer view-point. Fig. 7-3-4 shows the changes in expenditure on telecommunications and the percentage of consumer expenditure that they account for. Telecommunications expenditure was moving sideways in the early 1990s, but in the subsequent years the amount increased, as did the percentage of consumer expenditure. This increase is thought to have been caused by the rapid take-up of cellular phones (White Paper on Telecommunications). Fig. 7-3-5 shows changes over time in the number of subscribers to mobile phones. The number of subscribers surpassed the 10 million mark at the end of FY1995 (end of March, 1996), after which the number of subscribers has increased by approximately 10 million each year.

Figure 7-3-4 Breakdown of spending and total household spending on info-communications



Source: Ministry of Education, "Japanese Government Policies in Education, Science, Sports and Culture" (FY1999 edition)
Quotation: Management and Coordination Agency, Statistics Bureau, "Annual Report on the Family Income and Expenditure survey" and "Report on the Survey of Family Income and Expenditure"
See: appendix table 7-3-4

Figure 7-3-5 Trends in handy phone subscribers



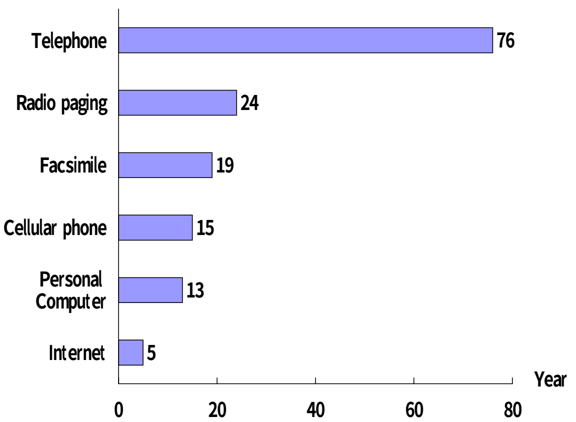
Note: 1) A numerical value is a numerical value at each end of a fiscal year. However, the 1999 fiscal year is a numerical value at the end of December 1999.
(2) Data are not included the number of subscribers to PHS and radio paging.
Source: Ministry of Posts and Telecommunications Document, "The Current State of Subscribers to Mobile Telecommunications Operations" (Ministry of Posts and Telecommunications Web-site)
See: appendix table 7-3-5

7.3.3 Take-up of Telecommunications Technology

These technologies are having a dramatic impact on society, and are providing society with convenience that did not hitherto exist. They are permeating companies, offices and the lives of everyday citizens.

Fig. 7-3-6 shows the time taken for the household penetration rate of main telecommunications media in Japan to reach 10%. For telephones this figure was 76 years, for mobile and car phones it was 15 years, for computers it was 13 years, with figures gradually becoming shorter as the years go by, to the point where the Internet only took 5 years.

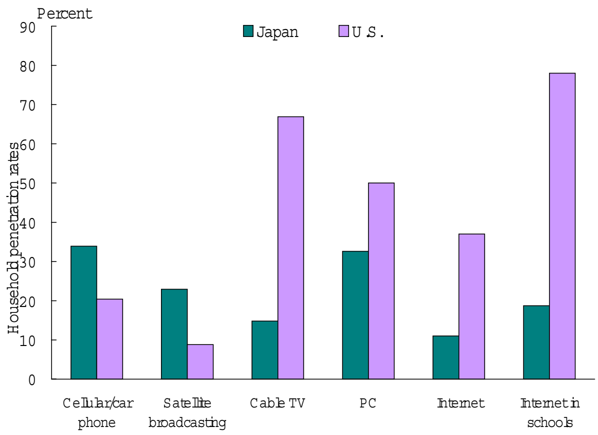
Figure 7-3-6 Time required to reach 10% penetration rate in Japan by media



Source: Ministry of Posts and Telecommunications, "White paper on Telecommunications" (FY1999 Edition)
See: appendix table 7-3-6

Next we will take a look at the take-up of telecommunications devices. Fig. 7-3-7 shows a comparison of the take-up of telecommunications equipment in Japan and the U.S.. Devices have been taken up to a great extent in both countries. Looking at individual items, the household penetration rate of computers is 50.0% in the U.S.. but only 32.6% in Japan, and there is a considerable gap between Japan and the U.S. in the Internet household penetration rate and the percentage of schools connected to the Internet. On the other hand, the individual penetration rate of cellular and car phones is higher in Japan than in the U.S..

Figure 7-3-7 Penetration of info-communications equipment and services in Japan and the U.S.



Source: Ministry of Posts and Telecommunications, "White paper on Telecommunications" (FY1999 Edition)
Quotation: Ministry of Posts and Telecommunications data, NHK, CTIA, dataquest and INTECO data, etc.
See: appendix table 7-3-7

7.3.4 Expansion of the Internet

In conjunction with the take-up of computers, the Internet is showing a rapid expansion. Table 7-3-8 shows the state of growth in the Internet worldwide in recent years. While the average annual rate of growth in the number of households that are telephone subscribers was 6% from 1990 to 1998, the number of subscribers to mobile communications services rose rapidly by 52%, and the number of Internet hosts grew extremely rapidly by 81% each year. Looking at the time required until services were used by 50 million people worldwide, while this figure was 74 years for telephones, it took only 4 years for users of the WWW.

Figure 7-3-8 Growth of Internet

Annual Growth Rate (1990-98)	
Phone Line	6%
Mobile Communication Subscribers	52%
Internet Host	81%
Years required to reach 50 millions subscribers	
Telephone	74
Radio	38
Personal Computer	16
Television	13
W W W	4

Source: International Telecommunications Union, Challenge to the Network; Internet for Development, (October 1999)

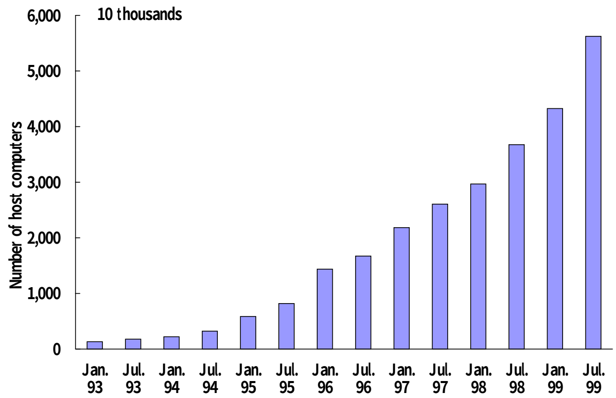
Next, we will take a look at which countries are playing a major role in the rapidly growing world of the Internet. Fig. 7-3-9 (A) shows the changes over time in the number of Internet hosts, while (B) shows the breakdown by country. These graphs show not only the accelerated growth in the number of hosts, but also that an overwhelming large percentage of hosts are in the U.S..

Next, looking at the growth of the Internet in Japan, Fig. 7-3-10 shows trends in the number of Internet domain names allocated in Japan. In October 1993 there were only around 1,000 (1,216) domain names, but by October 1996 this grew to 12,184, and by October 1999 this grew to surpass the 100,000 barrier, with 100,947 domains.

The growth of the Internet has also made it possible to realize new services and businesses which did not previously exist, such as financial transactions, sales of products, and auctions on the Net.

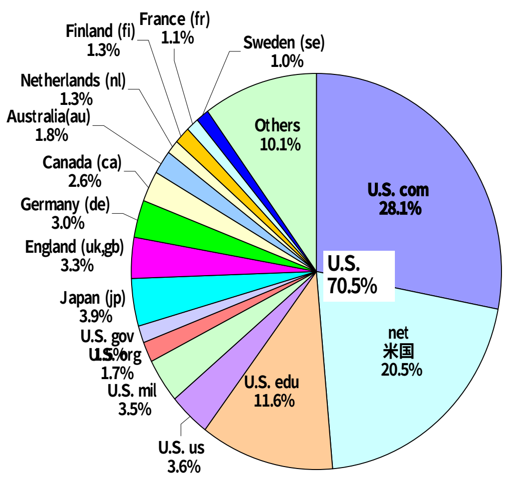
Figure 7-3-9 Trends in number of Internet host computers in the world

(A) Trend in number of internet host computer in the world



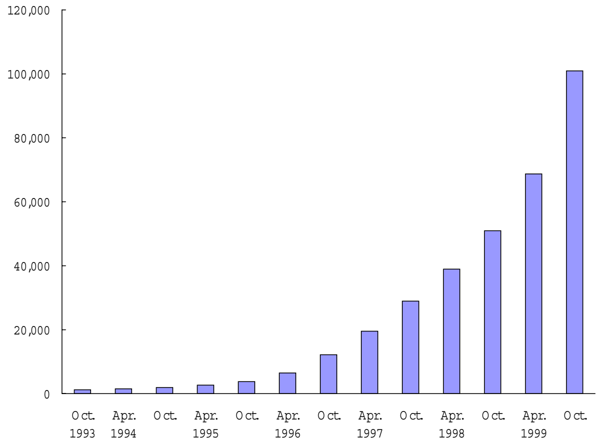
Source: Ministry of Posts and Telecommunications, "White Paper on Telecommunications" (FY1999 edition)
Quotation: Network Wizards data.
See: Appendix table 7-3-9 (1)

(B) Number of internet host computers by country



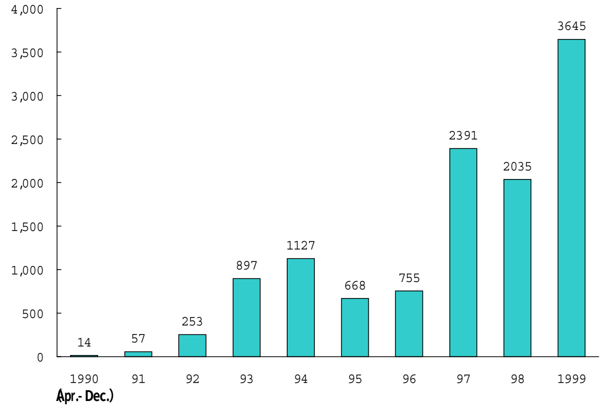
Note: Common top domains, such as com, net, and org, are included in the U.S.. with most use for convenience.
Source: Ministry of Posts and Telecommunications, ed., "White Paper on Telecommunications" (FY1999 Edition)
Quotation: Network Wizards data
See: 7-3-9 (2)

Figure 7-3-10 Trend in number of JP domain name



Source: Japan Network Information Center Document (Japan Network Information Center Website)
See: appendix table 7-3-10

Figure: 7-3-11 Number of reports of virus infection

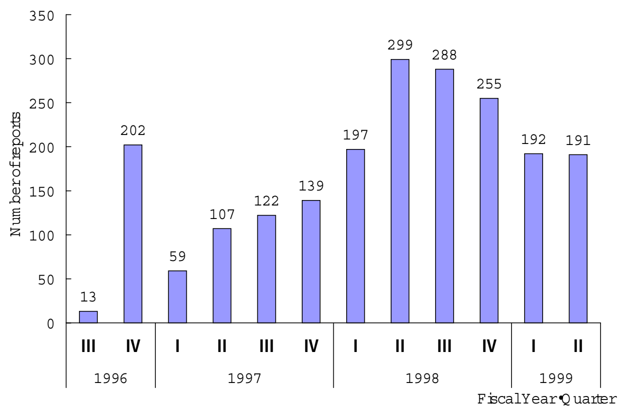


Source: Ministry of Posts and Telecommunications, "White Paper on Telecommunications" (FY1999 edition)
Quotation: Information-Technology Promotion Agency, Japan security center data
See: appendix table 7-3-11

7.3.5 Social Aspects of Telecommunications Technology

On the other hand, Net society has also resulted in new social problems. The expansion in damage from computer viruses, an increase in unauthorized access, management of personal information, problems of distribution of inappropriate information on the Net, protection of intellectual property and copyrights – all of these new problems brought about by the development of new technology and its rapid take-up by society are becoming more conspicuous.

Figure 7-3-12 Number of hackeries reported To JPCERT/CC

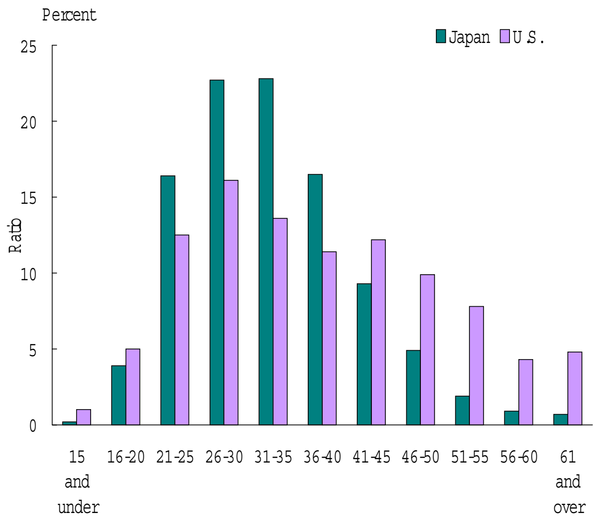


Source: Computer Emergency Response Center Document (Center Website, etc.)
See: appendix table 7-3-12

There are also fears of an expansion in the gap between people who can and cannot enjoy the benefits of Net society. Fig. 7-3-13 shows the age group structure of Internet users in Japan and the U.S.. While the 41 and older age group has a relatively broad utilization of the Internet in the U.S., usage by this age group in Japan is somewhat limited, in particular in the 61 and older age group, which is 5.4% in the U.S.. but less than 1% in Japan. This shows that Internet use in Japan is biased towards the younger generations.

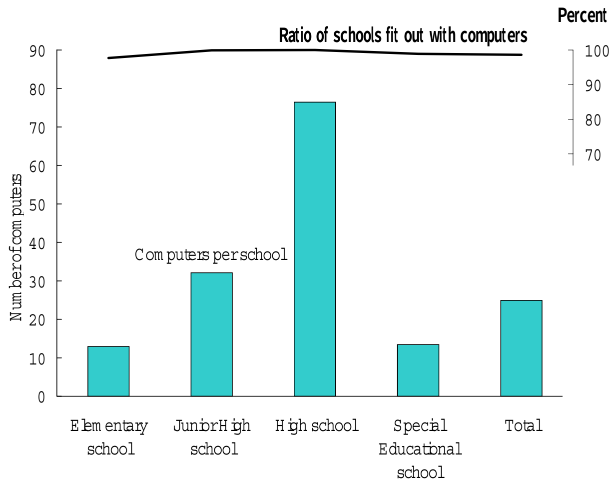
In recent years, efforts have been made to introduce computers to schools, and there are now hardly any schools which do not have computers, but looking at the number of computers in each school, while the number of computers per high school is 76.4, this number falls to 32.1 for junior high schools and 12.9 for elementary schools. Looking at averages, the situation is still such that a number of students have to share a computer in a lesson for one class (see Fig. 7-3-14).

Figure 7-3-13 Internet users in Japan and the U.S. by age group



Source: "The 7th internet active user investigation" (the Japanese multimedia February, 1999 issue), "10th WWW user investigation" (U.S. Georgia Institute of Technology)
See: appendix table 7-3-13

Figure 7-3-14 Number of schools fit out with computer



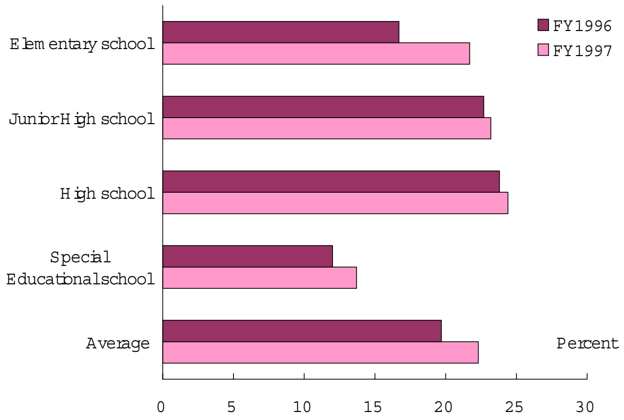
Source: Ministry of Education, "Japanese Government Policies in Education, Science, Sports and Culture"
See: appendix table 7-3-14

The education of skills in the use of the Internet for the youth of today, who are expected to play an important role in the Net society of the future, is becoming increasingly important. However, the take-up of computers and the Internet by Japanese schools is lagging behind that of the U.S. (see Fig. 7-3-7).

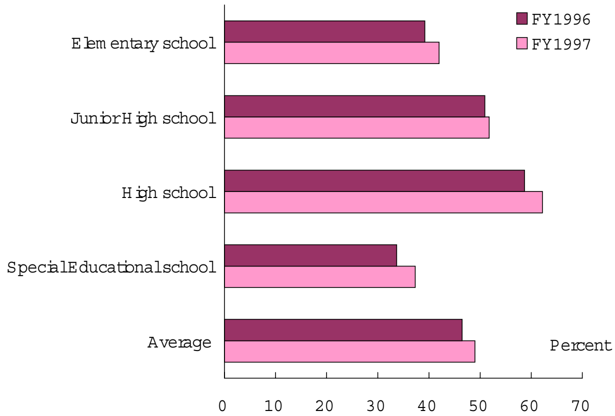
As can be seen from Fig. 7-3-15, which shows the number of staff engaged in computer instruction, there is not necessarily a large number of staff capable of using computers or instructing students in the use of computers at school, indicating that there are problems in the take-up of computers in schools and in the staff capable of giving lessons about computing.

Figure 7-3-15 Reality of Teachers Instruct in Computer

(A) Teachers who can instruct computer



(B) Teachers who can use computer



Source: Publishing Committee for the Comprehensive List of New Media for Education '99 ed., "Comprehensive List of New Media for Education '99", National Association for the Promotion of Education Engineering

See: appendix table 7-3-15

7.4 Contribution of Life Sciences

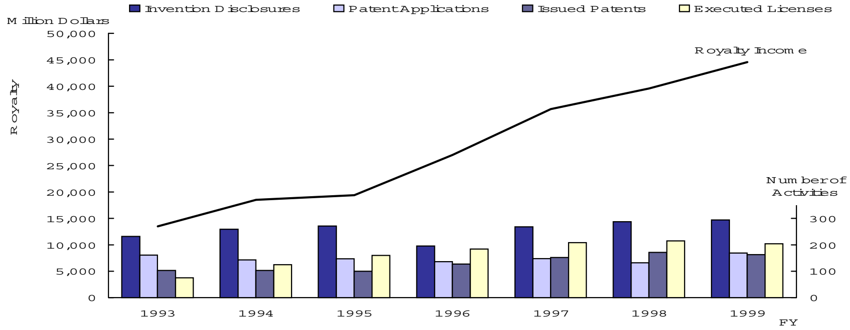
Life sciences are sciences that aim to unravel the complex and elaborate mechanisms of the biology of living things, and apply the results to health services, the environment, agriculture, forestry and fisheries, industry and a range of other fields.

In Japan, it may be said that knowledge of life sciences has been utilized in the field of fermentation, such as sake (Japanese rice wine), miso (fermented soybean paste) and organic chemical products. Development is also advancing of biopharmaceuticals using genetic engineering technology and cell fusion technology, with typical examples of these being insulin used in the treatment of diabetes, interferon used widely as a drug for the treatment of hepatitis B and C, and human growth hormone used as a drug to treat dwarfism.

Recent years have seen a great heightening of expectations of biotechnology as an industrial application of life sciences. Biotechnology-related industries currently employ approximately 30,000 people, with a market valued at around 1 trillion yen, but this market is expected to blow out to around 25 trillion yen by 2010. There are however, a great number of problems which need to be overcome if these expectations are to be answered, and there is a need for promotion of original R&D, development of human resources, bio-genetic resources, development of intellectual infrastructure such as databases, support for venture companies, and the securing of intellectual property rights. With regard to the promotion of R&D, recent years have seen a dramatic strengthening of government initiatives in Japan, but in the U.S. the life sciences have accounted for a selected position in government support for research (see Chapter 3 Fig. 3-3-11 Science and Technology-related Expenses by Social and Economic Objective), and the transfer of these results to the private sectors is also advanced (Fig. 7-4-1).

In this section, based on these circumstances, we will firstly take an overview of recent developments in Japan concerning "R&D Concerning the Life Sciences" which forms the basis for considering the contribution that life sciences make to society and the economy. We will then look at "patents concerning genetic engineering." We will then discuss the "utilization of genetic engineering technology in the field of agriculture, fisheries and forestry," and finally we will analyze the progress of technology in the "medical field," which accounts for an important position as the contribution of life sciences to society.

Figure 7-4-1 NIH technology transfer activities FY 1993 to FY 1999

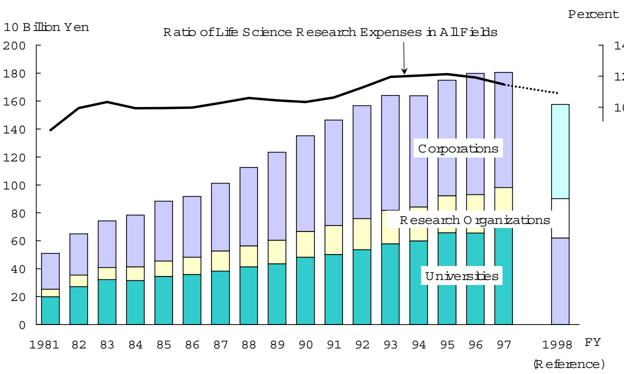


Source: U.S. National Institute of Health (NIH) Website   See: appendix table 7-4-1

7.4.1 Trends in Life Sciences Research Expenditure

Fig. 7-4-2 shows the changes over time in life sciences research in Japan, according to the parties carrying out the research. According to this graph, research expenditures arrived at by totaling universities and research institutions are approximately the same amount as research expenditures in companies. Looking at the rates of growth in the various expenditures, while steady increases have continued in universities and research institutions since 1981, life sciences research expenditures in companies showed high growth from the late 1980s to the early 1990s, but since then have basically moved sideways. The survey method changed greatly in FY1998, so figures for that year are for reference purposes only.

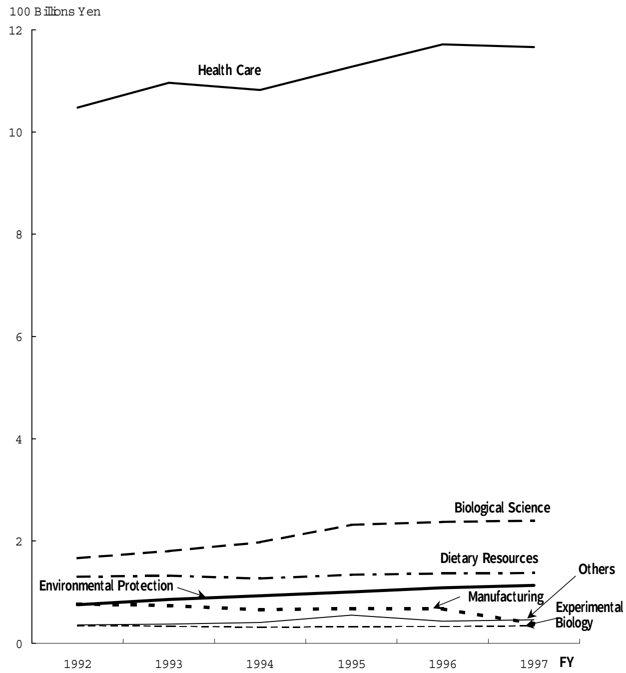
Figure 7-4-2 Trends in life science



Note: 1) It is the special public corporation "has with a company etc." the company and self-support accounting nature of the capital of 100 million yen or more.
2) Since the investigation method etc. was greatly changed about value in the 1998 fiscal year, it is reference value.
Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 7-4-2

Fig. 7-4-3 shows changes over time in life sciences research expenditures according to research objective. Looking at the figures for 1997, "Research into health and medical care" amounted to 1.1664 billion yen, accounting for 64.6% of the total, followed by "Unraveling the phenomenon of life overall and bionomics" amounted to 240.1 billion yen, while "R&D into securing sources of food" amounted to 137.5 billion yen, and "R&D concerning environmental conservation" amounted to 113.1 billion yen. Looking at the growth from FY1992 to FY1997, the total amount of life sciences research expenditure grew by 15% over this period, but "R&D concerning environmental conservation" grew by 50%, and "Unraveling the phenomenon of life overall and bionomics" grew by 44%, making these two sectors the ones with the biggest growth.

