Science and Technology Indicators

- A Systematic Analysis of Science and Technology Activities in Japan -

(NISTEP Report No. 37)

Science and Technology Indicator Project Team

1.1 Current State of Research and Development Activities

(1)Funding for R&D in Japan in fiscal 1993 amounted to 13.7091 trillion yen, 1.4% down on the previous year. This was the first time that R&D funding had fallen in thirty years, and something largely influenced by the continued reduction from the prior year in R&D funding (5.3% down on the previous year) in the private sector.

(2)Japan's R&D expenditure has increased approximately eight-fold over the past twenty years, the largest rate of increase of any advanced nation including the United States, Germany, France and England (Figure 1-1-1). In Figure 1-1-1, the "R&D purchasing power parity" was used instead of the usual "GDP purchasing power parity" in making the currency conversions necessary for international comparison of R&D expenditure.

(3)International comparison of the ratio of R&D expenditure to gross national product (GNP) shows that Japan has had the world's highest ratio since 1989. After reaching 3.0% in 1990 and 1991, however, the rate fell for two consecutive years to 2.96% in 1992 and 2.9% in 1993.

(4)Comparison of the R&D expenditure of different countries classified into defense-related and public-related R&D shows that Japan's defense-related R&D expenditure is extremely low, while the United States in characterized by its high level of expenditure in this area. Germany's proportion of defense-related R&D expenditure is low in comparison with England and France.

(5)Looking at R&D expenditure by sector (industry, academia and government), we see that the Japanese government provides less than 20% of funding, which is low particularly when compared to the major European and American countries (Figure 1-1-2). The industrial sector uses 70% of overall R&D expenditure. As far as the flow of R&D funds between sectors, in Japan there is very little which passes from the government to industry, with most of the R&D funding used in the industrial sector sourced by that sector itself. In the United States, on the other hand, there is a strong flow from government to industry.
Figure 1-1-1 Trends in R&D expenditure in major countries (calculated with the R&D PPP)
Note:Japan's R&D expenditure is studied by fiscal year, but has been represented as "year" to allow international comparison.
Materials:Management and Coordination Agency's "Report on the Survey of Research and Development" (Japan), other, material from each country.
Reference: Figure 4-1-1
Figure 1-1-2 Proportion of R&D expenditure borne by and used by each sector in major countries
Material: As per Figure 1-1-1
Reference: Figure 4-1-6

(6)For the past ten years, the proportion of R&D expenditure represented by basic research expenditure in Japan has been 13 - 14%, a low level when compared with other major nations (Figure 1-1-3). For the United States that proportion is about the same, or slightly higher, while it is somewhat higher in Germany and France at around 20%.
Figure 1-1-3 Trends in composition ratios according to the nature of the R&D expenditure in major nations
Note:Applied research and development are not differentiated in the case of Germany. No data for England.
Material:As per Figure 1-1-1.
Reference: Figure 4-1-9

(7)Researchers in Japan in 1994 numbered 642,400, an increase over the past twenty years of some 300,000 (Figure 1-1-4). The proportion of researchers in by sector is 60 - 80% in the industrial sector for advanced nations including Japan, with the rise in the number of researchers in all nations over the past twenty years largely attributable to the increase in researchers in the industrial field.
Figure 1-1-4 Trends in the number of researchers in major nations.
Note: FTE conversion has not been done for Japanese researcher figures.
Materials: As per Figure 1-1-1
Reference: Figure 4-1-11

(from Chapter 4, Part 4.1)

1.2 Development of Science and Technology Human Resources in School Education

Basic environment for developing human resources.

(1)An international comparison of mathematics and science education in primary, junior high, and high schools shows that Japanese students record the high performances in the world in these areas. Performances in science, however, gradually weaken in world rankings in the transition from primary and junior high to high school.

(2)A particularly strong characteristic in Japan is the waning of interest in science as students progress from primary to junior high to high school (Figure 1-2-1).

(3)In comparison with the Europe and the United States, the environment for science education in Japan shows a high number of students per teacher, and a low ratio of experimental observation. Japanese high school science teachers have not received many years of higher level education and the proportion of female teachers is low.
Figure 1-2-1 Level of interest in science (primary, junior high and high school)
Note:The closer to 1 the numerical value of interest the higher the level of interest (enjoyable), the closer to -1 the lower the level interest (not enjoyable), and 0 indicates neither enjoyable nor not enjoyable.
Materials:Created from the 1993 ??"International Comparison of Science Education"?? by the National Institute for Educational Research and originals.
Reference: Figure 2-1-1

Senior High School

(1)There has been a state of saturation from 1980 when the rate of advancement from junior high to senior high school reached 92%. The number of students in regular subjects in high schools has burgeoned in recent years with the increase in people wishing to attend university, while there is a downward trend in student numbers in technical subjects. The number of students is rising in information related subjects in the technical and commercial subjects.

