2.1.2.1 Share of R&D Expenditures

A look at the share of total research expenditures held by governments[7] shows France with the highest percentage, at about 40% of expenditures. Japan's share shows the lowest level among selected countries, a figure that is probably affected by such factors as the extremely low share held by defense research and by the large amount of activity in the private sector (Figure 2-1-6). The large share of R&D expenditures carried by the private sector means that the figures tend to be easily swayed by fluctuations in the business environment (Figure 2-1-7).

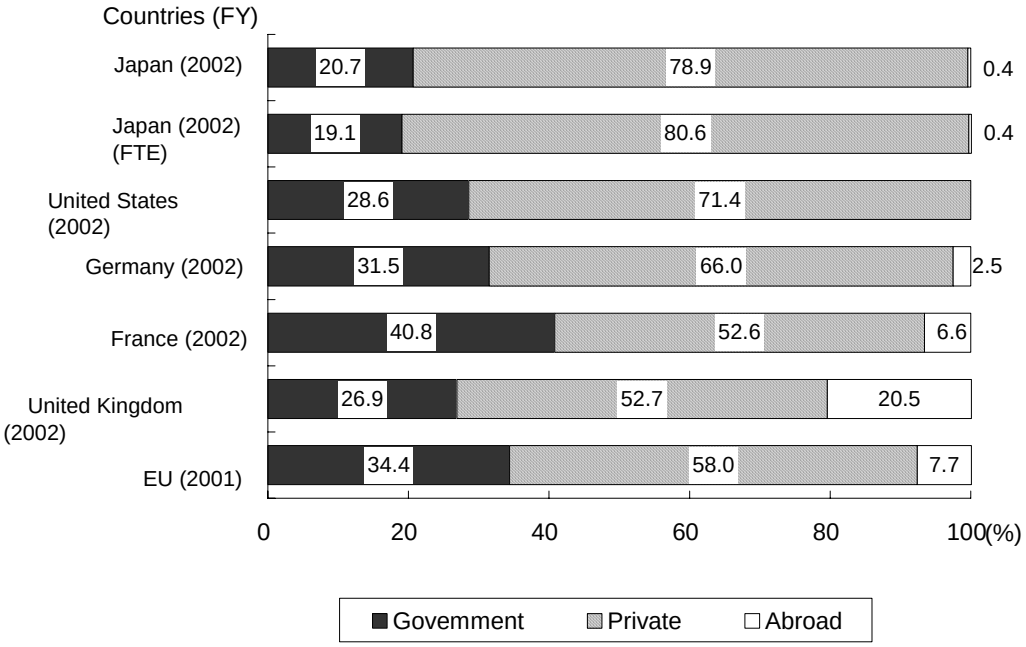


Figure 2-1-6 Share of R&D expenditures by financing sector in selected countries

Notes:1. For comparison, statistics for all countries include research in social sciences and humanities. The figure for Japan includes the FTE value.
2. Japan's FTE value is calculated by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) based on the Statistics Bureau data.
3. U.S. figures are for calendar years and provisional. France's figures are provisional.
4. Everything other than government and abroad is classified as private sector.
5. EU figures are OECD estimates.

Source: EU ─ OECD. "Main Science and Technology Indicators"

Others ─ Same as in Figure 2-1-3.

(See Appendix 3. (1), (2), (4))

7 Government: In Chapters 2.1 and 2.2, when research expenses and numbers of researchers are expressed, "governments" means central govern

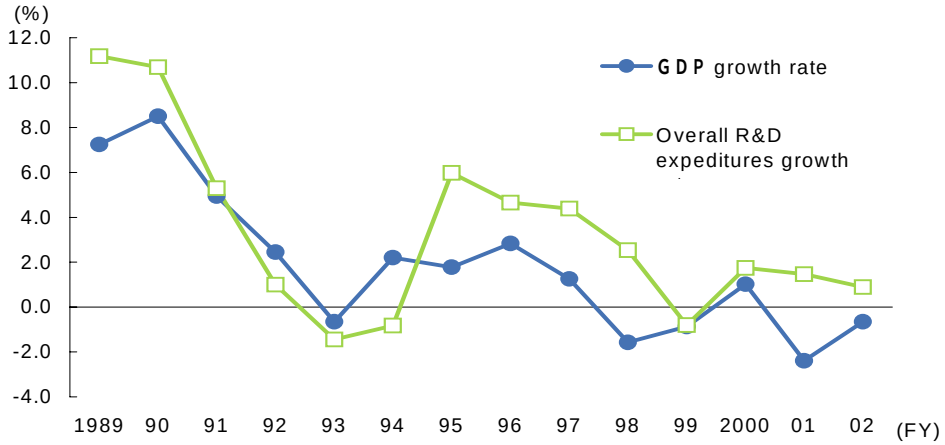


Figure 2-1-7 Trends in overall growth in R&D expenditures, and gross domestic product (GDP) growth rates

Source: Cabinet Office. "National Accounts"
Statistics Bureau. "Report on the Survey of Research and Development"

The decline in defense-related R&D expenditures since the end of the Cold War structure has resulted in a gradual, continuous decline in the share of R&D expenditures financed by governments in other countries, although it has been on the rise again in recent years. The share of R&D expenditures financed by the Japanese government has declined slightly for the third straight year. (Figure 2-1-8)

For the government share of expenditures in relation to gross domestic product (GDP), France had the highest percentage, followed in order by the United States, Germany, Japan, and the United Kingdom. The shares for the United States, Germany and France have been increasing, while that for Japan has remained flat (Figure 2-1-9).