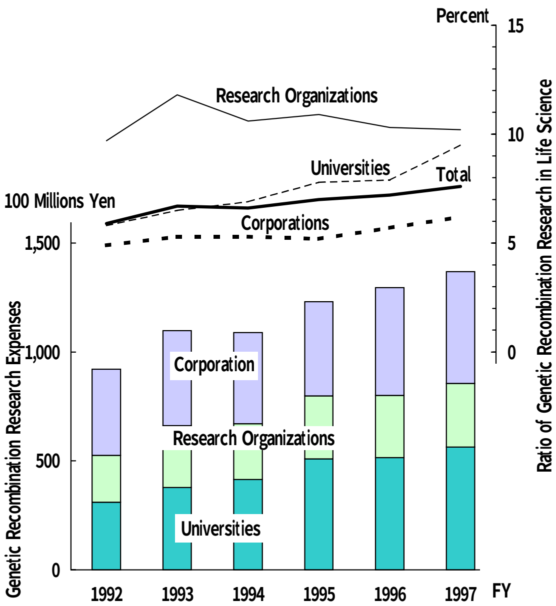
Figure 7-4-3 Trend in life science research by object



Source: Management and Coordination Agency, Statistics Bureau, "Report on the survey of Research and Development"
See: appendix table 7-4-3

Taking a look at the state of research expenditures concerning genetic engineering, which has recently been the focus of attention, research expenditures in FY 1997 were 136.9 billion yen, accounting for 7.6% of life sciences expenditure. Looking at the changes over time in these figures, they have been steadily growing since FY 1990, and recently the percentage of research expenditures incurred in this area has increased particularly in universities (Fig. 7-4-4).

Figure 7-4-4 Trend in genetic recombination research expenses by subject



Note: Consider as the special public corporation which has the company and self-support accounting nature of the capital of 100 million yen or more "with a company etc".
Source: Management and Coordination Agency, Statistics Bureau, "Report on the Survey of Research and Development"
See: appendix table 7-4-4

7.4.2 State of Patents Concerning Genetic Engineering

Here one of the indicators of results of research in genetic engineering is data concerning patents. Genetic engineering is the collective name given to the technology whereby functions different to those generally possessed by living things are assigned or where bionomics are changed by manipulating genes.

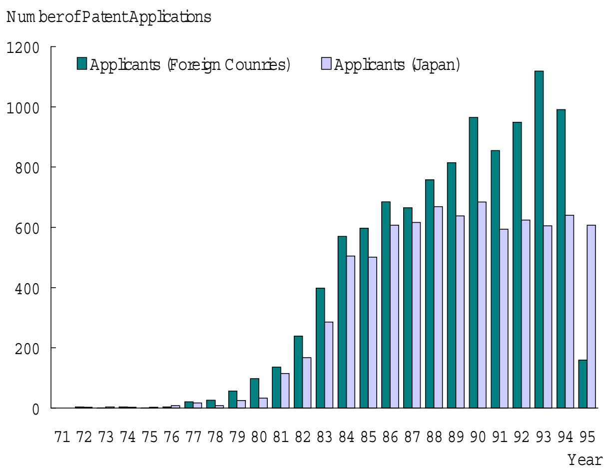
Fig. 7-4-5 shows the changes over time in the number of patents applied for in the field of genetic engineering in Japan.

In 1970 DNA (deoxyribonucleic acid) was first synthesized artificially, evidence that it could perform the role of a gene. In the years since then, genes started to be synthesized by U.S. and Japanese research groups in the practical sense of creating useful substances, and with the establishment of genetic engineering technology by Dr. Cohen Boyer of the U.S., genetic engineering became established. Seven years later, in 1980, the number of patent applications was only 131 (33 from Japan and 98 from overseas), but this number increased dramatically in the subsequent years, reaching 1,724 in 1993 (605 from Japan and 1,119 from overseas). This technology started from basic research including the structural analysis of genes, and has reached the stage today where it is used in the manufacture of useful substances, such as the mass production of hormones and drugs for coliform and natural yeast.

Looking at the number of patents applied for in the field of genetic engineering from Japan and from overseas, the number of applications from overseas has almost consistently exceeded the number from within Japan. In the total number of patent applications made and publicized from August 1971 to August 1998, some 54.0% of patents were made by foreigners. This figure far exceeds the percentage of patent applications in general made by foreigners, which is 7.4%.

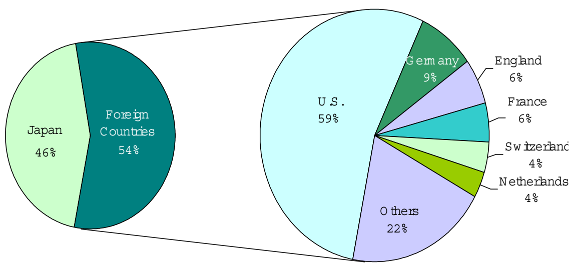
Looking at the nationalities of the foreign patent applicants, close to 60% are from the U.S., far above the second-ranking Germany (9%) (Fig.7-4-6).

Figure 7-4-5 Number of patent applications in Biogenetics by country (as of Mar., 1999)



Note: The patent for which it applied by the international application system based on a patent cooperation treaty has delay of time in an official announcement in Japan, and it has decreased seemingly 1995.
Source: Japan Patent Office Website
See: appendix table 7-4-5

Figure 7-4-6 Number of major patent applications in biogenetics by country (published applications from 1971 to August 1998)



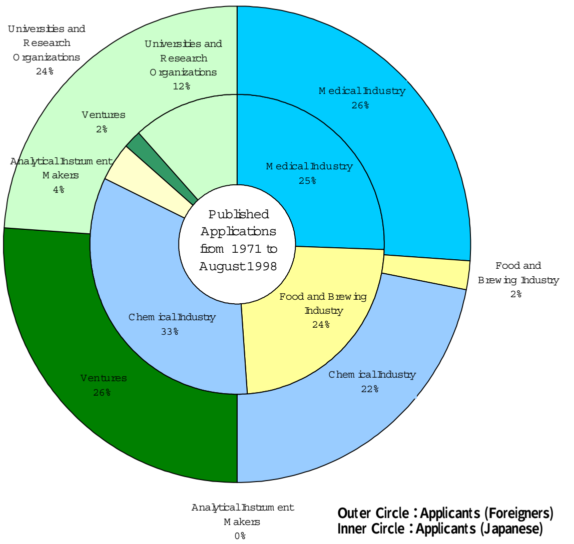
Source: Japan Patent Office Website
See: appendix table 7-4-6

Next, looking at companies with large number of patent applications (51 Japanese applicants who have made more than 35 applications, and 50 foreign applicants who have made more than 43 applications), we will take gain an overview of the features of technical development.

Firstly, Fig.7-4-7 looks at the structure by type of corporation. According to this graph, 25.5% of Japanese applicants are pharmaceutical companies, 23.5% are food/brewing companies, and 33.3% are chemical companies, while only 2.0% of companies started as venture companies. In contrast, for foreign applicants pharmaceutical companies again account for a large percentage with 26.0%, but food/brewing companies only account for 2.0%. On the other hand, venture companies accounted for a large percentage with 26.0%. While the percentage of Japanese applicants that are universities and research institutions is 11.8%, for foreign applicants this percentage was 24.0%, almost double the Japanese figure.

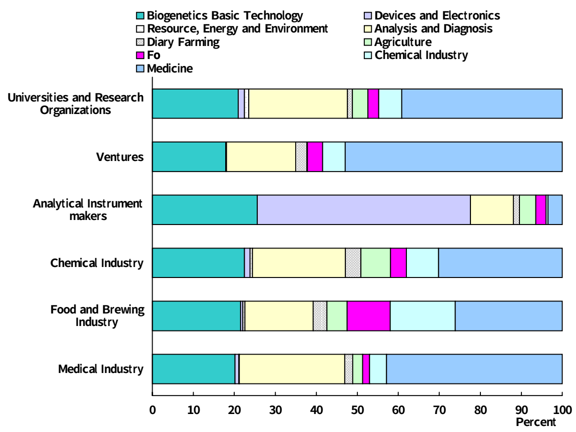
Comparing according to the type of corporation the structure of the field of use for which the development was carried out, while this was a matter of course for pharmaceutical companies, venture companies and universities/research institutions also had a high percentage of patents in the field of drugs (Fig.7-4-8).

Figure 7-4-7 Number of major patent applications in biogenetics (published applications from 1971 to August 1998)



Note: It is the items which extracted and carried out the corporation classification of 51 domestic applicants of 35 or more application cases, and the 50 applicants of 43 or more foreign application case.
Source: Japan Patent Office Website
See: appendix table 7-4-7

Figure 7-4-8 Major Patent in biogenetics by Industry and number of the utilization fields

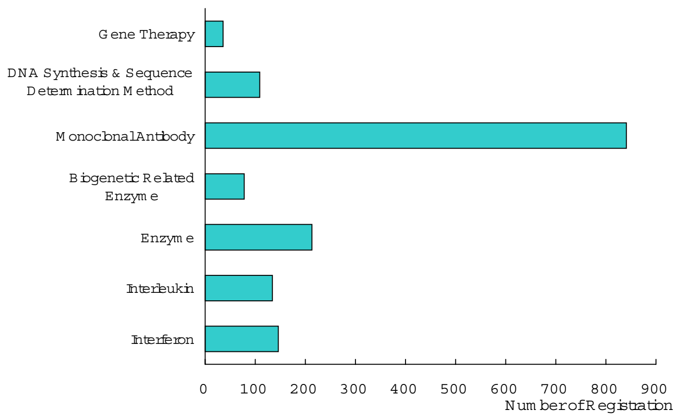


Note: It is the same as that of figure 7-4-7
Source: Japan Patent Office Website
See: appendix table 7-4-8

Next, taking a look at the number of patents granted concerning genetic engineering, from August 1971 to August 1998 some 3,700 patents were granted, of which patents concerning DNA technology accounted for approximately 70%. Furthermore, looking at the main fields of application of this genetic engineering, patents concerning monoclonal antibodies were the most common, with 841 patents, followed by enzymes (213 patents), interferon (146 patents), interleukin (134 patents), etc. (Fig. 7-4-9).

In recent years great leaps forward have occurred in genome analysis of different types of organisms throughout the world. For example, the it is hoped that the research in the "Human Genome Project" will provide valuable information, such as unraveling the secrets of cancer, aging, diagnosis and treatment of hereditary diseases, and the advanced functions of the human body, while at the same time creating a new industry. The U.S. and other countries are devoting a great deal of effort to research in this field, and international patent competition is intensifying in an effort to be the first to patent genetic information. In the future, as genome analysis advances and the functions of genes are unraveled, it is thought that patent applications will increase markedly.

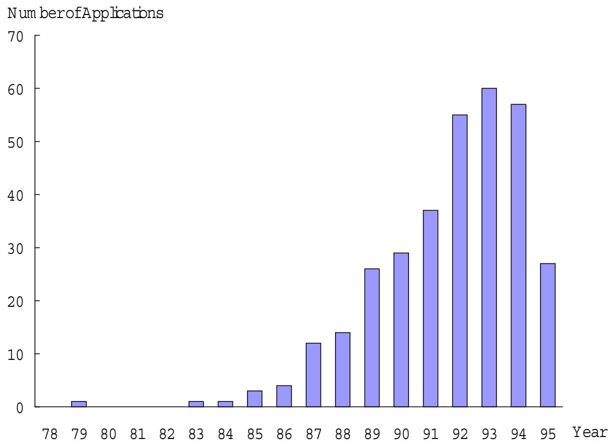
Figure 7-4-9 Number of patent rights in major biogenetics fields (from 1971 to August 1998)



Source: Japan Patent Office Website
See: appendix table 7-4-9

The number of patent applications for methods of gene therapy is also increasing rapidly in recent years. In Japan, "Guidelines for Clinical Research Into Gene Therapy" were approved in April 1993, and we entered the era of gene therapy. The ailments to which gene therapy was applied were initially AIDS, cancer and congenital disorders (i.e. hereditary disorders) which were deadly and for which there were no effective means of treatment, but more recently arteriosclerosis, myocardial infarctions and other disorders have come to be treated using this therapy, and it is hoped that it will become a revolutionary state-of-the-art treatment technology in the 21st century (Fig.7-4-10).

Figure 7-4-10 Trend in number of applications of gene treatment



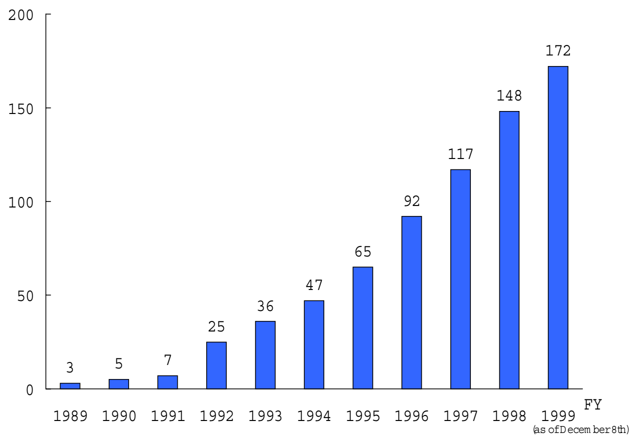
Note: The patent for which it applied by the international application system based on a patent cooperation treaty has delay of time in an official announcement in Japan, and it has decreased seemingly.
Source: Japan Patent Office Website
See: appendix table 7-4-10

7.4.3 Applications in Agriculture, Forestry and Fisheries

With regard to genetic engineering technology (technology which takes out particular genes and incorporates them into other living things, forming a new character) in agriculture, forestry and fisheries and the food industry, in addition to creating revolutionary new product types and improving the efficiency of the production process, it is hoped that it will become a new technology to resolve future food problems.

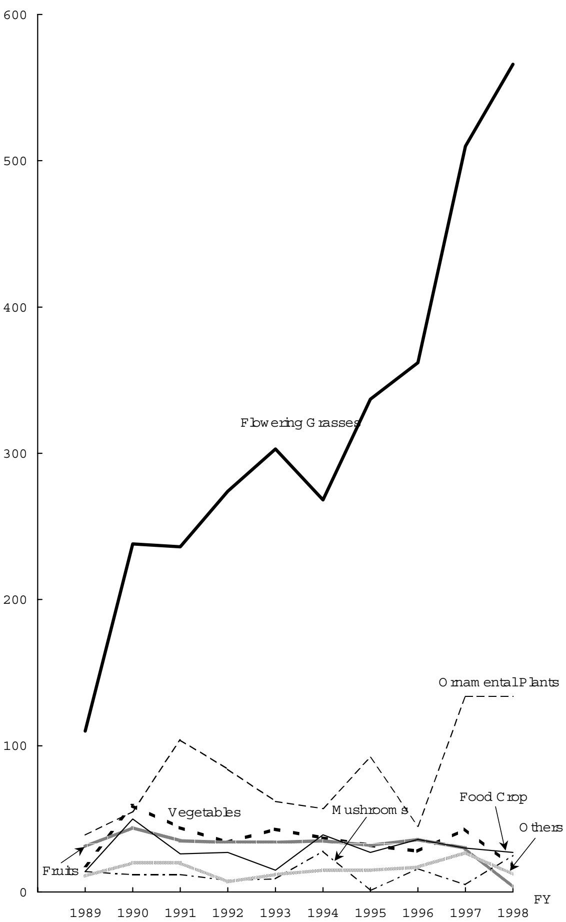
Fig.7-4-11 shows changes over time in the number of genetic engineering bodies utilization plans approved in accordance with the guidelines for the usage of genetically engineered substances in the field of agriculture, forestry and fisheries stipulated by the Ministry of Agriculture, Forestry and Fisheries. A steady increase is evident in recent years.

Figure 7-4-11 Confirmed recombinant DNA crop plants in Agriculture, forestry, fisheries and the food industry



Note: In a recombination objectuse plan, it is the sum total value of "the thing of an experiment stage", and "the thing of an industrial use stage".
Source: Ministry of Agriculture, Forestry and Fisheries, innovative Technology division website.
See: appendix table 7-4-11-

Figure 7-4-12 Trend in number of variety registrations



Note: 1) Seeds and Seedlings law will be revised in May, 1998 (December 24, 1998 enforcement).

2) "Other" is the number of cases of feed corps, technical crops, forest tree, a mulberry and seaweed.

Source:

See: appendix table 7-4-12

Looking at the changes over time in the number of new varieties registered from Fig. 7-4-12, the total number of varieties of produce registered has been steadily increasing in recent years, and in particular the increase in flowering grasses has been significant. While only some of these new varieties are related to genetic engineering technology, consumption of flowering grasses is increasing due to the following factors.

- Compared to food, there is less resistance to genetic engineering technology among consumers
- Food manufacturers, automobile manufacturers and other different industries are entering the field of flowering trees and shrubs one after another
- Home gardening is booming in recent years

For example, the purple-blue carnation developed by a food manufacturer and the first genetic engineering plant sold commercially in Japan is still fresh in our minds. The appearance of species of flower colors and shapes which had hitherto been unimaginable, like the "purple-blue carnation," acts as a stimulus to bring about new demand for flowers, and biotechnology in the field of flowering grasses is being focused upon as a means of propagating and breeding (improvements to species), and is starting to be used in a variety of aspects.

Meanwhile, the numbers of registrations in the food fields of "vegetables," "fruits," "food produce" and "mushrooms" are smaller than for flowering grasses, but in recent years in the area of food, advances have been made in the development of genetic engineering foods with the objective of improving the productivity of foods, improving quality and protecting the global environment. As one of the measures to counter the anxiety of consumers about genetically engineered foods, the Ministry of Health and Welfare is providing information, such as disclosing the details of deliberations and application documents relating to the safety assessments of such foods. In addition, the Ministry of Agriculture, Forestry and Fisheries has made public those items whose safety has been approved in accordance with guidelines for the use of genetically engineered substances in the field of agriculture, forestry and fisheries. The Ministry has also made in mandatory to label processed foods that contain genetically modified agricultural produce in their ingredients, and has stipulated labeling criteria.

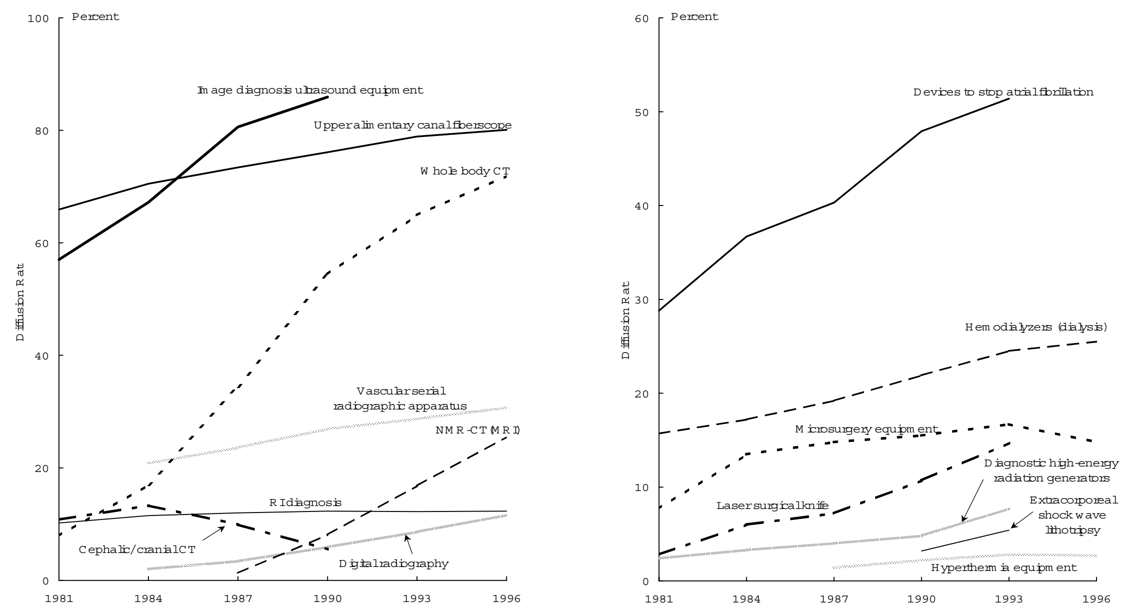
In addition, in the field of livestock production, cloning technology (which creates substances that are genetically identical) is hoped to become an effective means of promoting better livestock production. Using this technology, at a research institute in the U.K.., a cloned sheep "Dolly" was created using the cells of a ewe and born in July 1996, the first time such a feat has been achieved in the world (reported in February 1997). Then, in July 1998, the Ishikawa Prefectural Center for Animal Husbandry and Research (Livestock Center) and Kinki University cooperated to see the first successful birth in the world of a cloned cow (named "Noto" and "Kaga") originating from body cells from an adult animal. Since then Japan has seen the birth of 121 cloned cattle (as at the end of February 2000).

7.4.4 Technological Advances in Medical Care

As already seen in Section 7.4.1, research expenditures in medical care and welfare account for some 60% of the total of life sciences research expenditures, and recent years have seen great advances in the field of medical care.

Fig. 7-4-13 shows the rate of spread of selected medical devices in hospitals. Looking at the rate spread of these medical devices, for diagnostic equipment, fiberscopes for the upper digestive system and of CT for the whole body are rising considerably, with 80.1% and 71.9% of hospitals having these devices respectively in 1996. The rate of spread of these devices can be attributed to an acceleration in the progress in technical-development and improvements in the clarity of images. In addition, in contrast to CT, which looks mainly at morphological information, NMR-CT (MRI), which had only spread to 25.5% of hospitals in 1996, is one of the most advanced types of image diagnosis which make is capable of detecting changes in functions and chemical changes in body tissue and representing these changes in an image form. They are steadily spreading throughout Japanese hospitals. For treatment devices, cardiac defibrillators, artificial kidneys (dialysis) and so forth are showing steadily rising rates of spread.