(2)Of high school graduates finding employment in major industries, the proportion finding work in the manufacturing industry reached its peak in the mid-80's, after which there were repeated decreases and increases, with a slight fall seen in the last two years. The proportion finding work in the service industry is on a long-term upward trend. Meanwhile, fewer and fewer graduates are finding work in the finance and insurance industry.

(3)While there has been a upsurge in university applicants wanting to enter economics departments (including those with several preferences), an increase has also been seen in overall applicants to science and engineering departments, with entry competition increasing correspondingly. The recent economic downturn has caused a reduction of multiple applications as a part of total applications, with the effects of this also reflected in the total number of applications to science and engineering departments and entry competition. Although there is said to be a "drifting away from science and engineering", the entry competition for science and engineering departments has not particularly fallen over the long term in comparison with the average for all departments (Figure 1-2-2).

Figure 1-2-2 Trends in entry competition for main university departments
Materials: Ministry of Education's ?? "Report on the Basic Study on Schools"??
Reference: Figure 2-2-6

University Departments, Junior Colleges and Technical Colleges

(1)Entrants into university science and engineering departments started to increase from the mid-80's after the plateau experienced once staff numbers were achieved in line with the "income doubling plan" of the 1960's. The increase in female students was particularly remarkable. By subject, the entry quota for information-related subjects is increasing.

(2)Although the highest proportion of graduates from university science and engineering departments find work in the manufacturing industry, this has declined in recent years. Recently, the long-term increase evident from the mid-70's in information-related and other service areas has leveled off (Figure 1-2-3). There is a low proportion for the finance and insurance industry, which has declined since the 90's despite increasing for a time in the last half of the 80's.

(3)An increase in entrants in information specialist subjects has been seen in junior colleges and technical colleges recently. While the number of graduates of junior college engineering departments and technical colleges finding employment in the manufacturing industry has remained unchanged, or decreasing slightly over the long term, there has been a large, long-term increase in the ratio finding work in the service industry, such as information-related areas. Although few people go into the finance and insurance field, there is a slight upward trend.
Figure 1-2-3 Trends in the proportion of science and engineering department graduates in major industry fields.
Materials: Ministry of Education's ??"Report on the Basic Study on Schools"??
Reference: Figure 2-4-5

Post-graduate Masters and Doctoral Degrees

(1)There is an increase in people going on to masters studies in science and engineering (Figure 1-2-4). Although there was a downturn in people undertaking doctoral degrees from the early 70's, there have been signs recently that this is picking up. The number of holders of doctorates in science and engineering per capita is low when compared with the United States.

(2)The proportion of holders of masters degrees in science or engineering finding employment in the manufacturing industry in recent times has remained steady at 70%. The ratio finding work in information-related and other service industries continues to rise steadily. Few join the finance and insurance industry, which showed an increase in the mid-80's only to decline again once in the '90's.

(3)The ratio of doctorate holders gaining employment in the manufacturing industry has risen in recent times, as has the proportion going into information-related and other service industries, although the number remains small.
Figure 1-2-4 Trends in advancement to post-graduate studies in engineering.
Materials: Ministry of Education's ?? "Report on the Basic Study on Schools"??
Reference: Figure 2-5-4 (refer to Figure 2-5-3 for post-graduate science)

(from Chapter 2)

1.3 Support for Science and Technology from Society

Government Support

(1)In fiscal 1994 the Japanese government provided a budget for science and technology of 2.3585 trillion yen, which accounts for 3.2% of general funds. The science and technology budget has been steadily increasing in recent years, showing a large rate of increase in comparison with the governments' general expenditure budget.

(2) Looking at the ratio of government science and technology budget to GNP in major countries, Japan's is about half that of the United States, France and England (Figure 1-3-1). Arguably, Japan's science and technology budget is small vis-a-vis the scale of the economy.

(3) A breakdown by ministry and agency of the science and technology budget in Japan shows that almost half goes to the Ministry of Education, with half of that given to the Science and Technology Agency, and half of that again to the Ministry of International Trade and Industry. Of the funding received by the Ministry of Education, nearly 80% is assigned to national universities.

(4) Comparison of the content of science and technology budget of major nations was made using the OECD's "socio-economic factor classifications", with Japan characterized by the extremely high proportion represented by "general increase of knowledge" (assistance to university research and other non-classified research), and the fact that the "energy" field receives the next highest level of funding (Figure 1-3-2). "Defense' accounts for the largest proportion in the United States, France and England. Like Japan, Germany assigns a large proportion to "general increase of knowledge".
Figure 1-3-1 Trends in the ratio of science and technology budget to GNP in major countries
Materials: Science and Technology Agency's ?? "Outline of Science and Technology"??
Reference: Figure 3-1-7
Figure 1-3-2 Composition by socio-economic objective of science and technology budgets in Japan and the United States
Note: Science and technology budgets for fiscal 1993 (Japan) and fiscal 1990 (United State)
Material: from Science and Technology Agency
Reference: Figure 3-1-8, Figure 3-1-9

Assistance from Society

(1) In fiscal 1993, the science and technology related foundations, which function to supplement assistance from the government and other public bodies and whose main task is supporting research, had a total business expenditure of 46 billion yen, of which 10.9 billion yen was for research support funding (Figure 1-3-3). Although this sum is certainly not large given the scale of research and development across the country in Japan, it holds an important position as a source of funds for basic research.

(2)The number of academic societies in Japan stood at 1331 in 1992. Those relating to medicine and the humanities account for half of them, followed in order by those for engineering, science and agriculture. Medical societies overwhelmingly have the most individual members.
Figure 1-3-3 Trends in the number of research support foundations and scale of projects
Note: As data is unavailable for some years, only years for which clear data is available are given.
Material: Collated based on material from the ??Support Foundation Information Center??
Reference: Figure 3-2-1

(from Chapter 3)

1.4 Research and Development Activities by Industry, Academia and the Government

Industrial Research and Development

(1)Despite a steady rise in R&D expenditure in Japan's industrial sector, the figure for fiscal 1992 was down by 1.9% on the previous year, the first time a decline was seen since R&D statistics started being kept in 1953. Spending fell considerably in fiscal 1993 by 5.3%, but as the ratio of R&D expenditure to turnover was 2.83% and was 2.76% for fiscal 1992, this was not such a large drop.

(2)By sector, "electrical machinery manufacturing" has accounted for the highest proportion of R&D expenditure in recent years. This is followed by "chemical products manufacturing" and "transportation equipment manufacturing", with these three top industries representing some two thirds (F1993) of the entire industrial R&D expenditure (Figure 1-4-1).

(3)Classifying R&D expenditure in the industrial sector into products shows that the most funding goes to "communications, electronics and electrical meters", followed by "automobiles" and "electric machinery and equipment".
Figure 1-4-1 Trends in industrial R&D expenditure in Japan
Material: Management and Coordination Agency's "Report on the Survey of Research and Development"
Reference: Figure 4-2-1

(4)There has been an industry-wide increase in the number of researchers in the industrial sector over the past twenty years, none more so marked as in "electrical machinery manufacturing.

(5)R&D expenditure by turnover and by the number of researchers per employee were used as indicators of the degree of research intensity, which shows the level of R&D expenditure and personnel numbers assigned. According to these, the growth in the degree of research intensity for R&D expenditure in the manufacturing industry continues, despite slowing somewhat in the last half of the 1980's, and there is also steady growth in the level of research intensity in researcher numbers. The characteristics of each type of industry are also shown with the level of research intensity by industry type (Figure 1-4-2).
Figure 1-4-2 Level of research intensity by industry type (fiscal 1993)
Material: Management and Coordination Agency's "Report on the Survey of Research and Development"
Reference: Figure 4-2-10

Research and Development in Universities

(1)Recent years have seen private universities outstrip national universities in terms of R&D expenditure (Figure 1-4-3). Trends for the past twenty years also show higher growth in private universities than national and public universities. High growth is seen in the science areas.

(2)There are steadily rising trends in the number of researchers in universities, with slightly more in private universities than national universities. By discipline, the ratio of researchers in natural sciences to those in humanities and social sciences has become around 2 to 1 in recent years. Of the natural sciences, the largest number of researchers are found in the health field.

(3)R&D expenditure per researcher in universities is highest in private universities, with a high rate of growth that also exceeds that in national and public universities. Much goes to science and engineering in the natural sciences area, while it is low in the area of health.
Figure 1-4-3 Trends in R&D expenditure in Japanese universities
Material: Management and Coordination Agency's "Report on the Survey of Research and Development"
Reference: Figure 4-3-1

Research and Development by Research Institutes

(1)Although the proportion of R&D expenditure nationwide represented by national, public, private and special foundation research institutes in 1993 was only a small 13.8%, this has been increasing over the past few years. Breaking it down, the highest expenditure is seen in private research institutes (Figure 1-4-4). The phenomenal growth in R&D expenditure seen in private research institutes in the last half of the 1980's has now slowed down. In the meantime, there has been a marked increase in R&D expenditure in national institutes these past two years.

(2)In comparison to the industrial sector and universities, there has been little growth in the number of researchers in research institutes as a whole. The number of researchers in national institutes in particular remains unchanged. The largest growth in researcher numbers among research institutes is at private research institutes.