Figure 7-4-13 Trends in the rate of spread of major medical devices in hospitals



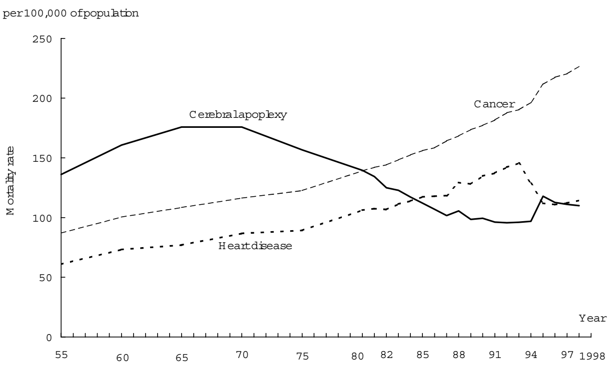
Note: 1) It is the value which divided the number of common hospitals which holds it in the common hospital total about the main medical apparatus set as the object of investigation in Ministry of Health and Welfare "Medical-facilities investigation" about saturation level.
2) The saturation level is the rate of the number of possession institution of per the number of hospitals.
3) About up alimentary canal fiberscope, 1981, 1984 and 1987 are the numerical value of stomach fiberscope.
4) About the ultrasonic equipment for diagnostic imaging 1981 are the numerical value of brain surgery microsurgery equipment.
5) Each year in 1984, 1987, 1990, 1993 and 1996 will be as of October 1 now at the end of December, 1981.

Source: Ministry of Health and Welfare It creates from "Medical apparatus investigation"

See: appendix table 7-4-13

Next, taking a look at the changes over time in Japan's mortality rate (number of deaths per 100,000 head of population) according to the main causes of death, since 1955, cancer, heart disease, a stroke have consistently occupied the highest rankings. Up until 1980, the number of deaths caused by stroke was the largest, but from 1981 deaths caused by cancer took over first place, since which the percentage of deaths caused by cancer has continued to rise (Fig.7-4-14).

Figure 7-4-14 Trends in the mortality rate of major diseases



Note: 1) Mortality rate is the number of death per 100,000 population. (100,000 the number of death/population)
2) It is thought that it is based on the influence of wee-known from enforcement before of notes in the death certificate (body reference document) (January, 1995 enforcement) with a new reduction of the "cardiopathy" in 1994 or "not writing the heart failure as a state of the end time of a disease, respiratory insufficiency, etc. to the cause column of death".
3) It is thought that the increase in the "apoplexy" in 1995 is based on clarification of the cause-of-death selection rule by the application of "ICD-10" from January, 1995.
Source: Ministry of Health and Welfare, "Vital Statistics".
See: appendix table 7-4-14

Cancer is a disease common to all mankind which threatens the life and health of humans, but technology to treat cancer is improving. Here we will concentrate on the "survival rate" as one yardstick to assess this technology. This figure is arrived at by investigating all patients who received diagnosis and/or treatment at medical institutions for a particular disease, and then calculating the percentage of patients who are still surviving after a given period (five years, for example).

The five-year survival rate for persons admitted to hospital for the first time for cancer at the National Cancer Center is shown in Fig.7-4-15. According to this graph, looking at the figures by sex and by the main location of the cancer, there are fluctuations between survey years, but a steady improvement is evident overall. In particular, the survival rates for stomach cancer, colon cancer and uterine cancer are steadily increasing.

The main factors behind these increases in treatment results are as follows:

Advances in early diagnosis due to cancer checks.

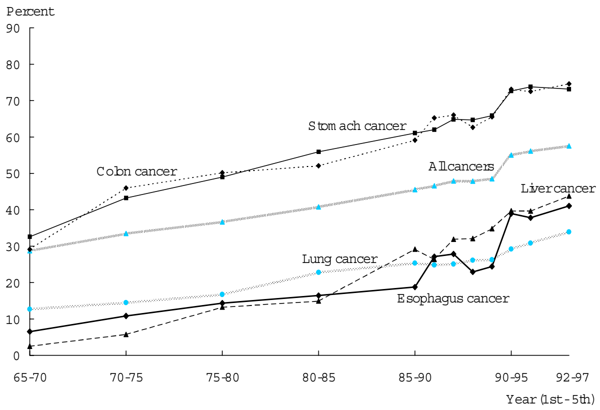
That it has become possible to provide appropriate treatment in accordance with the symptoms of patients.

Advances in treatment technology, such as surgical treatment methods (endoscopic operations for early stomach cancer), chemotherapy (advances in pharmaceutical treatment had resulted in the complete recovery of malignant lymphoma, etc.), and agglomerated treatment methods (in addition to surgical and pharmaceutical treatment, logical combinations of treatment methods such as radiation therapy, immune therapy and thermo therapy, etc.).

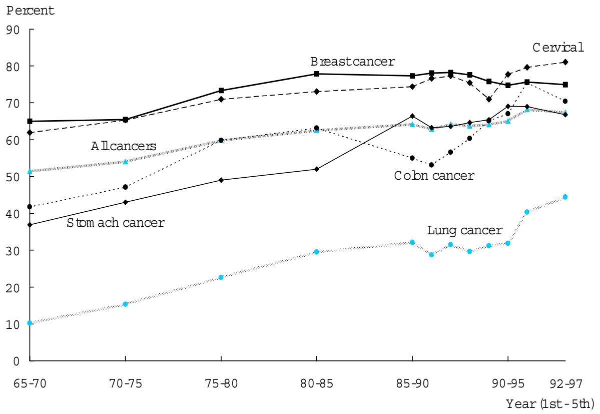
Hopes are also held for the results of gene diagnosis and gene therapy in the future.

Figure 7-4-15 Trends in the five-year cancer survival rates at the national cancer center

(A) Male



(B) Female



Note: 1) Five-year survival rates cover patients hospitalized at the National Cancer Center Central Hospital for the first time.
2) The figure for "all cancers" (total) is the average of the male and female totals for each period.

Source: National Cancer Center, Cancer Statistics

See: appendix table 7-4-15

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Chapter 8 Public Opinion on Science and Technology

With the remarkable advances in lead--ingedge science and technology in various fields such as life science and information technology, the impact of science and technology on society and humanity is becoming increasingly greater. Science and technology contributes immeasurably to social and eco-nomic progress, and to the enhancement of life. At the same time, negative aspects also exist and should be voiced. In this chapter, we will begin by introducing public opinion on science and technology based on the latest public opinion polls. This will be followed by an overview of public opinion in the areas of biotechnology, information and the environment.

8.1 Public Interest in Science and Technology

The latest public opinion on science and technology appears in the "Public Opinion Poll on the Future of Science and Technology" conducted between October and November 1998 by the Public Relations Office of the Prime Minister's Office.

Information on the survey target, period, method, and number of valid responses is as follows:

Survey target: Population: Adults over 18 years old from throughout the country
Size of sample: 3,000 people
Sampling method: Stratified, two-stage random sampling
Survey period: October 22 to November 1, 1998
Survey method: Interview questions by pollsters
Number of valid responses (rate): 2,115 (70.5%)

The results of the poll are described below.

Identical opinion polls concerning science and technology and society were conducted in December 1981, March 1987, January 1990 and February 1995, and will be used for making comparisons as the need arises.

8.1.1 Interest in Science in Technology

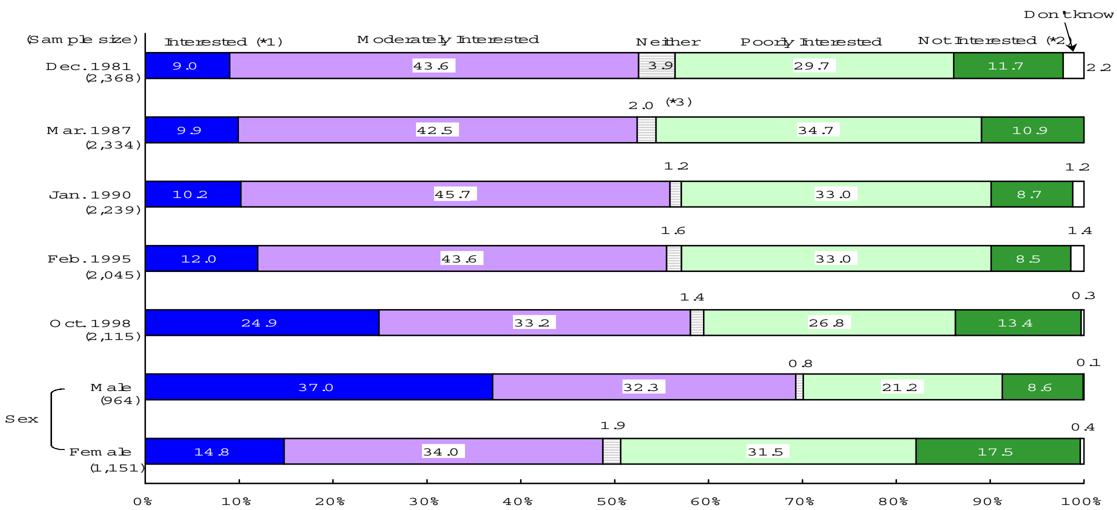
(1) Interest in Information on Science and Technology

When asked whether they were interested in news and topics about science and technology, 58.1% of the respondents replied that they were interested (24.9% "interested" and 33.2% "moderately interested"). In contrast, 40.2% of the respondents were not interested (26.8% "poorly interested" and 13.4% "not interested"). The results can be seen in Figure 8-1-1 and show little change in comparison to those of the previous survey from February 1995.

The breakdown of responses by gender shows that a high percentage of males are interested in science and technology, while a high percentage of females are not interested. Moreover, the breakdown by gender and age shows high percentages in males over the age of 30 who are interested, and in females from 18 to 29, in their 30s and over 60 who are not interested.

Figure 8-1-2 shows a comparison of the survey results from January 1990, February 1995 and October 1998 with regards to the degree of interest by age group. Among 18 to 29 year-olds, there was a decline in the percentage of respondents who were interested between 1990 and 1995. However, in 1998, this changed to an increase. Among the 30 to 39 year-olds, there was a decline in the percentage of respondents who were interested over the three surveys, while the percentage of respondents with no interest rose. The results for the 1998 survey show that the percentage of respondents who were interested and those who were not interested among 18 to 29 year-olds was roughly 50% for each. Among 40 to 49 year-olds, there were no significant changes over the years, with those being interested accounting for approximately 60%. For 50 to 59 year-olds, there was an increase in the number of respondents who were interested from 1990 to 1995, with no change between 1995 and 1998. Among those over 60, there was a rise in the percentage of people who responded as interested over the three surveys, while the percentage of those with no interest fell.

Figure 8-1-1 Interest in information about science and technology



Note: 1) Before [the investigation carried out in February 1995], it was "very interested".
2) In the investigation carried out in March 1987, It was "not interested at all".
3) In the investigation carried out in March 1987, "neither" and "don't know" were "neither/don't know" combined

Source: Prime Minister's Office, Public Relations Office, "Public Opinion Poll on the Future of Science and Technology"

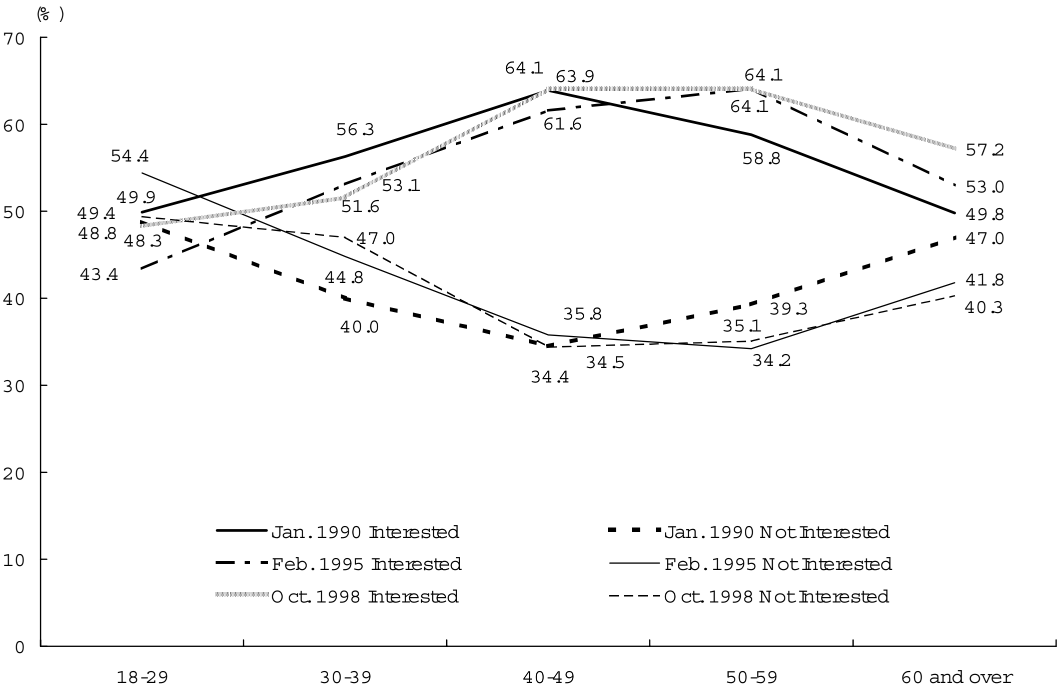
See: appendix table 8-1-1

(2) Interest in Talks by Scientists and Engineers

When asked if they would be interested in listening to talks by scientists and engineers if the opportunity arose, 57.1% of respondents replied that they would be (25.3% "interested" and 31.7% "moderately interested"). On the other hand, those not interested accounted for 40.7% (21.7% "poorly interested" and 19.0% "not interested at all").

In the breakdown by gender, 62.7% of males were interested and 35.4% were not interested. Among females, 52.4% responded that they were interested, while 45.1% responded that they were not interested.

Figure 8-1-2 Interest in information about science and technology – by age group -



Source: Prime Minister's Office, Public Relations Office, "Public Opinion Poll on the Future of Science and Technology"
See: appendix table 8-1-2

8.1.2 Images Surrounding Progress in Science and Technology

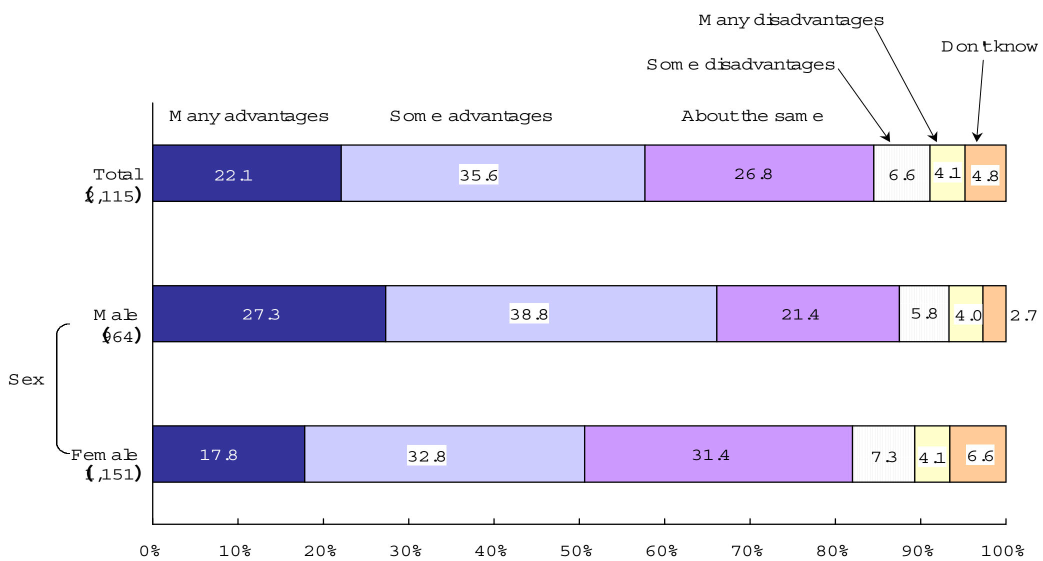
(1) Advantages and Disadvantages of Progress in Science and Technology

The development of science and technology has positive and negative aspects, but in overall terms, survey participants were asked their opinions on whether progress in science and technology has more advantages or more disadvantages. The results are shown in Figure 8-1-3. More than half of the respondents (57.7%) felt that progress in science and technology has advantages (22.1% "many advantages" and 35.6% "some advantages"). At the same time, 10.6% of participants felt that progress has disadvantages (6.6% "some disadvantages" and 4.1% "many disadvantages"). Those who responded with "about the same" accounted for 26.8%.

The breakdown by gender shows that a high percentage of males responded with "many advantages", while a high proportion of females responded with "about the same" or "don't know". In the breakdown by gender and age, a high proportion of males over 30 responded with "many advantages".

A comparison of the survey results from February 1995 and October 1998 concerning the advantages and disadvantages of progress in science and technology shows that 52.7% of people responded with "many advantages", 31.4% with "about the same", and 6.3% with "many disadvantages" in 1995, in contrast to 57.7%, 26.8% and 10.7% respectively in 1998. The decline in responses for "about the same" signifies a trend of polarization of opinions (however, the 1995 survey included the four choices, "many advantages", "about the same", "many disadvantages" and "don't know", whereas the 1998 survey added the choices, "some advantages" and "some disadvantages". Therefore, it can be argued that those who responded with "about the same" in the former survey more accurately reflects their opinion).

Figure 8-1-3 Public assessments of progress of science and technology



Source: Prime Minister's Office, Public Relations Office, "Public Opinion Poll on the Future of Science and Technology" (October 1998)
See: appendix table 8-1-3

(2) Improvements Due to Progress in Science and Technology

When asked whether there has been an improvement in the "abundance of goods", "satisfaction in personal life", "working conditions" and "health" due to progress in science and technology, a high percentage of respondents felt that there has been a rise in the abundance of goods, and in the enjoyment of living. In comparison, the proportion of respondents who felt improvements have been made in working conditions and health was relatively low (Figure 8-1-4).

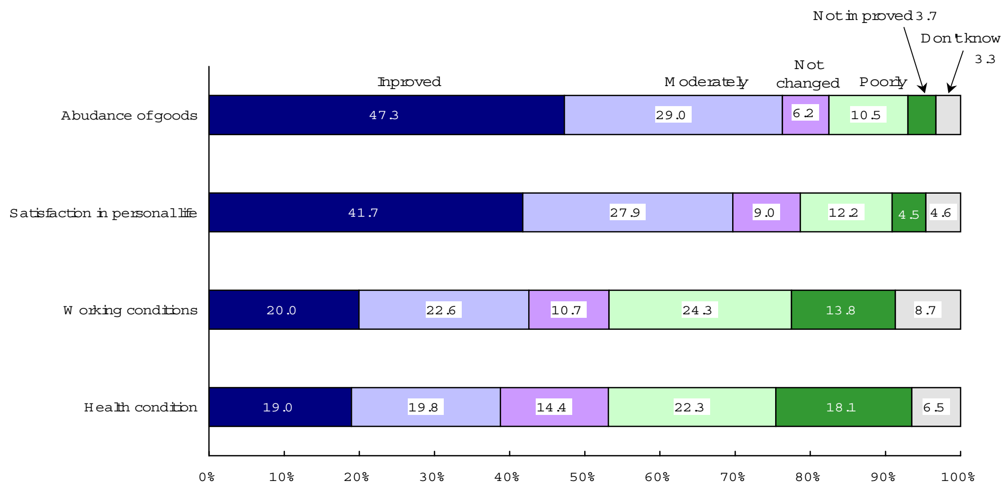
8.1.3 Areas of Science and Technology in which Development is Anticipated

(1) Important areas of Science and Technology for Future Development

When respondents were asked the areas of science and technology for which future development is important, 65.1% chose the "global environment and environmental preservation", while 63.0% chose the "development and efficient utilization of energy". The choice of "resource development and recycling" accounted for 59.0%, followed by "waste management and disposal" (56.8%), "civil engineering/construction, transportation/shipping, and information/communications" (44.3%), and "disaster and safety strategies" (44.1%) (Figure 8-1-5). (Note: There were multiple responses to this question.)

Compared to the previous responses in the survey from February 1995, there was an increase in the percentage of those who chose "civil engineering/construction, transportation/shipping, and information/communications" from 40.7% to 44.3%, whereas the percentage of those who suggested "disaster and safety strategies" fell from 53.9% to 44.1%. However, it is conceivable that this was influenced by the Hanshin-Awaji Earthquake, which happened in January 1995, less than two months before the survey was carried out.

Figure 8-1-4 Improvements by science and technology development



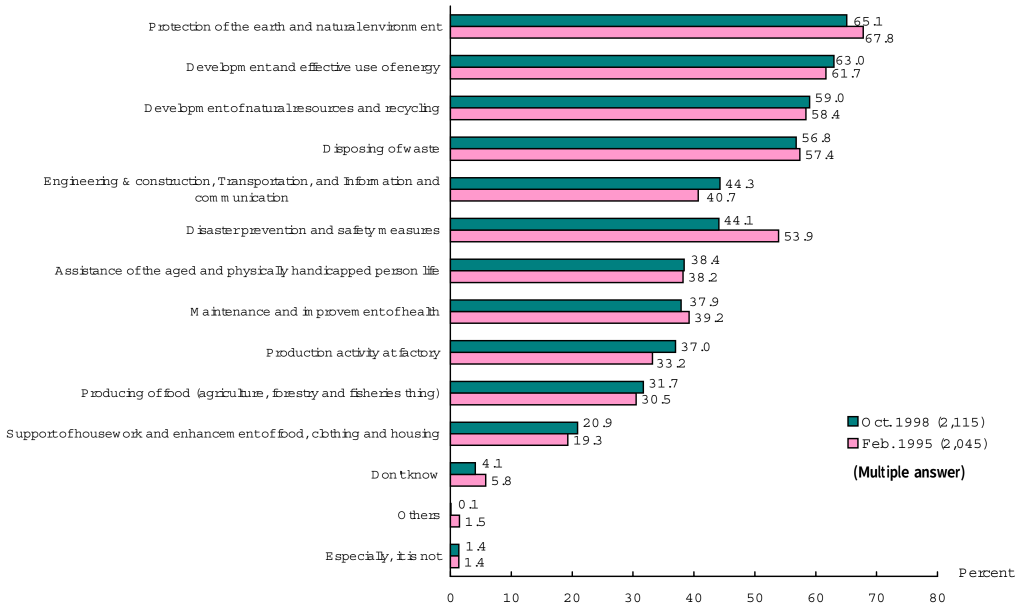
Source: Prime Minister's Office, Public Relations Office, "Public Opinion Poll on the Future of Science and Technology" (October 1998)
See: appendix table 8-1-4

(2) Opening Up New Fields in Science and Technology (Space and Marine Development)

Participants were asked their expectations about opening up space and marine development as representatives of new fields in science and technology. For space development, a large percentage of respondents chose, "realization of dreams and romanticism" (49%), and "technological progress and scientific quest" (47.1%). These were followed by an "expansion of humanity's sphere of activity" (35.1%). For marine exploitation, the largest percentage of respondents chose an "expansion of mankind's sphere of activity" (36.5%), followed by "part of the evolution of human life" (34.7%), "technological progress and scientific quest" (33.9%), and a "response to population increase and environmental problems" (33.7%). The results are shown in Figure 8-1-6. (Note: There were multiple responses to this question).