(3)Special foundations provide the largest amount of R&D funds per researcher of the research institutes. This is due to the move to large-scale research and development in these special foundation research institutes.
Figure 1-4-4 Trends in R&D expenditure in research institutes in Japan
Material: Management and Coordination Agency's "Report on the Survey of Research and Development"
Reference: Figure 4-4-1

(from Chapter 4, Part 4.2 - 4.4)

1.5 The Results of Research and Development

Theses

(1)The United States publishes the most papers on science and engineering of any nation, with Japan occupying second position after overtaking England in 1992 (Figure 1-5-1). Of al the countries, the rise in publications by Japan is particularly astonishing.

(2)Papers from the United States are also most often cited, exercising considerable influence as they account for approximately half worldwide. Although Japan is in third place in absolute terms for citations, the number of citations per paper is below the average world level.

(3)Japan's share of papers by field shows a considerable share in "pharmacology" and "material science", while figures are low for "earth science" and "ecology and the environment". Particularly obvious is the large share represented by the United States in "computer science" and the small share of Japan in the same field.
Figure 1-5-1 Trends in number of science and technology papers published by country
Material: Collated based on the "Science Citation Index Database".
Reference: Figure 5-1-1

(4)Citations from Japanese papers on "material science", "agriculture", and "astrophysics" exceed the world average, followed by the fields of "physics" and "chemistry" (Figure 1-5-2). On the other hand, fields from which few citations are taken include "ecology and the environment" and "computer science".
Figure 1-5-2 Level of citations from Japanese papers by field (average from 1990 - 1992)
Material: Collated based on the "Science Citation Index Database".
Reference: Figure 5-1-4

Patents

(1)Although there was a dramatic increase in the number of patent applications in Japan from the 1980's, the number of registered patents has not increased to the same degree (Figure 1-5-3). This is perhaps due to the fierce competition among Japanese industry for applications, and the inability of patent inspectors to cope with the massive increase in applications.

(2)The top three fields for patent applications in Japan in 1991 were "basic electronic components", "electrical communication technology" and "computing and factors".

(3)Most applications for foreign patents of Japanese inventions are made in the United States, followed by Germany and England (1992). In recent years the proportion of the total of overseas applications made to the United States and Germany has declined, while numbers have increased to Italy and other European nations, and Korea.
Figure 1-5-3 Trends in patent numbers in Japan
Material: "Patent Office Annual Report", Patent Office
Reference: Figure 5-2-1

(4)Of registered patents in the United States, Japan holds largest share of any foreign country, and continues to increase its share (Figure 1-5-4). Japan's share in1992 was 23% to America's 54%.

(5)There is a very high level of citation from Japanese patents of those registered in the United States, a trend which is rising (Figure 1-5-5).

(6)Japan's internal patent numbers are slightly higher than those of the United States to be the highest in the world. Japan is in third position behind the United States and Germany, however, in terms of external patents. Trends in patent numbers in Japan indicate a plateau in internal patent numbers, and an increase in external patent numbers.
Figure 1-5-4 Registered Patents in the United States: Share by Country
Material: CHI Research Inc., "International Technology Indicators Database"
Reference: Figure 5-2-7

Figure 1-5-5 Trends in level of citations from major nations in relation to American patents
Material: CHI Research Inc., "International Technology Indicators Database"
Reference: Figure 5-2-8

(from Chapter 5)

1.6 Science and Technology's Contribution to Society

Contribution to Economic Growth
Although Japan has a low level of value-added labor productivity when compared to the United States, Germany and France, it is rising at a faster pace than other nations (Figure 1-6-1). Since 1960, Japan's value for ?? productivity of all requisites?? has been at the highest level of any OECD nation, showing a large rate of increase.

Figure 1-6-1 Trends in value-added labor productivity factors in major nations
Note: Data is shown as a factor of real GDP over labor force. Currency conversions are based on the purchasing power parity of 1985 prices.
Material: OECD "National Accounts" and "Labor Force Statistics".
Japan Productivity Center, ?? "International Comparison of Labor Productivity"??, 1992
Reference: Figure 6-1-1

Contribution to Preservation of the Global Environment

(1)The effect of desulfurization and denitration equipment in Japan has been a significant improvement in the levels of atmospheric sulfur dioxide concentrations, and emissions for primary energy are now the lowest in the world. As far as nitrogen dioxide is concerned, although Japan has the lowest emission volumes for primary energy in the world, atmospheric concentrations have not fallen due to the increase in traffic volume and other factors (Figure 1-6-2).

(2)Almost 90% of carbon dioxide emissions are due to the consumption of fossil fuels. Japan's emission per primary energy are gradually declining and, although higher than in France and Canada, are at the lower end of the world scale (figure 1-6-3).

(3)In Japan, 39% of industrial waste generated by the manufacturing industry is recycled (fiscal 1991). Only 5% of household, office and other general waste is recycled or used as another resource.
Figure 1-6-2 Basic units for SOx and NOx emissions
Material: OECD, "Environmental Data, Compendium 1991"
Reference: Figure 6-2-8
Figure 1-6-3 CO_2 emissions per primary energy and the proportion of primary energy represented by nuclear power and hydropower
Note: Due to material restrictions, pre-1988 figures for China were calculated with TPER ratios.
Material: OECD, "Energy Balances of OECD Countries", and "World Energy Statistics and Balances".
Reference: Figure 6-2-11

Improvements in Medicine and Welfare

(1)In recent years, 30-40 new pharmaceuticals have been approved each year. In the 1980's the number of overseas-developed pharmaceuticals exceeded domestically-developed products, but in 1991 and 1992 these positions were reversed. There have also been advances in the development of pharmaceuticals which apply biotechnology recently.

(2)Dissemination rates for medical equipment show remarkable growth in full-body CTs in the area of diagnostic equipment, and a steady rise in super high-frequency equipment for image diagnostics such as magnetic resonance image (MRI) machines (Figure 1-6-4). Although the rate of dissemination for treatment equipment is lower than that for diagnostic equipment, this is also increasing at a steady pace.

(3)Under the ??highly advanced medical system?? of the Health Insurance Act, there have been increases in both the number of medical technologies that have been recognized as being highly advanced medicine, and in the number of hospitals using such technology.
Figure 1-6-4 Dissemination of main medical equipment in general hospitals (diagnostic medical equipment)
Note:1981, 1984 and 1987 figures for upper digestive tract fiberscopes are figures for gastric fiberscopes. The 1981 figure for super high-frequency devices for image diagnosis are figures for super high-frequency diagnostic devices.
Material: Ministry of Health and Welfare, ?? "Survey of Medical Facilities"??
Reference: Figure 6-3-3

(4)Trends in the mortality rates of the three major adult diseases show a continued decline in stroke mortality rates, and increases in the mortality rates for heart disease and cancer. The prevention of hypertension and advances in emergency medical systems are believed to have contributed to the declining mortality rate from stroke. In relation to cancer, although there is an increase in the per capita mortality rate due to such factors as the increased average life expectancy, improvement is evident in treatment results (Figure 1-6-5). This is likely due to advances in such areas as including diagnostic technology, surgical techniques, chemotherapy and combined treatments.

(5)Turning to welfare equipment, the production of wheelchairs has almost continuously increased since the early 1980's, and production of nursing beds leapt from 1982 to 1989, although trends have been flat since 1989 due to capacity being reached in terms of hospital numbers and bed numbers.
Figure 1-6-5 Trends in the 5-year survival rate in cancer patients (males hospitalized for the first time in the National Cancer Center)
Material: Compiled from National Cancer Center materials
Reference: Figure 6-3-7

(from Chapter 6)

1.7 Society's Perception of Science and Technology

The Japanese People's Perception of Science and Technology

(1)According to public opinion polls about science and technology, the Japanese generally rate Japanese science and technology as being at a high level.

(2)Interest in news and topics about science and technology is waning, particularly among those in their 20's (Figure 1-7-1). This is one face of the phenomenon known as "the drift away from science and technology by young people".

(3)By science and technology topic, there is a high level of interest in lifestyle-related areas including "energy issues", "environmental issues" and "issues relating to new medical technology", while little interest is shown for "new scientific discoveries", "space exploration" and other topics not closely related to daily life (by age group).
Figure 1-7-1 Ratio of respondents expressing an interest in "news and topics about science and technology"

Material: NISTEP's ?? "Comparative Research on Society's Perceptions of Science and Technology in Japan, the United States and Europe"??, 1992; ??Prime Minister's Secretariat, "Public Opinion Poll about Science and Technology and Society".??

Reference: Figure 7-2-6

(4)In terms of access to science and technology information, while the majority of Japanese are aware of the importance that science and technology has in daily life, they believe there is insufficient provision of information and opportunity to learn about it. Many people said they obtained science and technology information from "television news" and "newspaper articles" (Figure 1-7-2).

(5)There is a large disparity between men and women regarding interest in science and technology and where they obtain information. In general, women have less interest than men in science and technology-related news and topics, and a difference in knowledge of science and technology is evident between the genders.
Figure 1-7-2 Sources of information about science and technology (multiple answers)
Material: NISTEP's ?? "Comparative Research on Society's Perceptions of Science and Technology in Japan, the United States and Europe"??, 1992; ??Prime Minister's Secretariat, "Public Opinion Poll about Science and Technology and Society".??

Reference: Figure 7-2-8

(6)Level of recognition of science and technology terms is low for words in acronym form, such as "DNA". There is a higher degree of understanding among men, young people, highly educated people and those who enjoyed science in primary and junior high school.