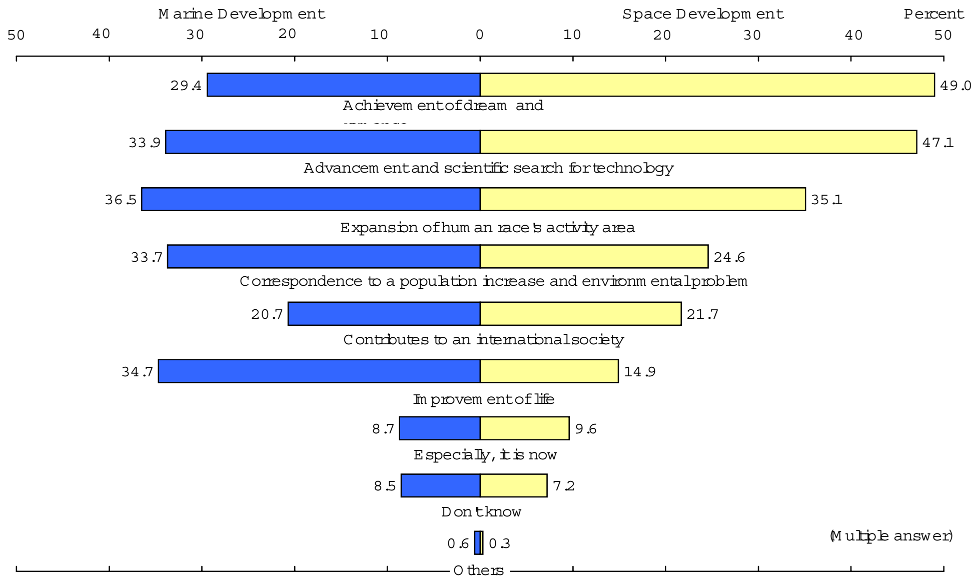
In contrast to the high expectations for the realization of dreams and romance for space development, the expectations for sea development were concentrated around realistic aspects such as the expansion of humanity's sphere of activity and the evolution of human life.

Figure 8-1-5 Fields where development of science and technology should be made



Source: Prime Minister's Office, Public Relations Office, "Public Opinion Poll on the Future of Science and Technology" (October 1998)
See: appendix table 8-1-5

Figure 8-1-6 Space and Marine development



Source: Prime Minister's Office, Public Relations Office, "Public Opinion Poll on the Future of Science and Technology" (October 1998)
See: appendix table 8-1-6

8.2 Biotechnology

Advances in cloning and human genome research and other developments in biotechnology in recent years have provided society with leading-edge knowledge about life and new medical applications. At the same time, there are areas of concern related to their social and ethical impact.

Here, we introduce the "Survey of Experts on Cloning" conducted by the Public Relations Office of the Prime Minister's Office as a means of indicating the awareness surrounding cloning technology, as one example of biotechnology.

Information on the survey target, period, method, and the number of valid responses is shown below. The 2,700 respondents for this survey were experts from throughout Japan. The breakdown of the respondents by area of expertise is as follows:

Breakdown
Academics 600
Mass communications professionals 300
Doctors 300
Professionals 300
Business administrators 300
Various group officials 300
Researchers 300
Administrative officials 300
Survey period: August 26 to September 16, 1998
Survey method: by mail
Number of valid responses (rate): 2,114 (78.2%)

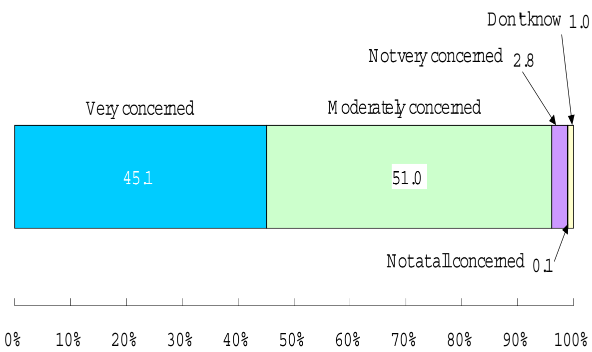
8.2.1 General Bioethical Issues

(1) Concern About Bioethical Issues

When participants in the survey were asked whether they were concerned about bioethical issues, 96.1% of them responded that they were concerned (45.1% "very concerned" and 51.0% "moderately concerned"). Only 2.9% of participants claimed that they were not concerned (2.8% "not very concerned" and 0.1% "not at all concerned"). The results appear in Figure 8-2-1.

The percentage of respondents who stated that they were concerned was high in all areas of expertise.

Figure 8-2-1 Concern about bioethical issues



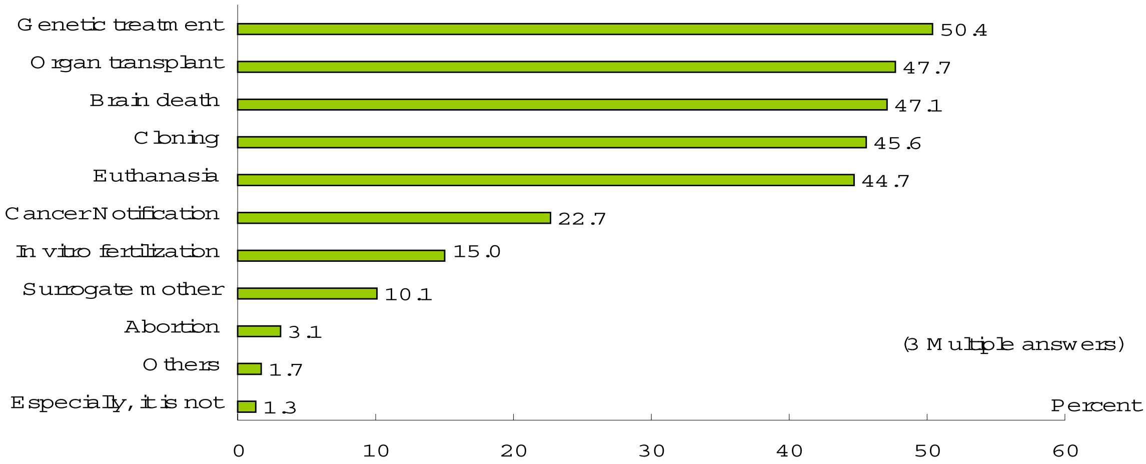
Source: Prime Minister's Office, Public Relations Office, "Survey of Experts on Cloning" (Sept., 1998)
See: appendix table 8-2-1

(2) Bioethical Issues with High Concern

When respondents were asked to choose the three bioethical issues about which they were particularly concerned, 50.4% chose genetic treatments, 47.7% chose organ transplants, 47.1% chose brain death, 45.6% chose cloning, and 44.7% chose euthanasia (Figure 8-2-2).

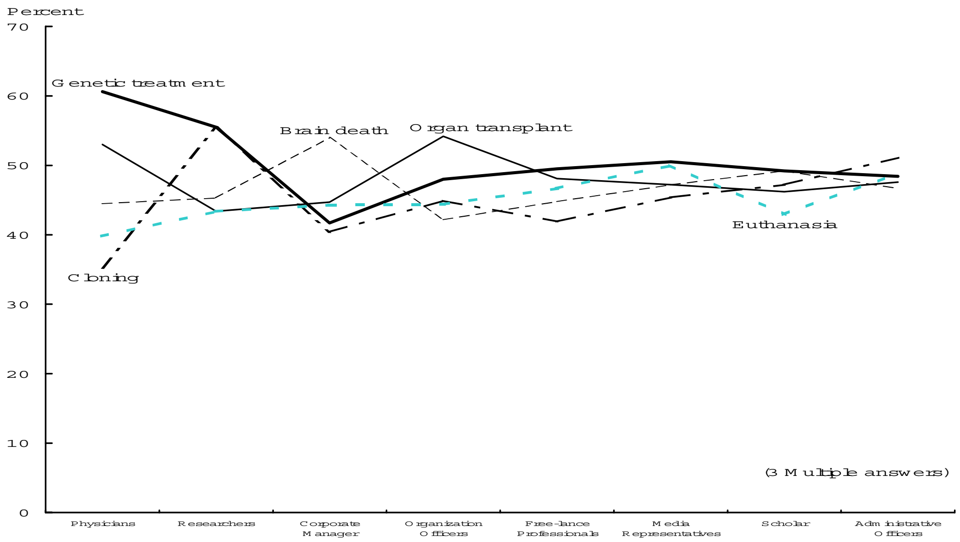
Looking at the comparison between the survey respondents areas of expertise and the issue in which concern is highest, doctors chose "genetic treatments", the group officials chose "organ transplants", business administrators chose "brain death", and researchers chose "cloning".

Figure 8-2-2 Bioethical Issues with high concern



Source: Prime Minister's Office, Public Relations Office, "Survey of Experts on Cloning" (September 1998)
See: appendix table 8-2-2

Figure 8-2-3 Bioethical issues with high concern



Source: Prime Minister's Office, Public Relations Office, "Survey of Experts on Cloning" (September 1998)
See: Appendix Table 8-2-2

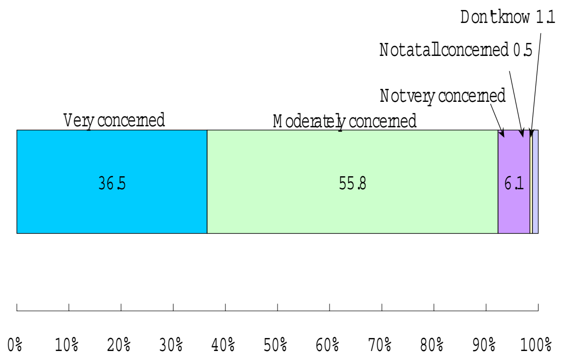
Turning our attention to the five issues in which the percentage of those concerned was high, a dispersion can be seen for the percentage of those concerned among the five issues for doctors. In other words, there was a variance in their areas of concern. In contrast, the percentage of concern between the five issues for administrative officials and mass-communications professionals was close, which suggests that the level of interest for all of the issues is the same (Figure 8-2-3).

(3) Concerns with Regard to Cloning

Next, respondents were asked the level of their concern about cloning. The majority (92.3%) said that they were concerned (36.5% "very concerned" and 55.8% "moderately concerned"). Only 6.6% said they were not concerned (6.1% "not very concerned" and 0.5% "not at all concerned"). The results are shown in Figure 8-2-4.

The percentage of respondents who stated that they were concerned was high in all areas of expertise.

Figure 8-2-4 Concern about Cloning



Source: Prime Minister's Office, Public Relations Office, "Survey of Experts on Cloning" (September 1998)
See: appendix table 8-2-3

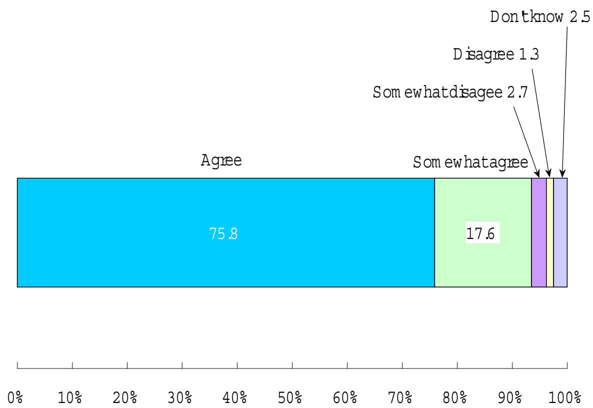
8.2.2 Bioethical Issues Surrounding Cloning

(1) Are Human Applications of Cloning Technology Unacceptable?

Survey participants were asked what they thought about the opinion that using cloning technology for human applications and to create humans is unacceptable from a bioethical viewpoint. The vast majority (93.5%) agreed (75.8% "agree" and 17.6% "somewhat agree"), and only a small percentage (4.0%) disagreed (2.7% "somewhat disagree" and 1.3 "do not agree"). The results appear in Figure 8-2-5.

The percentage of respondents who stated that they agreed was high in all areas of expertise.

Figure 8-2-5 Are human applications of cloning technology unacceptable?



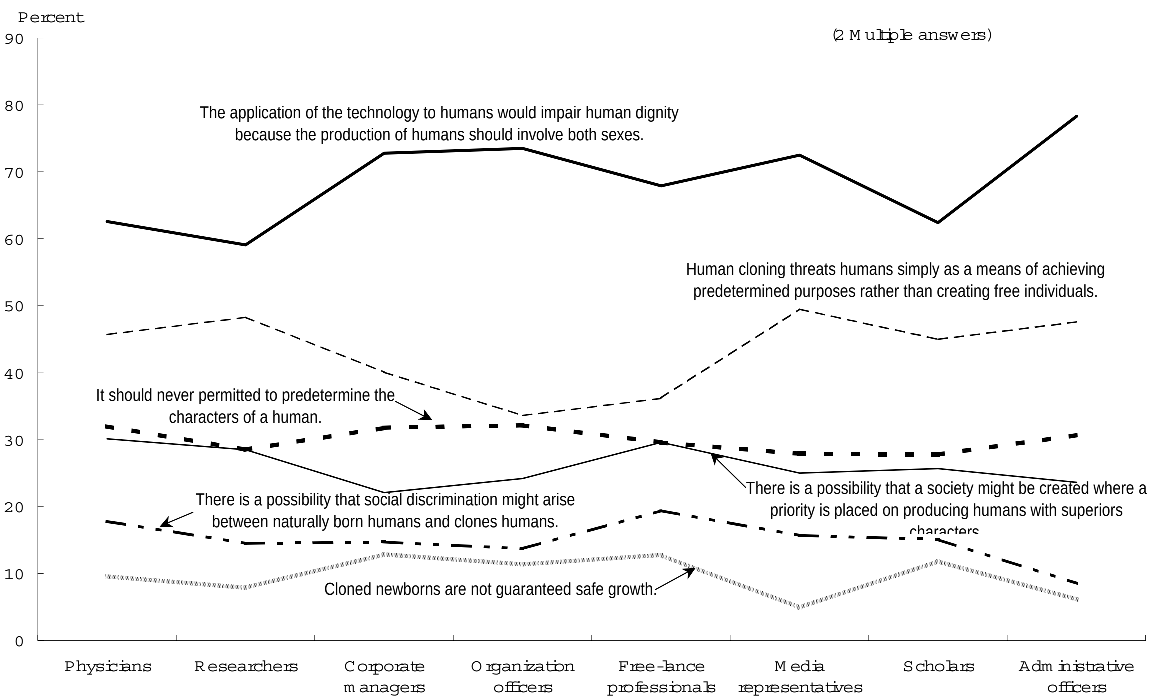
Source: Prime Minister's Office, Public Relations Office, "Survey of Experts on Cloning" (September 1998)
See: Appendix Table 8-2-4

(2) Reasons for Unacceptability of Human Applications of Cloning Technology

As a follow-up, those participants who agreed, above, were asked for the two reasons, which most closely matched their thoughts as to why human applications of cloning are unacceptable. The largest percentage of respondents (67.7%) chose "The application of the technology to humans would impair human dignity because the production of humans should involve both sexes". This was followed by "Human cloning threats humans simply as a means of achieving predetermined purposes rather than creating free individuals" (43.6%), and "It should never permitted to predetermine the characters of a human" (29.8%), and "There is a possibility that a society might be created where a priority is placed on producing humans with superiors characters" (26.1%).

Looking at the comparison between the area of expertise of the survey respondents, the percentage of those who chose "The application of the technology to humans would impair human dignity because the production of humans should involve both sexes" was high among administrative officials, but low among researchers (Figure 8-2-6).

Figure 8-2-6 Reasons for unacceptability of human applications of cloning technology



Source: Prime Minister's Office, Public Relations Office, "Survey of Experts on Cloning" (September 1998)
See: appendix table 8-2-5

8.3 Information Technology

Computers and networks, which are at the core of information technology, have been rapidly adopted as systems within society, making our lives increasingly convenient and are anticipated as the driving force behind an era of change. At the same time, an examination of the social issues, such as the protection of privacy, is called for when information technology is used as a tool within society.

In this section, we discuss the survey results regarding the use of computers, as a representative example of information technology, which come from the "Public Opinion Poll on the Future of Science and Technology" introduced previously.

(1) Use of Computers

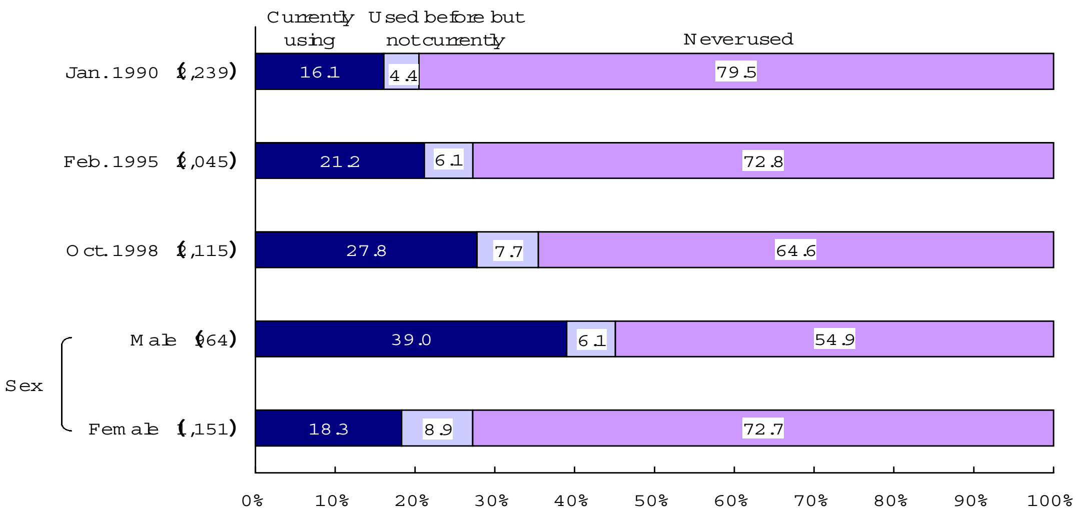
When asked whether they use computers at work or at home (excluding game consoles, word processors, and so on), 27.8% of participants responded with "currently using", 7.7% responded with "used before but not currently", and 64.6% responded with "never used" (Figure 8-3-1).

Compared to the survey results from February 1995, there was a rise in the percentage of people who responded with "currently using" from 21.2% to 27.8%, and a decline in the percentage of those responding with "never used" from 72.8% to 64.6%.

By gender, the percentage of males who responded with "currently using" and the percentage of females who responded with "never used" were both high.

By occupation, the percentage of managers, technicians and office workers who responded with "currently using", of housewives who responded with "used before but not currently", and of self-employed individuals, household employees, laborers, housewives and unemployed individuals who responded with "never used", were all high.

Figure 8-3-1 Use of computers



Source: Prime Minister's Office, Public Relations Office, "Public Opinion Poll on the Future of Science and Technology (October 1998)

See: appendix table 8-3-1

(2) Use of Networks

Those who responded with a "currently using" (587 people) to the question asked in (1) were then asked whether they use a network, such as the internet, when they use a computer. Those who replied with a "currently using" accounted for 44.6% , while those who replied with "used before but not currently" accounted for 4.9% , and those who replied with "never used" accounted for 50.4% (Figure 8-3-2).

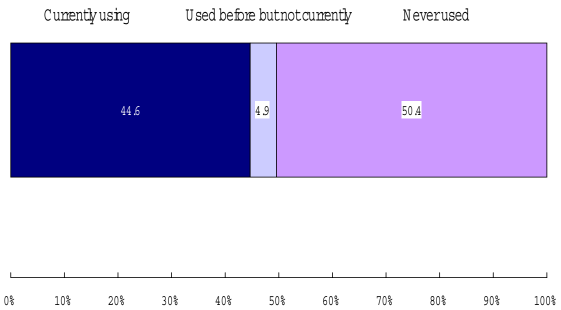
By gender, the percentage of males who responded with "currently using" was 48.7% , while those who responded with "never used" was 45.7% . Among females, on the other hand, the percentage of those who responded with "currency using" was 37.4% , and those who responded with "never used" was 58.8% .

(3) Future Use of Computers

Those who responded with "used before but not currently" and "never used" (1,528 people) were then asked whether they would like to use a computer in the future. The percentage of those who replied that they would like to use a computer was 45.7% (10.6% "yes, definitely" and 35.1% "yes, if I have the opportunity"). Those who replied that they would not like to use a computer accounted for 52.3% (14.5% "not unless I have to" and 37.8% "definitely not"). The results are shown in Figure 8-3-3.

By age, the percentage of those who replied that they would like to use a computer was high among the 18 to 29 year-olds, and those in their 30s and 40s. The percentage of those who replied that they would not like to use a computer was high among those in their 60s.

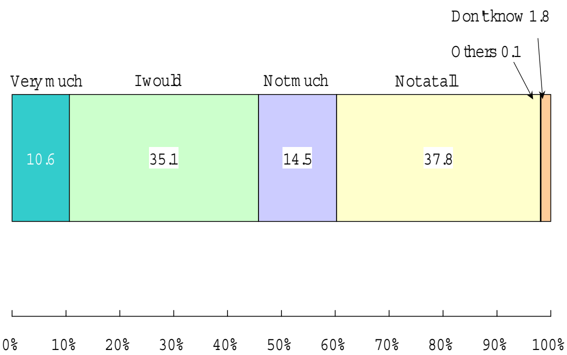
Figure 8-3-2 Use of networks



Source: Prime Minister's Office, Public Relations Office, "Public Opinion Poll on the Future of Science and Technology (October 1998)

See: appendix Table 8-3-2

Figure 8-3-3 Future use of computers



Source: Prime Minister's Office, Public Relations Office, "Public Opinion Poll on the Future of Science and Technology" (October 1998)

See: appendix Table 8-3-3

8.4 Global Environmental Issues

Although progress in industrial technology has brought about economic development and enhancements in the quality of life, it has also caused environmental problems, such as global warming, for which science and technology is expected to provide the solutions. There has been progress in international efforts to protect the earth's environment, with this topic being discussed as a man-made problem.

Among the questions about the "Important areas of science and technology for future development" from the "Public Opinion Poll on the Future of Science and Technology", which were introduced in Section 8.1.3(1), the majority of respondents chose the "global environment and environmental preservation", making it the item of the greatest national concern.

In this section, we will discuss the "Public Opinion Poll on the Global Environment and Lifestyles", conducted by the Public Relations Office of the Prime Minister's Office, as a means of illustrating the national consciousness concerning global environmental issues.

Information on the survey target, period, method, and the number of valid responses is shown below.

Survey target: Adults over 20 years old from throughout the country
Size of sample: Population: 3,000 people
Sampling method: Stratified, two-stage random sampling
Survey period: November 12 to 22, 1998
Survey method: Interview questions by pollsters
Number of valid responses (rate): 2,131 (71.0%)

(1) Concern About Global Environmental Issues

Survey participants were asked whether they were concerned about global environmental issues such as holes in the ozone layer, global warming, and the destruction of the tropical rainforests. The majority of respondents (82.0%) claimed that they were concerned (42.1% "concerned" and 39.9% "moderately concerned"). Those who were not concerned accounted for 17.3% (13.3% "not very concerned" and 4.0% were "not at all concerned") (Figure 8-4-1).

By gender and age group, the percentage of those who were concerned was high among males in their 40s and 50s, and females in their 40s. Meanwhile, the percentage of those who were not concerned was high among females in their 20s and those over 60.