(7)Although Japanese express a high level of trust in scientists and science and technology, they are not necessarily in favor of the effects of science and technology, emphasizing harmony between society and science and technology.

International Comparison of Perceptions of Science and Technology

(1) Comparison of the results of surveys conducted in Japan and the United States regarding people's interest in science and technology reveals that Americans have a higher level of interest in science and technology and are very accepting of it. There was also little difference in responses according to gender in the United States.

(2) Comparison of the results of surveys conducted in Japan, the United States, the European Union and China about level of understanding of science and technology knowledge showed that the percentage of correct answers from Japanese was in the upper range. The rate of correct answers was generally high in the EU, the influence of the religious view of nature evident in the United States, and a lag in the dissemination of knowledge about science and technology seen in China (Figure 1-7-4).

(3) Responses to the advantages and disadvantages of science and technology revealed a strong emphasis on the "advantages" in the United States, in contrast to less positive assessments seen in Japan and France. In Japan and France there are perceptions of lessening "advantages" and increasing views that "there is little difference", but in all three countries there were few negative opinions (Figure 1-7-3).
Figure 1-7-3 Level of understanding of scientific knowledge
Material:Prime Minister's Office, "Public Opinion Poll about Science and Technology and Society"; other material from various countries
Reference: Figure 7-3-7
Figure 1-7-4 Opinions about the advantages and disadvantages of science and technology (international comparison)
Reference: Japan - NISTEP, ?? "Comparative Research on Society's Perceptions of Science and Technology in Japan, the United States and Europe"??, 1992; US - "The Public Understanding of Science and Technology in the United States, 1990", J. D. Miller, 1991; France - "Attitude of the French Toward Science", 1990, Daniel Boy.
Reference: Figure 7-3-10

(from Chapter 7)

1.8 Internationalization of Research and Development

Exchange of Researchers and Technicians

(1)Just under 200,000 Japanese researchers and technicians went abroad in 1991, representing 1.9% of all Japanese who left the country that year. Meanwhile, foreign researchers and technicians entering Japan numbered just below 130,000, accounting for 3.3% of entries into Japan by foreigners. The number of such people entering and leaving Japan has shown a large rate of increase since the latter half of the 1980's. Although the number of such people entering remains on an upward surge, there was some stagnation evident in the rise in number of people leaving Japan in 1991 (Figure 1-8-1).

(2)People leaving Japan for the purpose of "exchanges, training and technical training" between 1986 and 1989 contributed significantly to the sudden increase in the number of researchers and technicians leaving Japan, while since 1990 this has been supported by those leaving for "academic research and surveys". More than half go to the United States, and many also go to Europe.

(3)By objective, foreign researchers and technicians mainly go to Japan for "exchanges", followed by "training", with 90% of them coming from Asian nations. Only around 10% of people go to Japan for "research", "instruction" or "technology".
Figure 1-8-1 Trends in the proportion of researchers and technicians among people leaving and entering Japan
Material:Ministry of Justice, ?? "Annual Report on the Control of Entry to and Exit from Japan"??
Reference: Figure 8-1-1

(4)There is a steady increase in the number of foreigners being accepted into the main public institutes. Long-term residents have particularly risen sharply since 1988. Although many of the come from western European countries, there is a downward trend in the proportion of the whole that they represent. The next highest number come from North America and Asia, and more and more have been coming to Japan from eastern Europe and the former Soviet Union since around 1990.

(5)Over the past ten years there has been an increase in a direct line of the number of researchers and technicians in the field of "science and culture" sent to developing nations under the "dispatch of specialists" programs in projects undertaken through the Japan International Cooperation Agency (JICA). Some two thirds of them are sent to Asian countries. The number of people sent as ?? "youth groups for international cooperation"?? in the area of "science and culture" is also rising steadily, with the majority being sent to Central and South America. There is an increase in the proportion of people being sent in the "science and culture" field under both of these systems.

Technology Trade

(1) Turning now to technology trade, which shows the levels of technology in various countries, Management and Coordination Agency statistics show Japan's fiscal 1993 technology exports amounted to 400.4 billion yen and technology imports stood at 363 billion yen. This was the first time a move away from excess imports was seen since statistics started to be compiled in fiscal 1971 to record an export surplus. This is due to a large-scale downturn in newly begun technology imports in fiscal 1993 (approx. 45 billion yen, down 52.5% on the previous year).

(2)Trends in the technology trade balance overall show the growth in export values exceeding that of import values. As such, the balance ratio (export value/import value) has hovered around the 1 mark since the latter half of the 1980's. Nonetheless, the significant fall in the value of technology imports in fiscal 1993 brought the balance ratio to 1.1, the first time it rose above 1 (Figure 1-8-2).