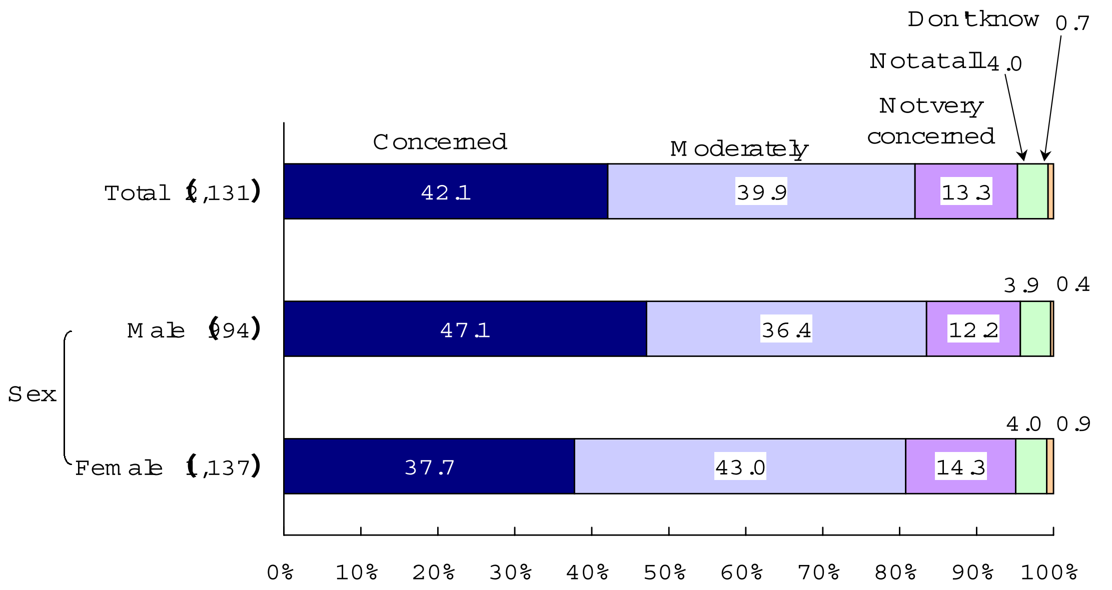
(2) Awareness of The Causes of Global Warming

In recent years, the earth's temperature has been rising due to rapidly increasing emissions of carbon dioxide - resulting from the consumption of coal and petroleum - being trapped in the atmosphere. When respondents were asked whether they were aware it was a problem, 86.5% of them answered affirmatively (43.7% "well aware" and 42.8% "somewhat aware"). Those who replied that they were not aware accounted for only 13.2% (10.5% "not very aware" and 2.7% "not at all aware") (Figure 8-4-2).

By gender, the percentage of those who were aware was high among males, and among those who were unaware, the percentage was high for females.

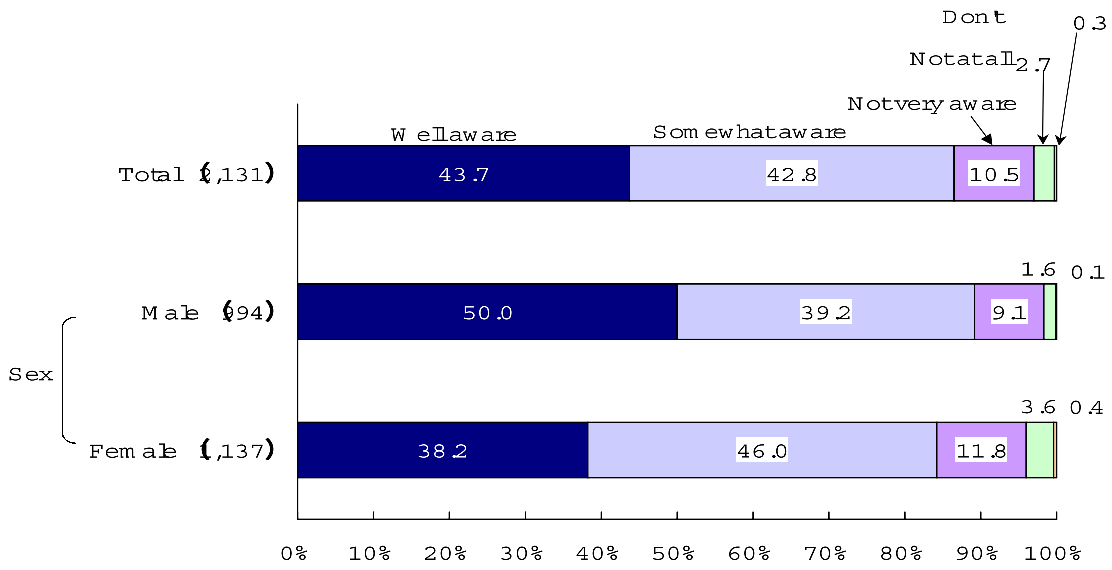
By gender and age group, the percentage of those who were aware was high among males in their 40s, and the percentage of those who were unaware was high among females in their 20s and those over 60.

Figure 8-4-1 Concern about Global Environment Problems



Source: Prime Minister's Office, Public Relations Office, "Public Opinion Poll on the global Environment and Lifestyles" (November 1998)
See: appendix table 8-4-1

Figure 8-4-2 Public application of global warming factors



Source: Prime Minister's Office, Public Relations Office, "Public Opinion Poll on the Global Environment and Lifestyles" (November 1998)
See: appendix table 8-4-2

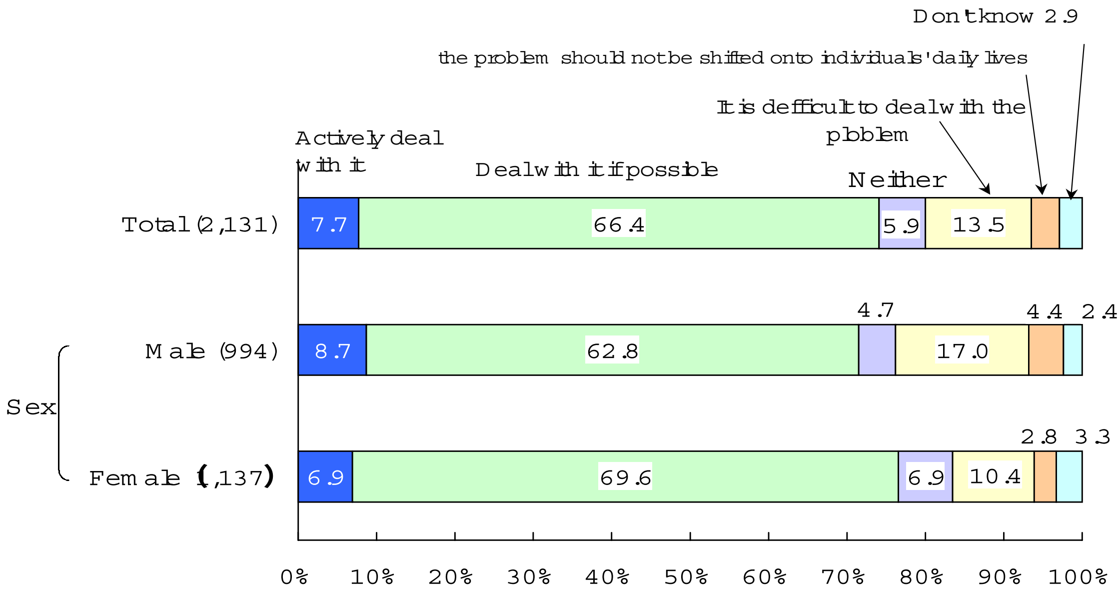
(3) Preventing Global Warming

Respondents were asked whether they thought individuals should deal with the problem of global warming in their daily lives, to which 74.1% responded that they should (7.7% "actively deal with it" and 66.4% "deal with it if possible". People who claimed "it is difficult to deal with the problem" accounted for 13.5%, while those who claimed "the problem should not be shifted onto individuals' daily lives" accounted for 3.6% (Figure 8-4-3).

By gender, a large percentage of females responded positively, whereas a large percentage of males responded with "it is difficult to deal with the problem". By age group, the vast majority of those in their 30s (82.1%) responded affirmatively.

It is said that we currently lead lifestyles of high energy consumption. The participants in the survey were asked what lifestyle changes they thought individuals should make in order to prevent global warming. The majority (56.8%) chose "make an effort to turn off lights and electrical appliances to avoid wasting energy". This was followed by "use air conditioning in moderation" (50.3%), "use bicycles and public transport instead of cars as much as possible" (38.6%), "use fuel-efficient cars" (31.3%), "switch to more energy-efficient household appliances" (29.2%), "use solar-powered water heaters" (19.8%), "improve the effectiveness home insulation" (18.7%), "use solar power, wind power, etc. in homes" (14.7%), "no changes are necessary" (5.7%), and last, "do not know" (2.3%). (Note: there were multiple responses to this question).

Figure 8-4-3 Efforts to preventing global warming



Source: Prime Minister's Office, Public Relations Office, "Public Opinion Poll on the Global Environment and Lifestyles" (November 1998)
See: appendix table 8-4-3

8.5 Conclusion

Above, we outlined the Japanese citizens' awareness surrounding science and technology.

Nearly 60% of the survey respondents were interested in information concerning general science and technology, and almost 60% also expressed a desire to listen to talks by scientists and engineers. However, there were differences in the degree of interest according to gender and age, and with regard to the fields in which people were interested in listening to information about, the global environmental issue was the at the top in several fields, and it is desirable to provide information in a detailed and easy to understand form.

Following this, we looked at a detailed exposition of the biotechnology, information and environmental fields. It was evident that the expert respondents in the survey related to biotechnology, were keenly interested in bioethical issues such as cloning.

A comparison of the surveys on information technology from February 1995 and October 1998 showed a rise in the percentage of people who use computers, indicating that computers are becoming increasingly widespread among citizens in Japan.

With regard to global environmental issues, those concerned about the issues, and those who were aware of the causes of global warming account accounted for a high percentage, and it was evident that these were reacted to as topics of national concern.

We also paid close attention to the differences between males and females throughout, and found that a larger percentage of males were interested in information on science and technology, and also believed that progress in science and technology has many advantages. Moreover, in the area of information technology, it was found that a greater percentage of males used computers. Also, a greater percentage of males claimed they were interested in global environmental issues, as well as claiming awareness of the causes of global warming. However, the gap between males and females was small compared to the question about the use of computers. Further, a greater percentage of females responded affirmatively to the question about whether individuals should deal with the problem of global warming in their daily lives. As we can see, in general, males have a higher level of interest in science and technology than females, and make more use of its achievements. However, it seems that females have a greater level of awareness when it comes topics close to themselves, such as dealing with global environmental issues through their daily lives

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Chapter 8
Mami Ohyama

Chapter 9 Regional Science and Technology Activities

Many issues remain as to whether indicators for estimating regional science and technology activities should be defined under the same framework as national indicators. So far, the regional versions of science and technology indicators have been created as scaled-down versions of the national indicators themselves by observing the regional distribution of each type of indicator, and taking that as the regional science and technology indicator. However, in reality, it is inconceivable that the regional science and technology activities are exactly the same as their national counterparts; therefore, it seems appropriate to assume that the indicators estimating these activities are also different. Local government bodies are not the only organizations responsible for policies. For researchers and technicians, a significant feature of regions is that they serve as a place to develop research activities, and at the same time, as a place to live. This is where the starting point of human intellectual creativity lies. Furthermore, since the substance of this relies on the temporal and spatial accumulation of regional intellectual resources, it is predicted that indicators that can quantitatively measure these things will differ from the science and technology indicators of the past. The same thing can be said of industry, where the significance of the region as a base for industrial activities cannot be measured only by simple economic indexes.

As the above show, the development of regional science and technology indicators is not predicted to be so simple, and at this stage, reliable regional science and technology indicators, which will stand up to use, have not been developed. Consequently, the indicators below have been created in a form which follows the stream of regional indicators up until now, and, excluding indicators concerning the characteristics of mobilities between regions for some industries and changes in regional industrial structures, they are basically the same.

In this chapter, we gain a clear picture of regional science and technology activities from the six aspects of "education", "R&D activities", "regional science and technology promotional policies", "achievements of science and technology activities", "science and technology activities and regional economies", and "changes in regional industrial structures", with indicators created by prefectures.

However, because of limitations in the data that can be used as science and technology indicators for each prefecture, we have also included indirect indicators that are considered to represent the science and technology activities for the prefectures. Moreover, depending on the type of data, we have made an effort to objectively show the status and special features of the science and technology activities of each prefecture by showing standardized, per-capita indicators.

9.1 Education

The indicators for higher education and social education serve as the fundamental indicators most directly related to regional science and technology activities. Below, we show the indicators for the universities and social education institutions, which are the basis of science and technology education, for each prefecture.

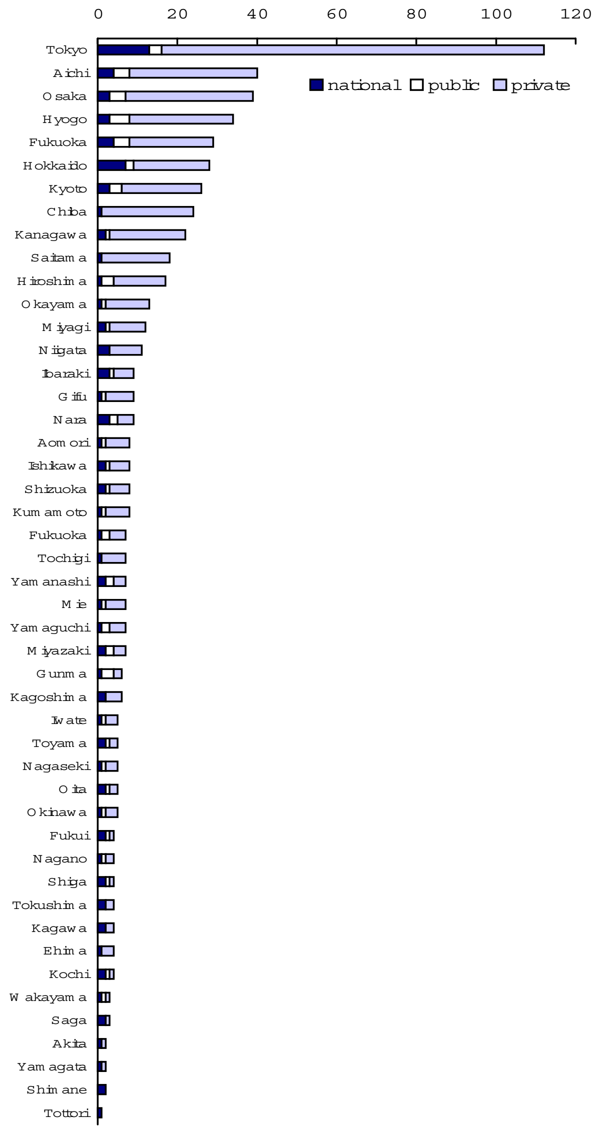
9.1.1 Number of Universities and University Students

(1) Number of Universities

In FY1998, there were a total of 604 universities throughout Japan, the distribution of which is shown by prefecture in Figure 9-1-1. Tokyo has an especially large number of universities, with a total of 112 national, public and private universities, which accounts for approximately 18.5% of the total number. Tokyo is followed by Aichi, Osaka, Hyogo, Fukuoka, Hokkaido and Kyoto. These seven regions account for roughly 51% of the total number of universities in Japan.

The populations of the prefectures are as shown in Figure 9-1-1 in the Attachment, with the nine most populous prefectures, beginning with Tokyo, account for approximately 51% of the national population. And so, we should not simply conclude that there are a large number of universities in populous prefectures. The concentration of universities in specific prefectures is more unevenly marked than that of population. For example, although the population of Tokyo accounts for roughly 9.35% of the national total, the number of universities accounts for approximately 18.5% of the total. Compared to national and public universities, there are particularly large differences in the regional distribution of private universities, with more than 20% of private universities being based in Tokyo (see Figure 9-1-2 in the Attachment).

Figure 9-1-1 Number of universities by prefecture (FY1998)

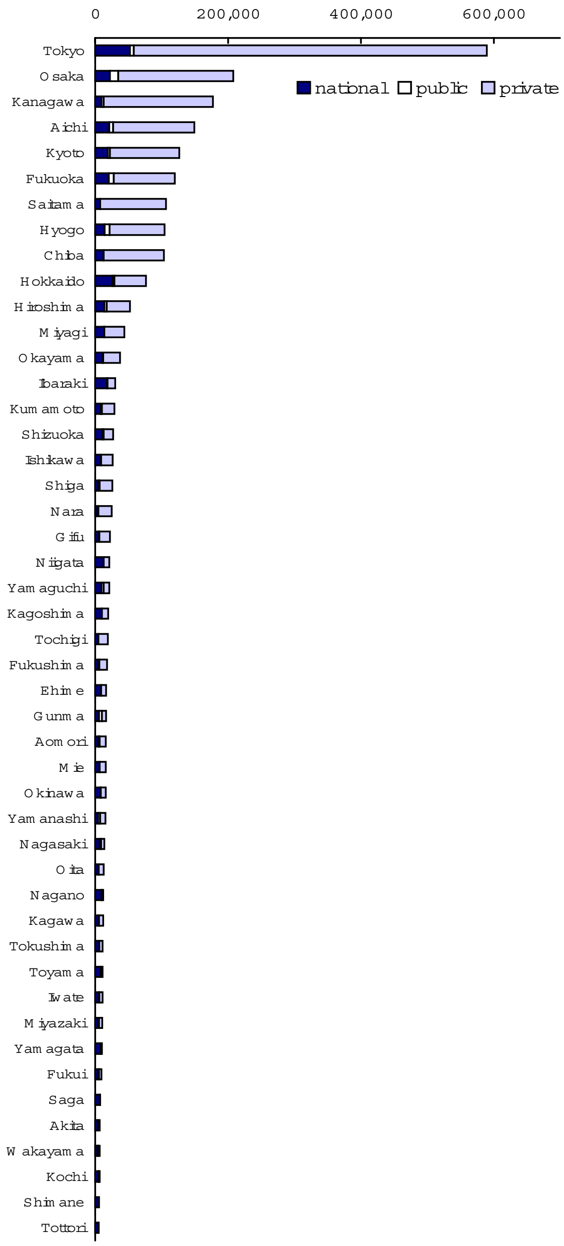


Note: Number of each prefecture is calculated at the location of university headquarters (secretariat)
Source: Ministry of Education, "Report on Basic Survey of Schools"
See: appendix table 9-1-2

(2) Number of University Students

Figure 9-1-2 shows the number of university students (undergraduates) by prefecture. The number of students was totaled according to the location of each department to which students belonged. The total number of students was 2,430,000. The number of students by prefecture shows that Tokyo, Osaka, Kanagawa, Aichi and Kyoto had the largest number, together accounting for about 51% of the country's total. The number of university students in Tokyo was particularly large, with 24% of the national total, and it is obvious that the regional distribution in the number of students is also uneven.

Figure 9-1-2 Number of university students by prefecture (FY1998)



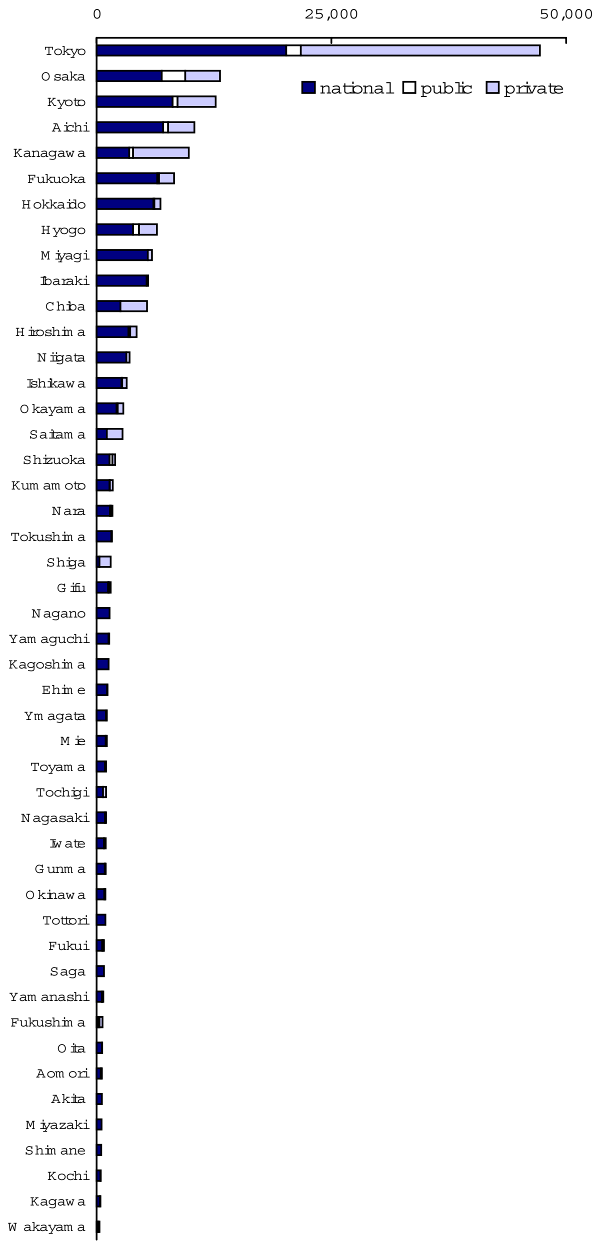
Note: Number of each prefecture is calculated at the location of a faculty on the register.
Source: Ministry of education, "Report on Basic Survey of Schools"
See: appendix table 9-1-3

9.1.2 Number of Graduates

Figure 9-1-3 shows the distribution of university graduate students by prefecture. The number of graduates was totaled according to the location of each postgraduate course to which students belonged. There were approximately 180,000 graduate students throughout the country. The number of graduate students by prefecture shows that Tokyo, Osaka, Kyoto, Aichi and Kanagawa had the largest number. Tokyo alone accounted for about 26% of the country's total, and the five regions together accounted for about 52% of the total.

If it can be considered that R&D activities flourish in universities with a large number of graduate students, it is apparent that regional disparities in the volume of R&D activities at universities are biased by the uneven distribution of graduate students.

Figure 9-1-3 Number of graduate school students by prefecture (FY1998)



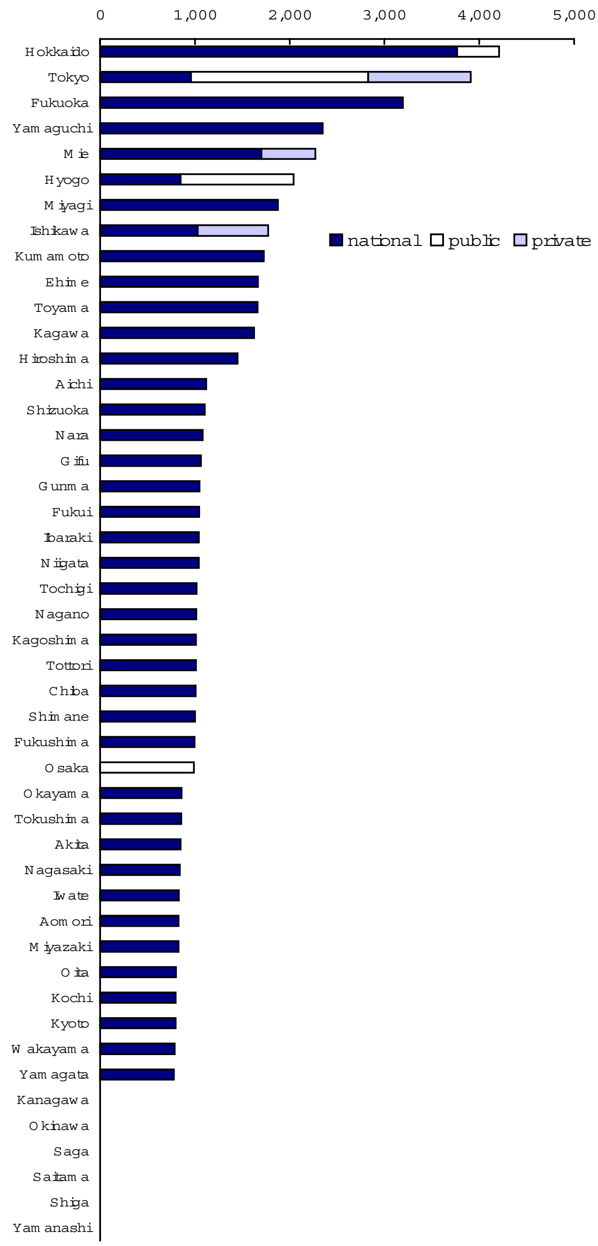
Note: Number of each prefecture is calculated at the location of a graduate course on the register.
Source: Ministry of education, "Report on Basic Survey of Schools"
See: appendix table 9-1-4

9.1.3 Number of Students at Post-secondary Technical Schools

Figure 9-1-4 shows the number of students at post-secondary technical schools by prefecture. The distribution of students at post-secondary technical schools by prefecture shows a concentration of numbers in several prefectures, though not as pronounced as the case with university students. In FY1998, about 56,000 students attended post-secondary technical schools, with the highest number in Hokkaido, Tokyo, Fukuoka, Yamaguchi and Mie. If we include the prefectures of Hyogo, Miyagi, Ishikawa, Kumamoto, Ehime, Fukuoka and Kagawa in addition to these five regions, these 12 regions account for roughly 50% of the country's total.

As described above, there is a bias in the distribution of post-secondary education facilities and students in each prefecture toward certain regions, and the extent of that bias is often greater than the variation in population between the prefectures. While the uneven distribution of the volume of research activities is evident from the number of graduate students, it appears that there is also a considerable regional uneven distribution in the number of personnel who will be responsible for future science and technology activities considering the fact that students often find work with companies near to the school from which they graduated.

Figure 9-1-4 Number of technical college students by prefecture (FY1998)



Note: Number of each prefecture is calculated at the location of a subject of study on the register.

Source: Ministry of education, "Report on Basic Survey of Schools"

See: appendix table 9-1-5

9.1.4 Community Education

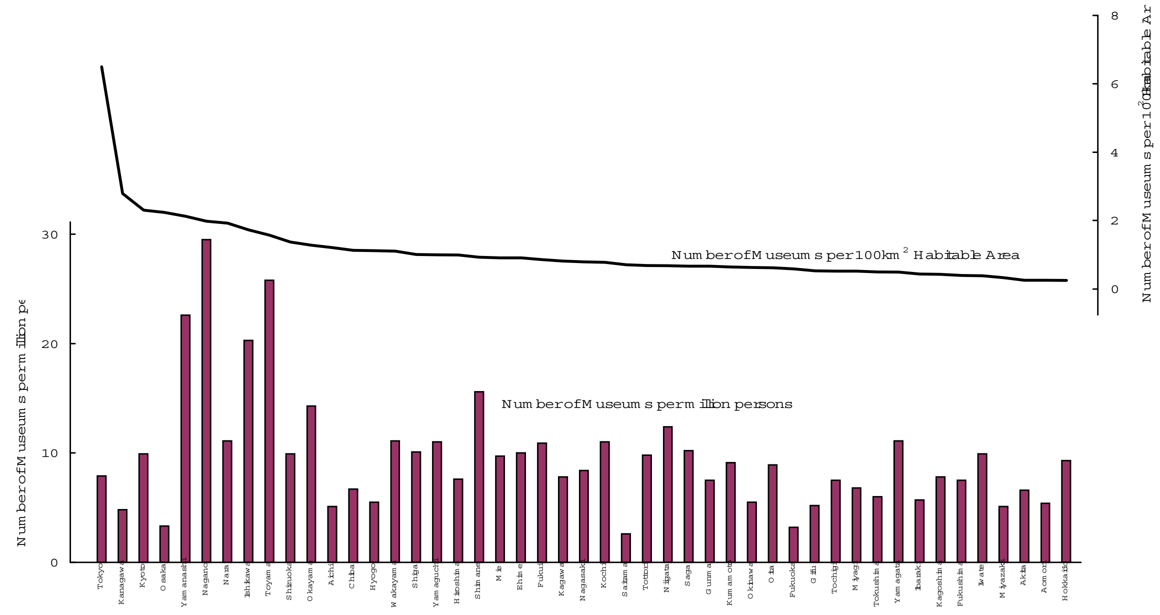
In this section, we discuss the number of museums and public libraries as an indicator of regional social education institutions.

(1) Number of Museums

Museums fulfil a valuable role in heightening the interest and concern of citizens in science and technology, especially for young people. In this instance, museums were totaled to include institutions designated as museums and "institutions accorded museum status" under the Museum Act. Museums specified under the Museum Act include general museums, science museums, history museums, art museums, outdoor museums, zoos, botanical gardens, combined zoo/botanical parks, and aquariums.

Figure 9-1-5 shows the number of museums per one million people and per 100 square kilometers of livable space for each prefecture. The number of museums per 100 square kilometers of livable space is highest in Tokyo, Kanagawa, Kyoto, and Osaka. This suggests that the number of museums situated close to the residents in these regions is higher than other prefectures. The numbers calculated per one million people are highest in Nagano, Toyama, Yamanashi and Ishikawa Prefectures. The numbers per livable area for these prefectures are also large, and moreover, these prefectures rank relatively highly in the number of patent applications per 10,000 people (see Figure 9-4-1).

Figure 9-1-5 Number of museums by prefecture (1996)



Source: Management and Coordination Agency, Statistics Bureau, "Social Life Statistics Indicators" (1998)
In addition, the numerical value per area which can be resided is calculated on the basis of this report in the National Institute Science and Technology Policy.
See: appendix table 9-1-6

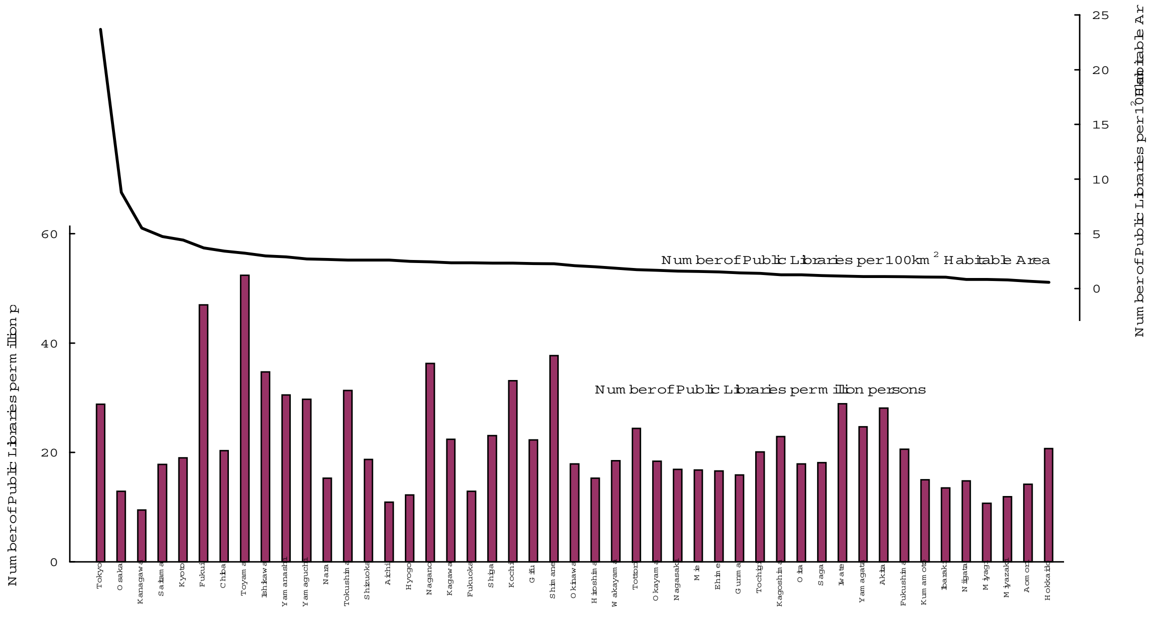
(2) Number of Public Libraries

As with museums, public libraries are considered to fulfil a valuable role in heightening the interest and concern of citizens in science and technology. Here, we show the number of public libraries per one million people and per 100 square kilometers of livable space for each prefecture.

As Figure 9-1-6 shows, populous regions such as Tokyo, Osaka and Kanagawa rank at the top in the values calculated per livable area. The values calculated per one million people, however, are highest in the prefectures of Toyama, Fukui, Shimane, Nagano, and Ishikawa. Among these, Toyama, Fukui and Ishikawa also rank near the top in the number of public libraries per livable area, and moreover, they also rank relatively highly in the number of patent applications per 10,000 people (see Figure 9-4-1).

As shown above, the numbers of museums and libraries per population and per livable area are comparatively high for prefectures in the Chubu Region, such as Toyama Prefecture. Further, the number of patent applications per population, which is one of the indicators of the achievements of science and technology activities, is high in these regions. In this sense, it is evident that these social education institutions somehow play a fundamental role in supporting regional science and technology activities.

Figure 9-1-6 Number of public libraries by prefecture (1996)



Source: Management and Coordination Agency, Statistics Bureau, "Social Life Statistics Indicators" (1998)

In addition, the numerical value per housing possible area is calculated on the basis of this report in the National Institute of Science and Technology Policy.

See: appendix table 9-1-7

9.2 R&D Activities

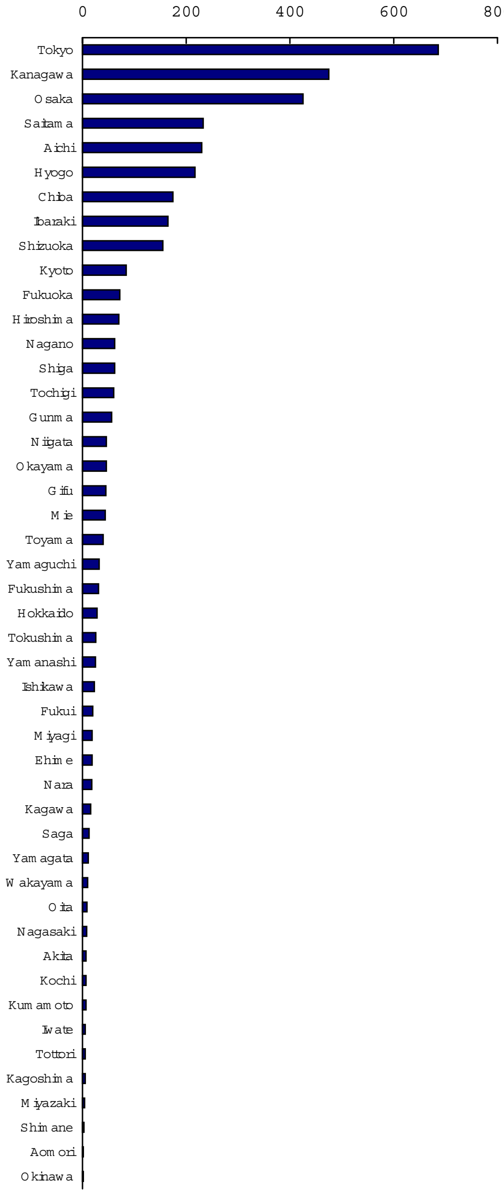
In this section, we discuss the number of private and public research facilities as an indicator of regional science and technology activities.

9.2.1 Number of Research Facilities at Private Companies

Due to a lack of comprehensiveness and continuity in the data for R&D private research facilities in each region, an indicator for the distribution of private research facilities has been created based on a general survey of the "Directory of National Testing Laboratories" (Lattice Ltd.). The term "research facility" with regards to this indicator includes corporate R&D departments, such as independent research laboratories, technical development departments, and so on. Moreover, when a single company has several R&D departments, each of them is counted separately.

The total number of R&D departments at private companies was 3,802. By region, Tokyo had the largest number (686 facilities), accounting for roughly 18% of the country's total (Figure 9-2-1). Kanagawa, Osaka, Saitama, Aichi, and Hyogo followed it. Together with Tokyo, these six regions accounted for about 60% of the country's total. In this way, the R&D facilities of private companies are highly concentrated in specific regions. If we combine this with the fact that these regions also have a large number of universities (Figure 9-1-1), and so on, it is evident that there is a regional bias in the number personnel involved in R&D.

Figure 9-2-1 Number of research institutions in private companies by prefecture (FY1998)



Source: It is calculated on the basis of Lattice Ltd., "Nationwide List of Research Institute: 1999-2000" (1999) in the National Institute of Science and Technology Policy.
See: appendix table 9-2-1

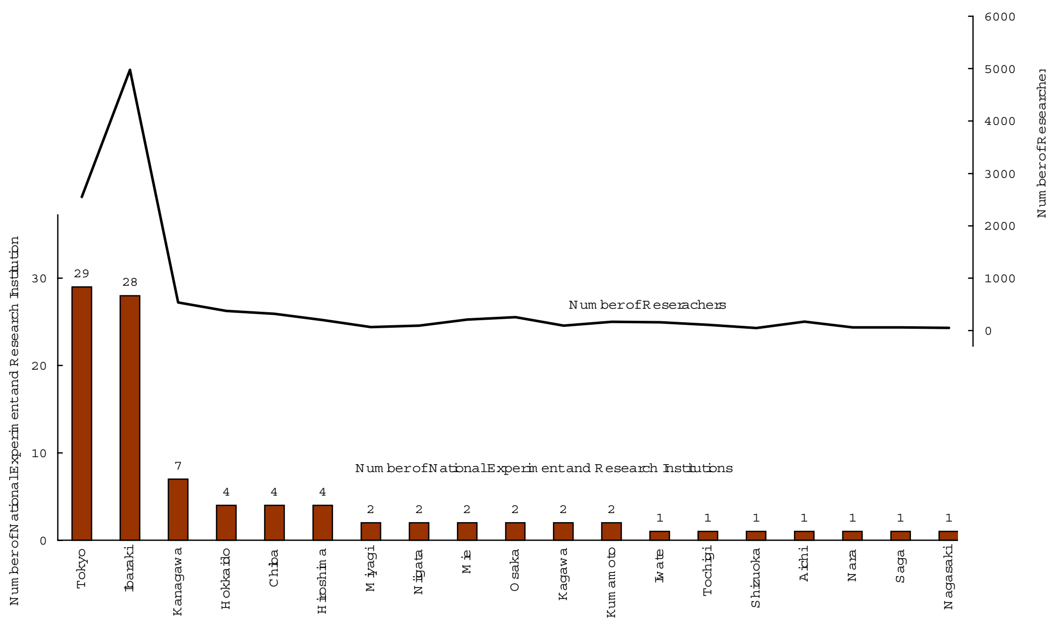
9.2.2 Number of National Research Institutes and Researchers

The regional distribution of the number of national research institutes (abbreviated as "national institutes" below) and researchers in FY1998 is shown in Figure 9-2-2. The distribution of national institutes among prefectures is extremely unbalanced. There are 28 facilities in Tsukuba Science City in Ibaraki Prefecture, which is second only to Tokyo's 29 facilities. With a total of 95 national institutes in Japan, 60% of them are concentrated in Tokyo and Ibaraki. National laboratories have been established in 19 prefectures, while 28 prefectures do not have such an institute. There has been no change in this situation since FY1995. In addition, Ibaraki Prefecture has the largest number of national institutes researchers with 4,977, followed by Tokyo with 2,551 researchers. Together, these two prefectures account for about 72% of the total number of researchers at national institutes (10,525 people), indicating that there is also a marked regional bias in the number of researchers at national institutes.

The reason why there are a greater number of national institutes researchers in Ibaraki than in Tokyo is the fact that many of the national institutes in Tsukuba Science City have a large number of researchers.

The linking of regional revitalization to the accumulation of national institutes in Tsukuba Science City, and the various ripple effects from the national institutes to the region have attracted attention. In recent years, even closer cooperation with the regions has been expected as one of the roles of national institutes.

Figure 9-2-2 Number of national experiment and research institutions and researchers by prefecture (FY1998)



Source: Science and Technology Agency, "Science and Technology Directory" (FY1999 edition)
See: appendix table 9-2-2

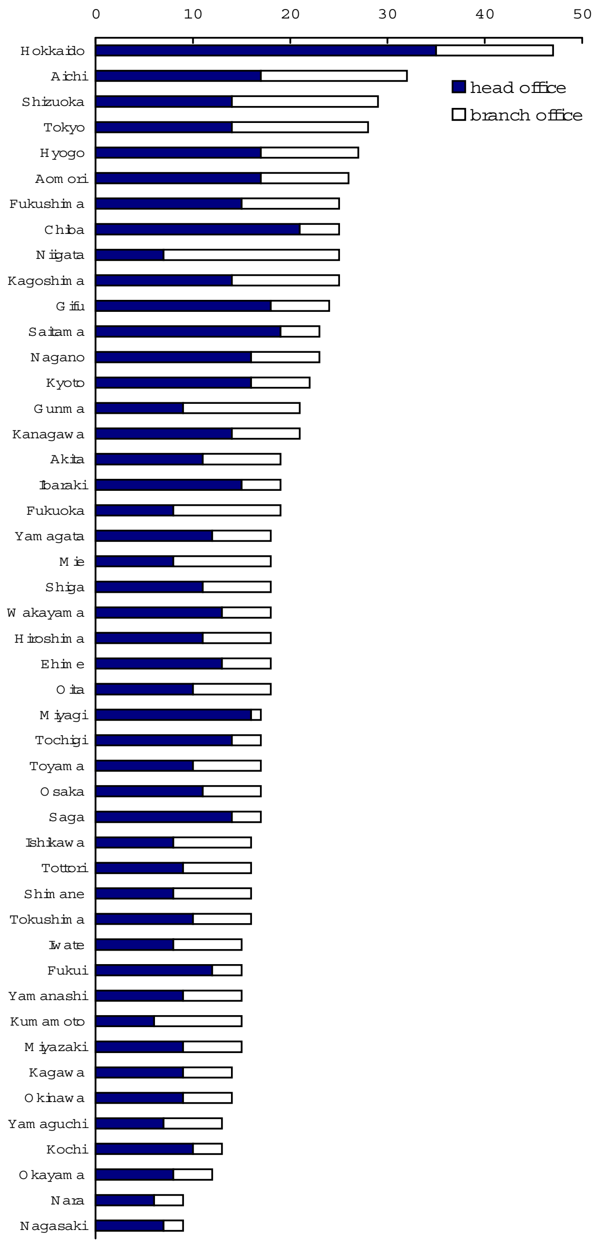
9.2.3 Number of Regional Research Institutes and Researchers

(1) Number of Regional Research Institutes

(Regional research institutes Kosetsu-shi: prefectural/municipal industrial research institutes) are positioned as one of the instruments of regional research institutes functions, and are expected to fulfil various roles, including supporting industrial development in the region. The data for regional research institutes shown here are the result of a survey ("Study on Regional Science and Technology Promotion", Fourth Survey, 1999) conducted by the National Institute of Science and Technology Policy, and target institutes established by prefectures and ordinance-designated cities.

As shown in Figure 9-2-3, there were a total of 575 regional research institutes throughout Japan in FY1997. Hokkaido had the highest number of facilities (35), followed by Chiba Prefecture (21), and Saitama, with 19 facilities. A simple comparison with the number of regional research institutes that existed in Japan in FY1995 shows there were 15 fewer facilities in FY1997. This can be attributed to the effects of mergers between facilities due to the reorganization of regional research institutes. However, from the fourth survey (FY1997), the number of branches employing regular workers was added as a survey item. The result of this was 339 branch institutes in addition to the head offices of the regional research institutes, which, if included in the total, brings the number of facilities to 914.

Figure 9-2-3 Number of public experiment and research institutions by prefecture (FY1997)



Note; The public establishment examination research organization which an ordinance-designated city manages is shown in accordance with the all prefectures as for which and ordinance-designated city carries out a whereabouts.

Source: Science and Technology Agency, National Institute of Science and Technology Policy, "Study of Regional Science and Technology Promotion (4th survey)" (NISTEP REPORT NO.59.), 1999

See: appendix table 9-2-3

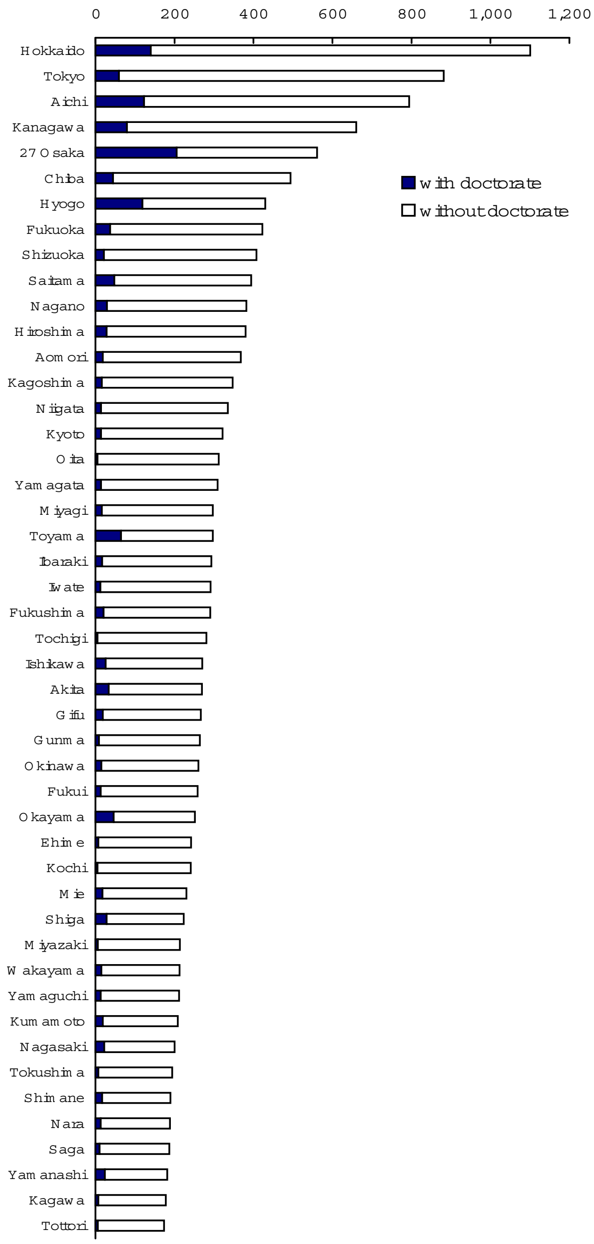
(2) Number of Researchers at Regional Research Institutes

In FY1997, there were 15,792 research personnel (i.e. those personnel engaged mainly in research and science and technology activities, among all full-time personnel) registered at regional research institutes. This is approximately 1.7 times the number of research personnel (9,115 researchers) that were at the 73 national research institutes of natural science in the same fiscal year.