(3)Looking at technology trade in major industries, excess exports have been evident in recent years in the "motor vehicles" with the value of technology exports uncharacteristically high. The value of technology exports for "iron and steel manufacturing" also remains high, with excess exports continuing for almost twenty years. Although there is also an export surplus in the "industrial chemicals and chemical fibers industry", growth rates for both technology export and import values are low. Recently, an equilibrium has been reach in the balance of trade in technology relating to the "drugs and medicines". There is an import surplus for the "communication and electronics equipment industry", for which both technology import and export values are high (Figure 1-8-2).

(4)Technology exports by region indicate that the majority is bound to Asia (excluding western Asia), North America and Europe with basically equal value going to Asia as to North America and Europe together. Of the major industries, much for "motor vehicles" goes to North America, while Asia receives a lot of technology related to "communication and electronics equipment" (Figure 1-8-3).
On the other hand, in technology imports by region, North America accounts for more than 70%, with the majority of the remainder coming from advanced nations in Europe (Figure 1-8-4).
Figure 1-8-2 Trends in Japan's technology trade balance (all industries and major industries)
Material:Management and Coordination Agency's "Report on the Survey of Research and Development"
Reference: Figure 8-2-3
Figure 1-8-3 Breakdown by region and by industry of Japan's technology export values (fiscal 1992)
Material:Management and Coordination Agency's "Report on the Survey of Research and Development"
Reference: Figure 8-2-7
Figure 1-8-4 Breakdown by region and by industry of Japan's technology import value (fiscal 1992)
Material:Management and Coordination Agency's "Report on the Survey of Research and Development"
Reference: Figure 8-2-9

(5)Data produced by the Management and Coordination Agency and the Bank of Japan are frequently used as statistics for Japan's technology trade. Due to the different subjects and methods used, however, there is a vast disparity in the balance ratio for technology trade given, with the former at 0.91 and the latter at 0.45 (fiscal 1992). Seeking to ascertain an accurate picture of Japan's technology trade, we investigated a suitable method and used that to arrive at a revised value of around 0.6, which we believe is a closer value for the overall state of Japan's s technology trade.

(6)According to our statistics relating to the introduction of technology, the introduction of software accounts for 50.3% of the total in Japan (fiscal 1992), and is a factor that is driving up the value of technology imports.

(from Chapter 8)

1.9 Regional Science and Technology Activities

The Foundation for Science and Technology

(1) The rate of population increase is high in the Tokyo metropolitan area and Osaka prefecture. In terms of population density, the prefectures representing the top five largest populations account for 34% of the Japan's population (1990). In contrast, the prefectures representing the largest youth populations account for 31% of the total population.

(2) Regional concentrations of primary, junior high and senior high schools students rise with increase in age groups. Additionally, there is a great deal of inter-prefectural movement in the transition from senior high school to university, with concentrations of university students in Tokyo and other specific prefectures.

(3) Regarding the population that participates in economic activity, there is a high regional concentration in comparison with the overall population. In particular, 52% of new employees who have newly entered into employment contracts do so in the top five prefectures (Figure 1-9-1).
Figure 1-9-1 Number of regular workers and new employees by prefecture (fiscal 1992)
Material: Ministry of Labor, ?? "Report on the Survey of Employment Trends"??

Reference: Figure 9-1-9

(4)Science and technology expenditure by regional governments was 614 billion yen for fiscal 1992. This equates to 29% of government science and technology expenditure, and signifies that regional governments play a major role in supporting science and technology in the public sector.

Research and Development Activities

(1)National research institutes are established in 22 prefectures, leaving 25 prefectures without, indicating the lack of emphasis originally placed on regional development. In recent times however, various carry-on effects have been observed in the regions.

(2)There are 656 public research institutes nationwide which have been established by regional governments (fiscal 1993), with seven such institutes even in the prefecture with the least number, so there is relatively little regional concentration and imbalance. Many regional governments have been undertaking reorganization of public research institutes, showing signs of becoming more research oriented.

(3)Regional distribution of universities show that there is at least one national or public university in each prefecture, with little polarization given the scale of the respective populations. The nationwide distribution of national and public universities is a significant factor in the regional dispersion of research and development resources. In contrast, private universities are concentrated in specific prefectures.

(4)There is a high concentration of private industry research institutes in certain prefectures, with the top five prefectures accounting for 58% of the national total. Regional distribution by industry characteristics shows regional research and development tendencies, with a particularly high ratio of non-manufacturing industries in the southern Kanto district (including the Tokyo area), a rather large proportion of basic material industries concentrated in the western Kinki area (including Osaka prefecture), and also quite a high concentration of lifestyle related industries in the Tokai region (Figure 1-9-2).