By prefecture, Hokkaido had the largest number of personnel, with 1,110, followed by Tokyo (882), and Aichi (794). The breakdown of the number of research personnel with doctorates shows Osaka with the highest number at 206. Of these, 97 were researchers at "the Osaka City Institute of Public Health and Environmental Sciences" and "the Osaka Municipal Technical Research Institute". Next was Hokkaido (140 researchers), Aichi (123), and Hyogo (119). The marked regional bias seen in the national research institutes is not apparent in Figure 9-2-4.

If we consider the fact that the number of regional research institutes and the number of researchers at those institutes widely exceeds the numbers for the national research institutes, in the future, it seems extremely important to consider the question of how to make the best use of regional research institutes in a region, or conversely, in what way regional research institutes should contribute to a region

Figure 9-2-4 Number of researchers at public experiment and research institutions by prefecture (FY1997)



Note; The public establishment examination research organization which an ordinance-designated city manages is shown in accordance with the all prefectures as for which and ordinance-designated city carries out a whereabouts

Source: Science and Technology Agency, National Institute of Science and Technology Policy, "Study of Regional Science and Technology Promotion (4th survey)" (NISTEP REPORT No.59), 1999

See: appendix table 9-2-4

9.3 Policies for Regional Promotion of Science and Technology

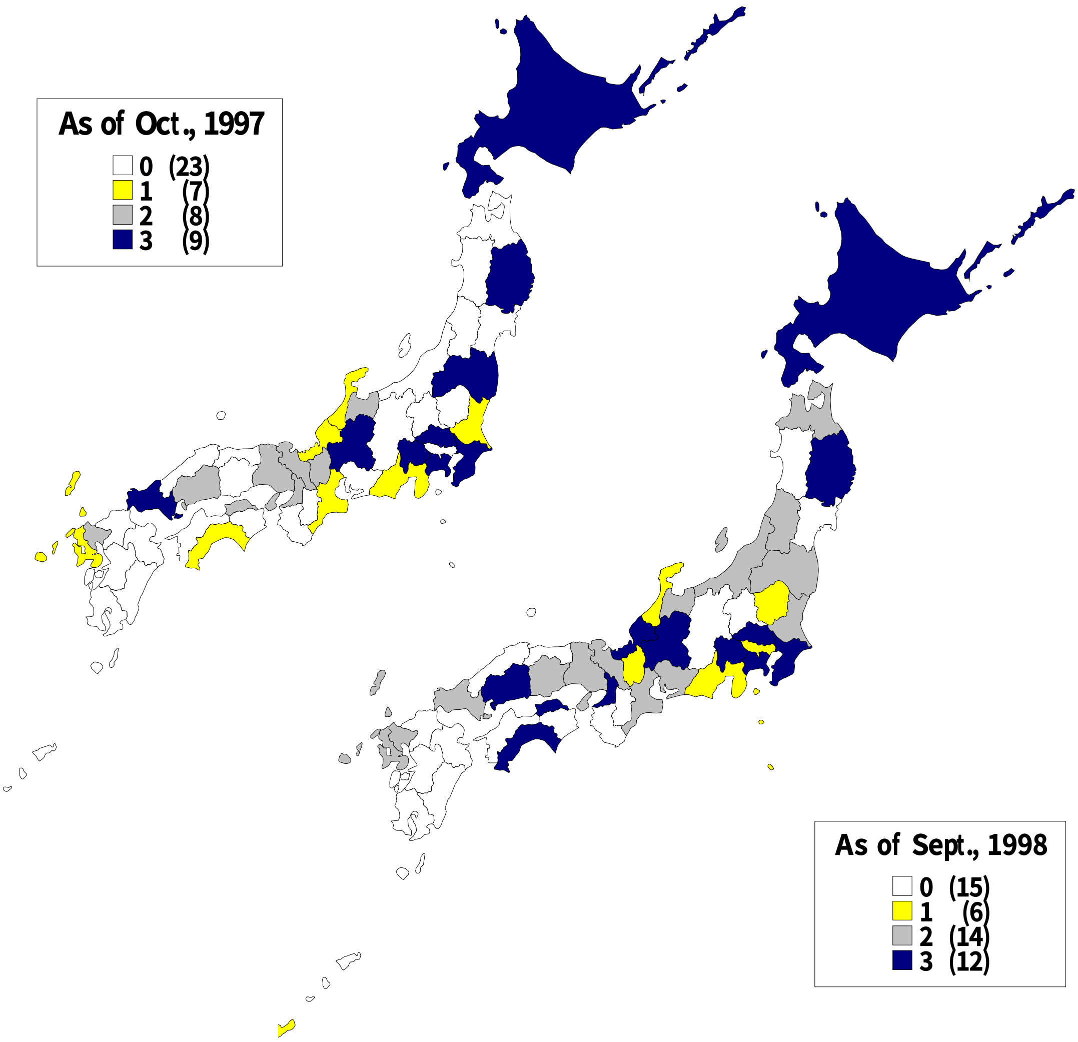
In this section, we describe the various indicators with regard to the promotional policies for science and technology in the 47 prefectures that are considered to have a significant influence on regional science and technology activities.

9.3.1 Provision of Comprehensive Regional Promotion Systems

The number of prefectures implementing the systems to drive policies promoting science and technology are increasing. The system activities in each prefecture are considered from the viewpoint of (1) the establishment of full-time positions, (2) the establishment of S&T council, etc., and (3) the drawing up of fundamental plans, etc., the implementation status of which are shown as indicators. The case in which all three systems above have been implemented is shown as a 3 in Figure 9-3-1, while the case in which only two systems have been implemented is shown as a 2, and so on.

According to this map, two-thirds of the prefectures had implemented at least one of the systems as of September 1998. Moreover, if we compare this to the situation as of October 1997, we can see that a considerable number of prefectures implemented some of the systems in this one-year period, which shows that these systems are making progress in the prefectures. However, the breakdown of the implementation of these systems shows that the number of prefectures having completed the establishment of full-time positions is limited to less than half of the 47 prefectures. Thus it appears as though the creation of systems to put the fundamental plans, and so on, into effect is being postponed. If it is conceivable that the implementation of these fundamental plans, and so on, make it possible to revitalize local industry and cope with the needs of prefectural residents, it is hoped that systems for the implementation of tangible measures, which are not limited to the establishment of full-time positions, will be promoted.

Figure 9-3-1 Development of a framework for comprehensive implementation



Notes: About all prefectures the number of matters took effect such as installation of one's full-time post, a council, etc. and a masterplan is illustrated. In addition, the corresponding number of organizations appears in parentheses.

Source: Science and Technology Agency, National Institute of Science and Technology Policy, "Study of Regional Science and Technology Promotion (Fourth Survey)" (NISTEP Report No.59), 1999.

See: appendix table 9-3-1

9.3.2 Regional Expenditures on Science and Technology

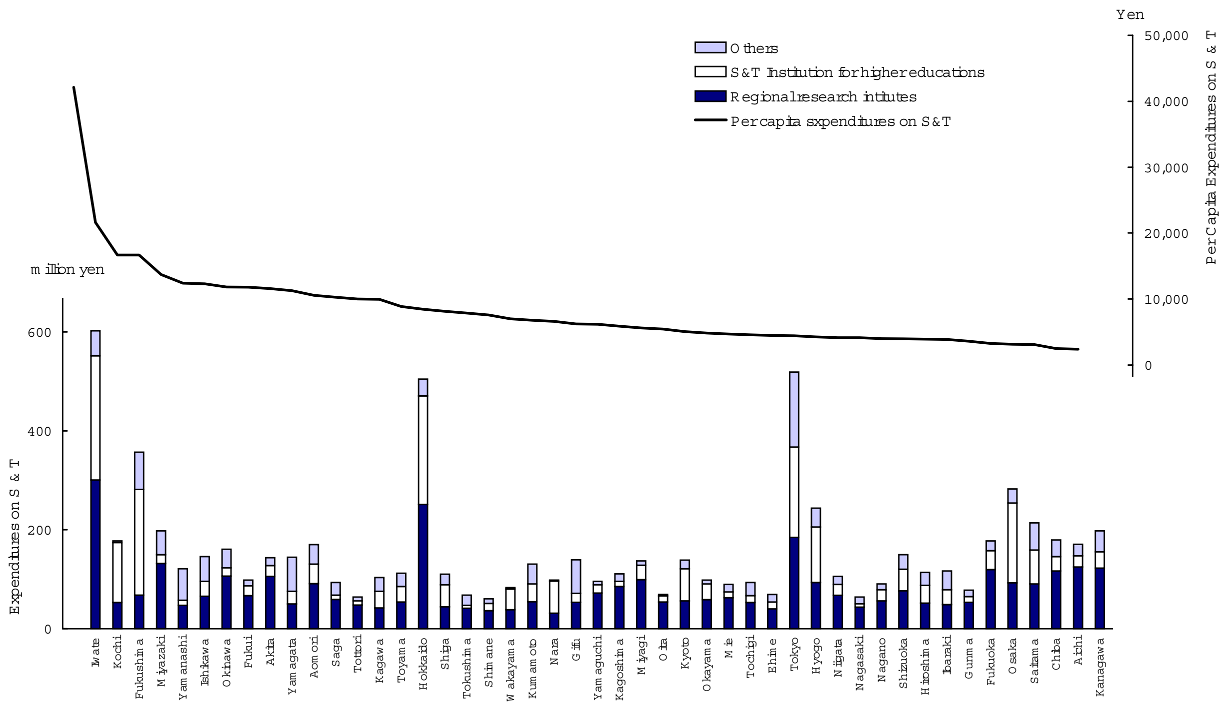
Here, we take up total expenditures made by prefectural governments to implement policies promoting science and technology (referred to as "science and technology expenditures" below) as indicators.

Figure 9-3-2 shows the science and technology expenditures for each of the 47 prefectural governments in FY1997. From this, it is evident that there are considerable disparities between prefectures not only in the total amounts for science and technology expenditures, but also in the total per capita amounts. Moreover, we can also see that the majority of science and technology expenditures by prefectural governments are comprised of expenditures related to regional research institutes and institutions of higher education in science and engineering.

It should be taken into consideration, however, that regional science and technology expenditures in a given fiscal year will increase sharply during the construction of large-scale facilities, and then fall sharply when the construction is complete. For example, in Figure 9-3-2, Iwate Prefecture had the highest per capita expenditures in FY1997 due to the construction of several large-scale facilities including the Iwate Prefectural University with a faculty of nursing and a faculty of software and information science, together with an agricultural technology center serving as a regional research institute. As a result, its science and technology expenditures were large relative to the other prefectures. There was also an increase in expenditures for Fukushima Prefecture in FY1997 due to the construction of the School of nursing of Fukushima Medical University.

Prefectures with large science and technology expenditures have several institutions of higher education in science and engineering, such as medical universities. These institutions fulfil a significant role in the promotion of science and technology in the regions in which they are located. In general, although the populous prefectures have a tendency to have small per capita expenditures, in the case of Hokkaido, the per capita expenditures are high. The reason for this is thought to be due to the many head offices and branch offices of agricultural experimental stations and fisheries experimental stations that are established in Hokkaido's extensive area, and to the operation of the Sapporo Medical University.

9-3-2 Expenditures on science and technology by prefecture (FY1997)



Source: The numerical value per people of a prefecture is calculated in the National Institute of Science and Technology Policy.
See: appendix table 9-3-2

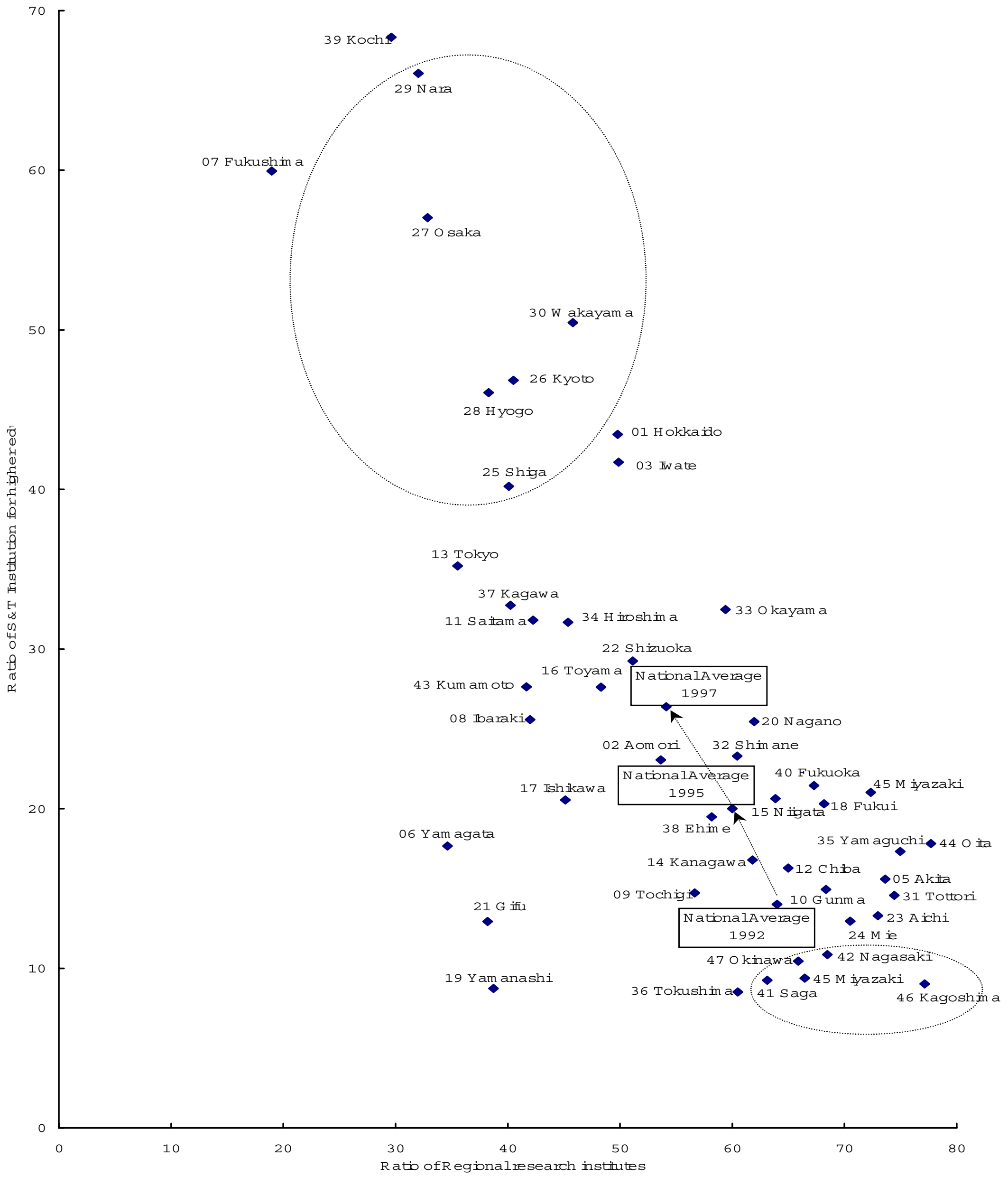
9.3.3 Regional Expenditures by Each Prefectural Government for Regional Research Institutes and Institutions of Higher Education in Science and Engineering

As stated above, the majority of science and technology expenditures by each prefectural government are accounted for by expenditures on regional research institutes and institutions of higher education in science and engineering. By examining the ratio of these two expenditures to the total science and technology expenditures, it is possible to get a grasp of the attributes of the policies for the promotion of science and technology in a particular prefecture. Based on this idea, indicators have been created that show the ratio of these two expenditures to the total science and technology expenditures. However, as mentioned previously, the construction of a large-scale facility, such as a institution of higher education in science and engineering, causes a rapid increase in a prefecture's expenditures in a given fiscal year, which leads to a temporary increase in this ratio, the impact of which must be taken into consideration.

Figure 9-3-3 (see the next page) shows the plot for the ratio accounted for by these two expenditures for each prefectural government in FY1997, along with the simple average of these ratios (referred to as the "national average") for every prefectural government in FY1992, FY1995 and FY1997.

According to this, the majority of prefectures in the Kinki Region are located in the upper-left of the graph, whereas the majority of the prefectures in the Kyushu Region are at the bottom-right of the graph. An examination of the prefectures located in the upper-left part of the graph shows that in FY1997 they had large expenditures for the construction of institutions of higher education in science and engineering, or for the operation of universities including medical faculties, science departments, technology departments, and so on. Furthermore, the national average is moving to the upper left. If we consider the amounts for science and technology expenditures from this perspective, it is evident that institutions of higher education in science and engineering account for a growing proportion of the science and technology promotional policies implemented by prefectural governments.

Figure 9-3-3 Ratio of regional research institutes and S&T institution for higher education (FY1997)



Notes: The numerical value of the national average is arithmetic average value of the numerical value of all prefectures, and is not weighted average value.

Source: Science and Technology Agency, National Institute of Science and Technology Policy, "Study of Regional Science and Technology Promotion (2nd survey)" NISTEP REPORT No.39, 1995, (3rd survey - NISTEP REPORT No.56), 1997 and (4th survey-NISTEP REPORT No.59), 1999.

See: appendix table 9-3-2, 9-3-3, 9-3-4

9.4 Achievements of Science and Technology Activities

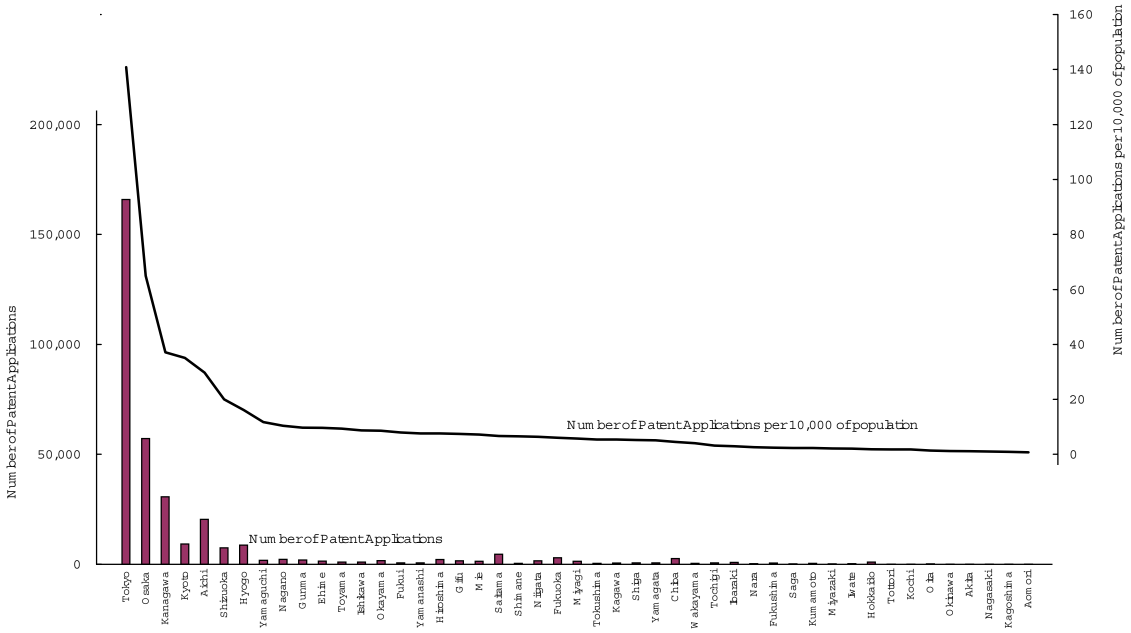
One of the ways of indicating the regional achievements of science and technology is by the number of patent applications. In this section, we discuss indicators of the number of patent applications for each prefecture.

9.4.1 Number of Patent Applications

The number of patent applications for the prefectures have been totaled according to the address of the applicant. However, the inventor and the applicant are not always the same, and many large corporations lodge applications from their head offices (often located in Tokyo or Osaka), which is not where the invention actually occurred. Thus the number of applications by prefecture does not directly indicate the regional achievements of science and technology, but it can be considered to reflect the achievements of science and technology activities or industrial activities to a certain degree.

Figure 9-4-1 shows the number of patent applications by prefecture per 10,000 people. There is a considerable bias toward Tokyo and Osaka, which account for over half of the total number of applications in the country. However, the reason given above must be taken into account. Even if we consider the numbers calculated per 10,000 people, there is no change in the large numbers for Tokyo and Osaka. The number per 10,000 people is high for Kyoto, which rivals prefectures with high absolute numbers, such as Kanagawa and Aichi. Thus, populous prefectures are not necessarily ranked highly when we consider the numbers calculated per 10,000 people.

Figure 9-4-1 Number of patent applications by prefecture (1996)



Source: Patent Agency, "Patent Agency Annual Report" (FY1996 edition)

All prefectures population is Statistics Bureau of the Management and Coordination Agency from the "Population Estimates Yearbook" to a total. The numerical value per 10,000 populations is calculated in the National Institute of Science and Technology Policy.

See: appendix table 9-4-1

9.5 Science and Technology Activities and Regional Economies

The science and technology activities of a region are closely linked with its economic activities. Consequently, we will discuss indicators that are closely linked with regional economic activities in this section.

9.5.1 Number of Venture Companies

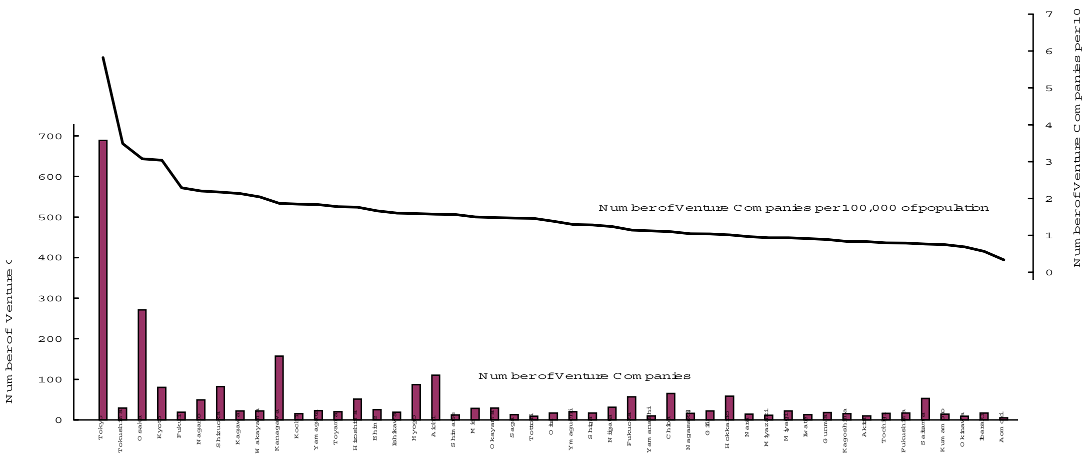
Venture companies are knowledge-intensive companies that are highly specialized and highly innovative.

Venture companies often apply the achievements of the latest R&D activities to industry, and since this tendency is considered to be closely related to the development of a region through science and technology, we will focus on the indicator for the number of venture companies in each region. However, due to the lack of comprehensiveness and continuity in the data, we have created an Indicator for the venture companies listed in the "Nikkei: Annual Corporation Reports of Venture Business" published by the Nihon Keizai Shimbun, in order to get a grasp on the number of venture companies. The criteria for being listed in this book are that a company has unique technology and know-how, has maintained a high growth rate for the past several years, is relatively young, or, if it is a company with a long history, it has recently converted to a new type of industry.

Figure 9-5-1 shows the number of venture companies for each prefecture, totaled according to the method above, along with the number per 100,000 people. A look at the number of companies per 100,000 people shows that in addition to Tokyo and Osaka, Tokushima, Kyoto, Fukui, Nagano and Shizuoka are ranked at the top.

If we consider the fact that among these, Kyoto and Shizuoka also ranked near the top for the number of patent applications per 100,000 people in Figure 9-4-1, and that Nagano and Fukui also ranked relatively highly, it is evident that science and technology activities in these prefectures are thriving.

Figure 9-5-1 Number of venture companies by prefecture (1998)



Source: It totals on the basis of Nihon Keizai Shimbun, "the Nikkei Venture Business Yearbook (version in the FY1999)". In addition, all prefectures population is Statistics Bureau of the Management and Coordination Agency from the "Annual Report on the Population Estimates" to a total. In addition, the numerical value per 100,000 populations is calculated in the National Institute of Science and Technology Policy.

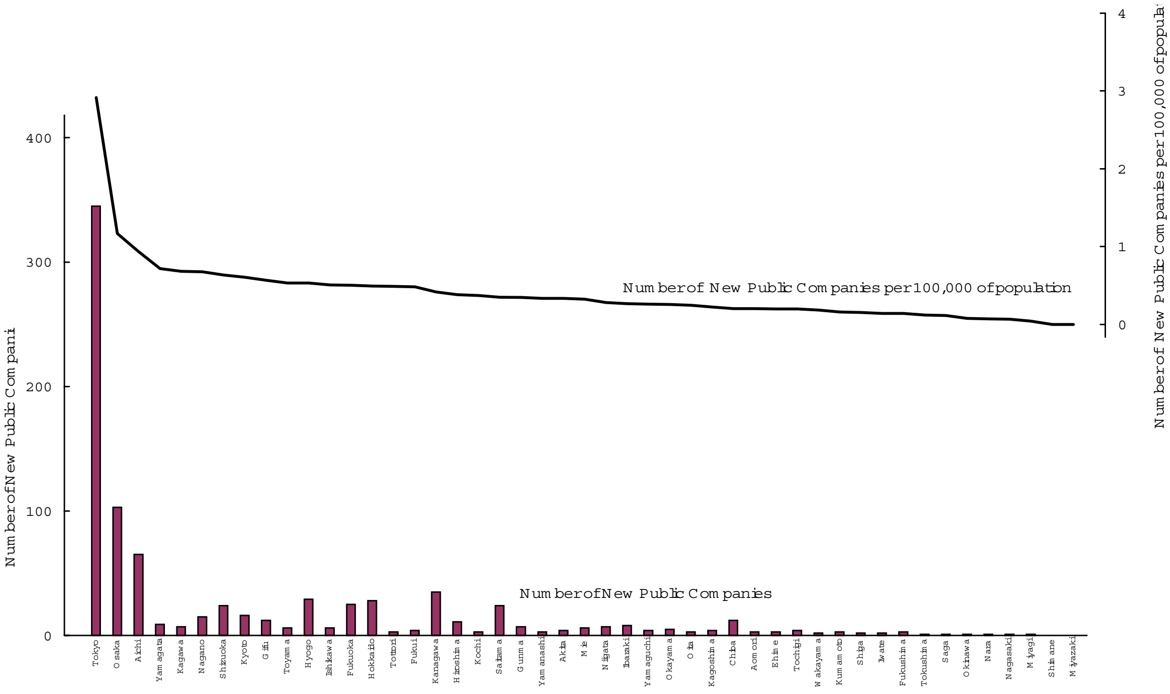
See: appendix table 9-5-1

9.5.2 Numbers of Companies with New Listings and Over-the-counter Issues

Those companies which have grown steadily may be listed on the stock exchange or issue over-the-counter shares in order to make it easier to raise funds as a means to further development. As a result, the growth and commencement of new companies in regions where R&D is thriving is considered to be linked to the listing of companies in many cases. Thus, we examine the number of companies with new listings and over-the-counter issues for each prefecture.

In Figure 9-5-2, the number of newly-listed companies or companies with over-the- counter issues within Japan for the six year period from 1993 to 1998 have been totaled by prefecture, based on the address of the head office. For the values calculated per 100,000 people, there are large numbers of companies for populous regions such as Tokyo, Osaka, and Aichi. Moreover, Kyoto, Shizuoka, Nagano and Toyama, ranked highly in the number of patent applications and in the number of venture companies per 100,000 people (see Figures 9-4-1 and 9-5-1 above), and in comparison to other prefectures, it is evident that the achievements of science and technology in these prefectures is tied to the creation of new companies.

Figure 9-5-2 Numbers of new public companies and over-the-counter issues by prefecture (1993 to 1998)



Source: It totals on the Basis of "Transition by New Public Company All Prefectures" (thing of as printing of April 1, 2000) in the homepage "A Daiwa Venture Land" of the Daiwa Securities creation. Each prefectures population is Statistics Bureau of the Management and Coordination Agency from the "Annual Report on the Population Estimates" to a total. In addition, the numerical value per 100,000 population is calculated in the National Institute of Science and Technology Policy.

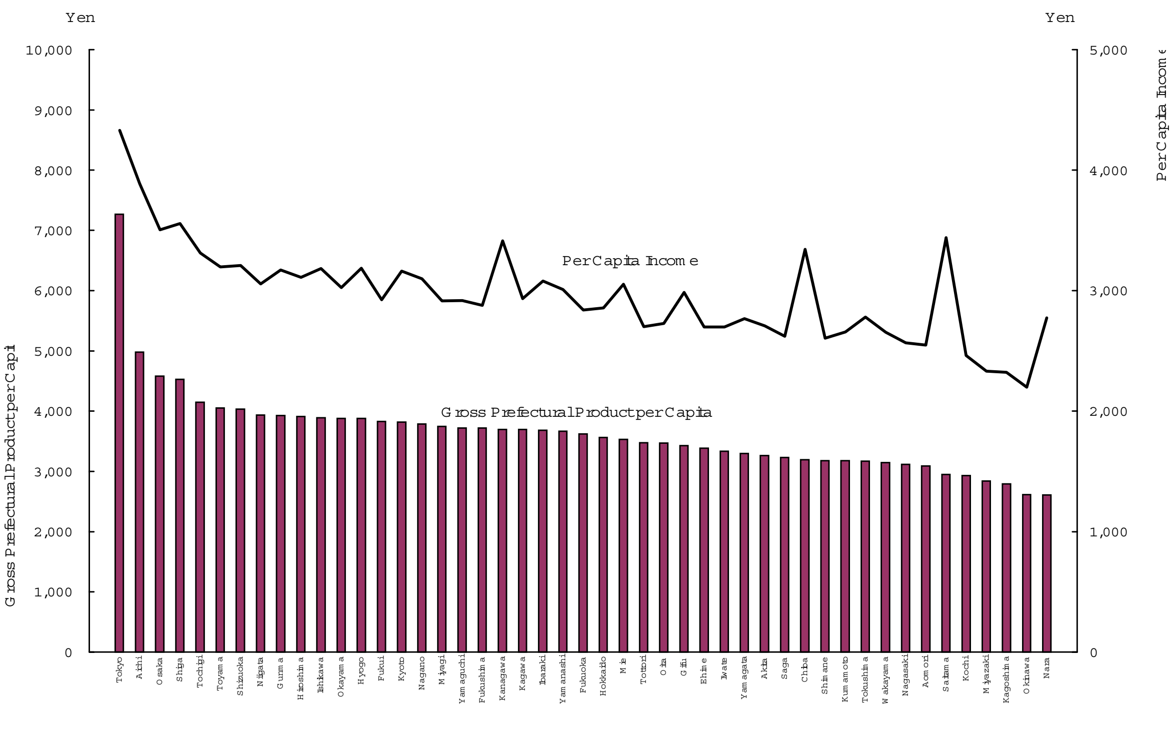
See: appendix table 9-5-2

9.5.3 Gross Prefectural Product and Prefectural Income Levels

Regional science and technology activities in any form are thought to be reflected in gross prefectural product and prefectural income levels, thus these two values are taken up as indicators in this section. The former represents the value which has been newly added by the production activities within a prefecture during a set period, and is based on the concept of "activities within the prefecture", which covers the economic activities that occur within a prefecture regardless of the residence of those taking part in them. The latter, on the other hand, is based on the idea of "activities by prefectural residents", which covers the economic activities of the residents of a prefecture, regardless of the location of those activities.

Figure 9-5-3 shows the per capita gross prefectural product and prefectural income. According to the figure, on a national scale, the incomes for prefectures surrounding Tokyo, such as Kanagawa and Chiba, are high relative to their gross prefectural product. This is thought to be due to the movement of wealth as a result of the residents of these prefectures working and collecting their incomes in Tokyo, with its high gross prefectural product.

Figure 9-5-3 Gross prefectural product per capita and per capita income by prefecture (FY1996)



Source: Economic Planning Agency, "Annual Report on Economic Calculations of Prefectural Residents".
See: appendix table 9-5-3

9.6 Stractural Change of regional industries

In this section, we consider changes in the industrial structure of each prefecture as seen from the numbers of workers.

Here, we use the data for the 15 year period from 1980 to 1994 for the number of workers in the manufacturing industries of each prefecture (from among 23 industrial categories) as represented by the industry edition of the industrial statistical tables, (compiled by the Ministry of International Trade and Industry), and analyze them according to the factor below.

(Note: the source of the method of calculation, chart and graphs below is the National Institute of Science and Technology Policy's Study on Spatial Mobility of Manufacturing Industry and Structural Change of Regional Industries in Japan, 1999 (NISTEP Report No.60).)

$$ICRIS \equiv \frac{1}{2} \times \sum_{r} \left| A_{ir}/A_i - A_{nr}/A_n \right|$$

A_{ir}: Type r of industry condition variable by prefecture i (number of workers)
A_i: All type of industry condition by prefecture i (number of workers)
A_{nr}: Type r of industry condition variable in nationally. (number of workers)
A_n: All type of industry condition variable in nationally (number of workers)

ICRIS (Index for Conversion of Regional Industrial Structure) indicates the extent of the deviation between the distribution of the industry condition variable (number of workers) nationally and in prefecture i, for manufacturing industries. That is, ICRIS represents the characteristics of the industrial structure of each prefecture relative to the industrial structure of the whole of Japan.

The ICRIS values have been calculated for each prefecture according to Equation 9-6-1. The smaller the value, the closer the component ratio of a prefecture's industrial structure - that is, its industry condition variable (number of workers) - is to the national average. The smallest value of 0 means that the industrial structure of a particular prefecture is consistent with the national average. The larger the ICRIS value, the greater the extent of deviation between the national average and the industrial structure of a given prefecture. Thus, if a prefecture has only one type of industry, this value will be close to one.

The vertical axis in Figure 9-6-1 represents the industry condition variable, while the horizontal axis represents the ICRIS value. These values are plotted for each year showing a time-series of movements that indicate the changes in the industrial structure of each prefecture.

Figure 9-6-1

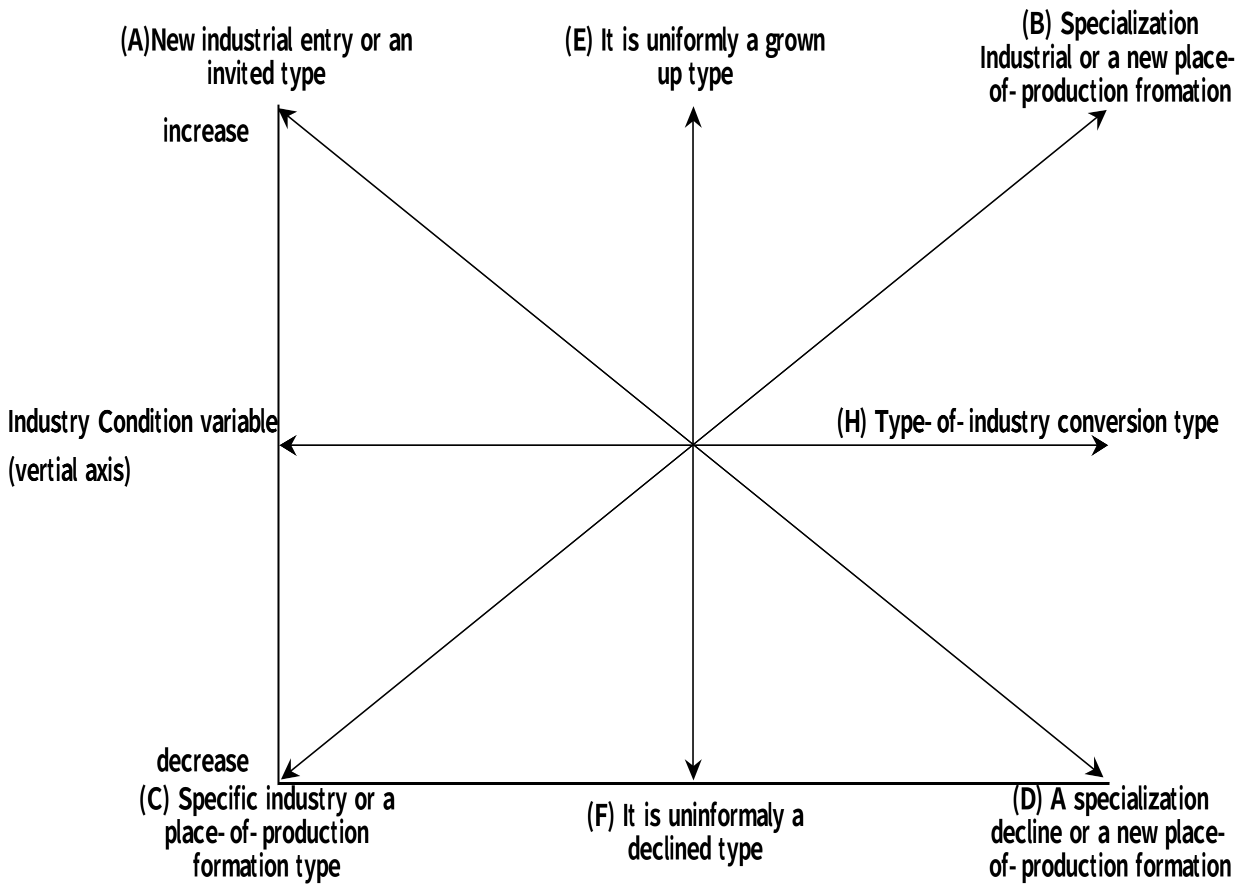

(A)New industrial entry or an invited type
(E) It is uniformly a grown up type
(B) Specialization Industrial or a new place-of-production fromation
increase
Industry Condition variable
(vertial axis)
(H) Type-of-industry conversion type
decrease
(C) Specific industry or a place-of-production formation type
(F) It is uninformaly a declined type
(D) A specialization decline or a new place-of-production formation

Figure 9-6-1 (A) indicates that the industrial structure of a given prefecture tends toward the average, with a rising industry condition variable, which suggests development and growth within the prefecture due to new industries entering or being lured in.

(B) indicates that the industrial structure of a given prefecture tends toward a dominant industry and growth. This means that the existing industries, with their high component ratios, are experiencing further growth, such that their component ratios will rise even further.

(C) indicates a downward tendency in the industry condition variable of a given prefecture, while the industrial structure is moving toward the average. The decrease in the component ratios of existing industries means that the component ratio for other industries is relatively high. As a result, the industrial structure is changing and moving toward the average of this country.

(D) is the opposite to this, and indicates that industries with a low component ratio in a given prefecture will decline further, while the component ratios of the industry condition variable for the existing industries will tend to become relatively high, thus leading to a decline in the industry condition variable.

(E) indicates a rising industry condition variable with a static industrial structure for a given prefecture, which means that all industries are growing evenly as the industry condition variable rises.

(F) is the converse to (E), and indicates the situation in which the industrial structure is unchanged while the industry condition variable falls.

(G) represents the case in which the existing industries decline at the same time new industries enter or are lured in. Although the industry condition variable for a particular prefecture does not fluctuate, the industry component ratio moves towards the average of this country as the industrial structure changes.

(H) represents the situation in which those industries with large component ratios increase further, at the same time as those industries with small component ratios fall. Thus, although the industry condition variable for a particular prefecture does not fluctuate, its industrial structure tends toward dominant industries.

Those prefectures with special characteristics with regard to the industrial structures described above are shown below.

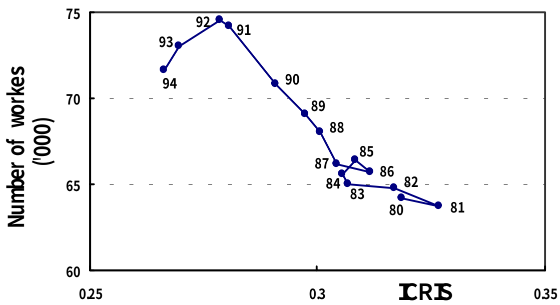
Tables and graphs showing the time series for the number of workers and the ICRIS values for all 47 prefectures can be found in the appendix to this chapter (see Table 9-6-1 and Figures 9-6-8-1 to 9-6-8-47).

(1) Regional Growth Due To Entry or Attraction of New Industries

As an example of this type of industrial structure, we will use Saga Prefecture. As shown in Figure 9-6-2, the number of workers in this prefecture grew remarkably until around 1991, while the ICRIS values consistently fell. This indicates that as the composition of the types of industries diversified, the industrial scale, represented by the number of workers, expanded as a whole.

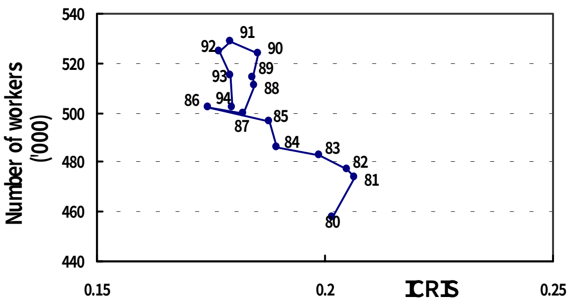
For a prefecture which displays this kind of an increasing industry condition variable and declining ICRIS values, we examine Shizuoka Prefecture below and so on.

Figure 9-6-2 Variance of number of workers by Saga prefecture



In the case of Shizuoka, the growth of the metalworking, electrical equipment or precision equipment industries replaced the traditional pulp and paper industry; thus, it seems that the change in the industrial structure was due more to the rise and decline of existing industries than to the entry of new industry (Figure 9-6-3).

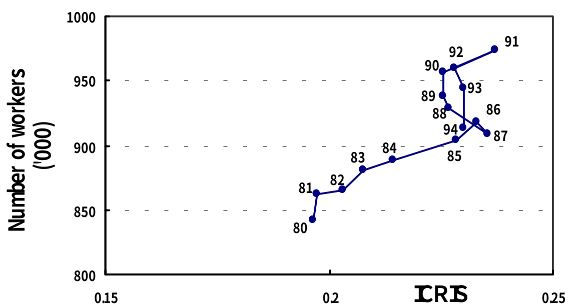
Figure 9-6-3 Variance of number of workers by Sizuoka prefecture



(2) Regions with Dominant Industries or New Production Centers

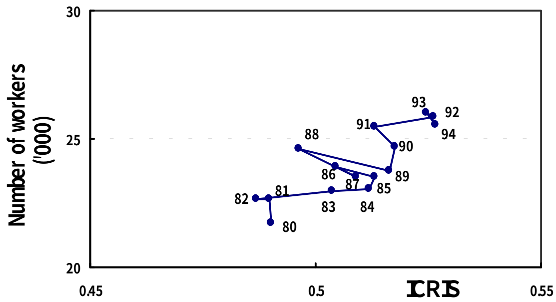
Aichi Prefecture is discussed as a region typical of this type of structure. The dominant industry in Aichi Prefecture is the transportation equipment manufacturing industry, which is at the center of the automobile industry. The number of workers in this industry has been maintained at a component ratio of over 20% in the prefecture over a 15 year period (Figure 9-6-4).

Figure 9-6-4 Variance of number of workers by Aichi prefecture



Also, in Okinawa Prefecture, as the number of workers in the dominant industries of food processing and ceramics increased, the component ratios increased (Figure 9-6-5).

Figure 9-6-5 Variance of number of workers by Okinawa prefecture

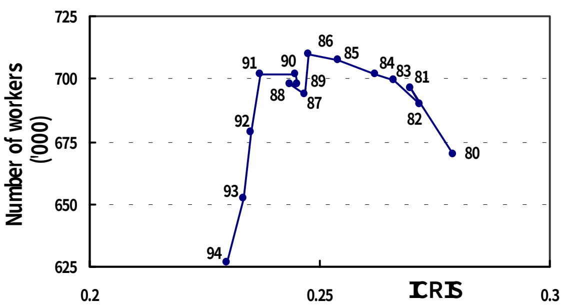


The growth in the number of workers in both prefectures indicates a situation in which the industrial base was strengthened due to a further strengthening of the traditional dominant industries.

(3) Regions with Dominant Industries or Declining Production Centers

Kanagawa Prefecture is discussed as an example of this type of region. At one time, the electrical equipment and transportation equipment industries accounted for over 40% of the total number of workers in the prefecture. However, due to an increase in the number of workers in other industries in the 1980s, the ratio of workers in these two industries fell (i.e. the ICRIS values fell). After 1991, the number of workers in Kanagawa suddenly declined, largely due to a decline in the number of workers in the electrical equipment and transportation equipment industries. The decline in both the ICRIS values and the number of workers after 1991 in the graph for Kanagawa is a graphical representation of the decline of both industries in the prefecture.

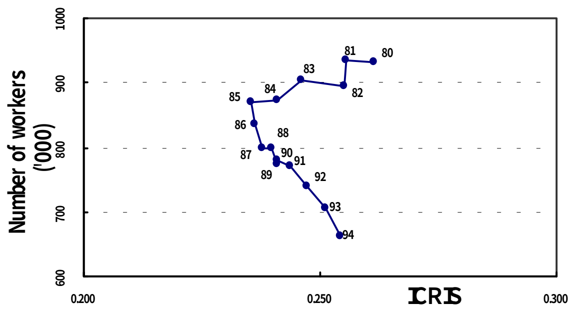
Figure 9-6-6 Variance of number of workers by Kanagawa prefecture



(4) Declines in Dominant Industries and New Production Centers in a Region

In this example, we look at the number of workers in Tokyo. From around 1985, there was a significant decline in the number of workers in the electrical equipment and general machinery manufacturing industries, which were the main industries up to that time in Tokyo. However, the extent of the decline in the main industry of publishing and printing was small, leading to a rise in the industry's position (Figure 9-6-7).

Figure 9-6-7 Variance of number of workers by Tokyo



Although the number of workers have been assesses in this instance, by carrying out an assessment of other industry condition variables (number of business locations, volume of products shipped, amount of value added production) there are also prefectures for which differences in the characteristics of the industrial structure are becoming evident.

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