The Results and Contributions of Science and Technology

(1)The top five prefectures account for 40% of the nation's total value of shipments of industrial products, which shows a concentration in specific regions when compared to population although it is distributed in comparison with R&D activities. Looking at the value of shipments per worker of small-to-medium companies and large companies, Shiga, Saitama and Shizuoka prefectures have high values for small-to-medium businesses, while high values are recorded for large companies is Aichi, Kanagawa and Shiga prefectures. In addition, in a comparison between 1980 and 1990, Yamanashi prefecture recorded the largest increase, followed by large increases in Gunma, Shiga and Yamagata prefectures (Figure 1-9-3).
Figure 1-9-2 Regional distribution of private industry research institutes (1991)
Material:?? "Nationwide Directory of Research Institutes (1991-1992)"??, edited by the Science and Technology Agency, ??Lattice Pty., Ltd.,?? 1992
Reference: Figure 9-2-12
Figure 1-9-3 Growth in shipment values of industrial products by prefecture (1980 R 1990)
Material: Ministry of International Trade and Industry's "Industry Statistics"
Reference: Figure 9-3-2

(2)Of industrial property rights applications there is a concentration of patent applications in Tokyo and other specific prefectures. On the other hand, utility models, many of which are applied for by small-to-medium companies, show little regional concentration among industrial property rights.

(3)Although venture industries are concentrated in Tokyo and other certain prefectures, there is some vigorous activity by venture industries in regional locations, as indicated by companies in other prefectures with many registered patents.

(4)Looking at economic growth from the perspective of prefectural gross product and prefectural income, Shiga, Gunma, Yamanashi, Ibaragi and Aichi prefectures are regions to whose growth secondary industry has contributed. Large contributions to growth by tertiary industries include Tokyo, indicating differing development according to region.

(5)A look at regional development by prefectural income shows bi-polarization of per capita prefectural income - that is, there is a division of affluent and not so affluent prefectures, suggesting there are many issues to be addressed regarding regional development (Figure 1-9-4).
Figure 1-9-4 Trends in per capita distribution of prefectural income
Material: ?? Economic Planning Agency's, "Annual Prefectural Economic Report"
Reference: Figure 9-3-10

(from Chapter 9)

1.10 Composite Indicators: International Comparison of Overall Science and Technology Capability

(1)Composite indicators are a composition by some method of multiple indicators of science and technology activities to represent them using one or two minor indicators. Doing so provides a grasp of the overall trends in a nation's science and technology activities, and enables comprehensive international comparison and chronological analysis.

(2)Thirteen types of separate indicators relating to Japan and four other nations were used to show the position of Japan's science and technology activities against other countries. These were "R&D expenditure", "researcher numbers", "scientist numbers", "engineer numbers" and "value of technology imports", which are seen as indicators of science and technology activity input, and "number of papers", "number of citations", "number of internal patents", "number of external patents", "number of patent citations", "value of industrial product production", "value of high tech product production" and "value of technology exports", which are seen as indicators of science and technology output. The indicators were combined by using the main component analysis method and factor analysis method of the multivariate analysis method.

(3)Factor I (horizontal axis), indicating the science - technology or basic - applied character, and Factor II (vertical axis), indicating the input - output character, were found through structural analysis by the factor analysis method (Figure 1-10-1). Looking at the values of each country for these factors (??factor points??), we see that Japan leans towards technology and application, with a tendency to input. The United States tends towards science, basic and input, Germany towards technology, application and output, and France and England towards science, basic and output (Figure 1-10-2).

(4)A correlation in input and output in each country becomes evident once composite indicators of science and technology activity are obtained through the main component analysis method. Input and output are growing steadily in Japan. Although a decline was seen in output in the first half of the 1980's in the United States, significant growth was witnessed in this area in the latter half. All three European countries have greater output than input, indicating a high level of efficiency.

(5)Japan's composite indicator value (science and technology comprehensive indicator), representing the overall strength of the country's science and technology activities, is approximately half that of the United States, with Germany, France and England having values half that of Japan's. As an indicator of the total volume of science and technology activities of these countries, we believe this essentially reflects the current state. Trends in each country show a steady rise in Japan, and stable states in all three European nations. Although the United States experienced a downturn in the first half of the 1980's, this started to rise again from the mid-1980's (Figure 1-10-3).

Figure 1-10-1 Structure of science and technology activity variables (??factor burden??)

Note:As a correlation (??actual relationship??) appears between variables when positioning variables in factor analysis, it is possible to position them in a place other than the meaning of the name given in the definition of the variables.

Reference: Figure 10-1

Figure 1-10-2 Trends in science and technology ??factor points?? in major countries

Reference: Figure 10-2

Figure 1-10-3 Trends in science and technology comprehensive indicators for major countries

Reference: Figure 10-6

(from Chapter 10)