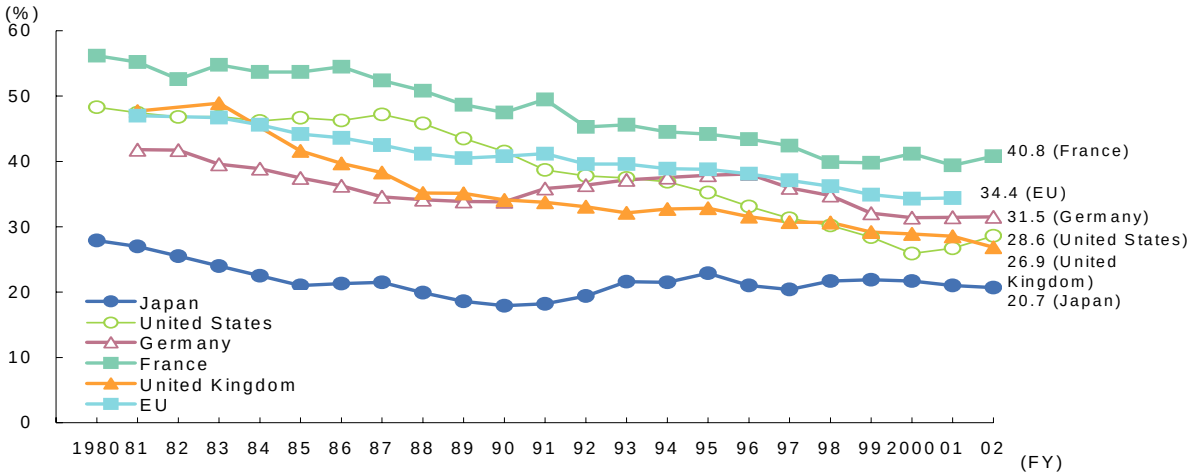


Figure 2-1-8 (1) Trends in government-financed R&D expenditures — Share of R&D expenditures financed by government

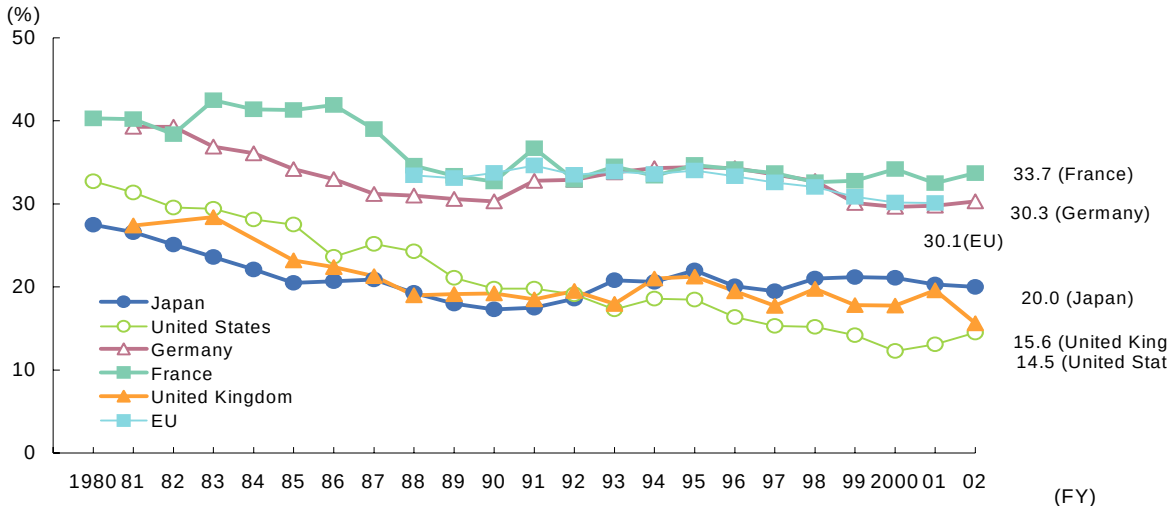


Figure2-1-8 (2) Trends in government-financed R&D expenditures ― Share of R&D expenditures exclusive of defense-related R&D expenditures

Notes: 1. For comparison, statistics for all countries include research in social sciences and humanities.

2. Government percentages exclusive of defense-related research expenditures are calculated by the following equation.

$$\frac{\text{(Government - financed R \& D expenditures)} - \text{(Defense - related R \& D expenditures)}}{\text{(R \& D expenditures)} - \text{(Defense - related R \& D expenditures)}} \times 100\%$$

It should be noted that the results of defense-related R&D often not only affect defense but also contribute to the development of science and technology for the civil welfare.

3. Japan added industries as new survey targets in FY1996 and FY2001.

4. U.S. figures are for calendar years, and figures for FY2001 and later are provisional.

5. French figure for FY2002 is provisional.

6. EU government share is OECD estimates.

Source: Defense-related R&D expenditures in Japan ― MEXT. "Budget for Science and Technology".

Defense-related R&D expenditures in the U.S. ― The Budget of the U.S. Government

Defense-related R&D expenditures in the U.K. ― "SET Statistics".

Others ― Same as in Figure 2-1-3

(See Appendix 3. (1))

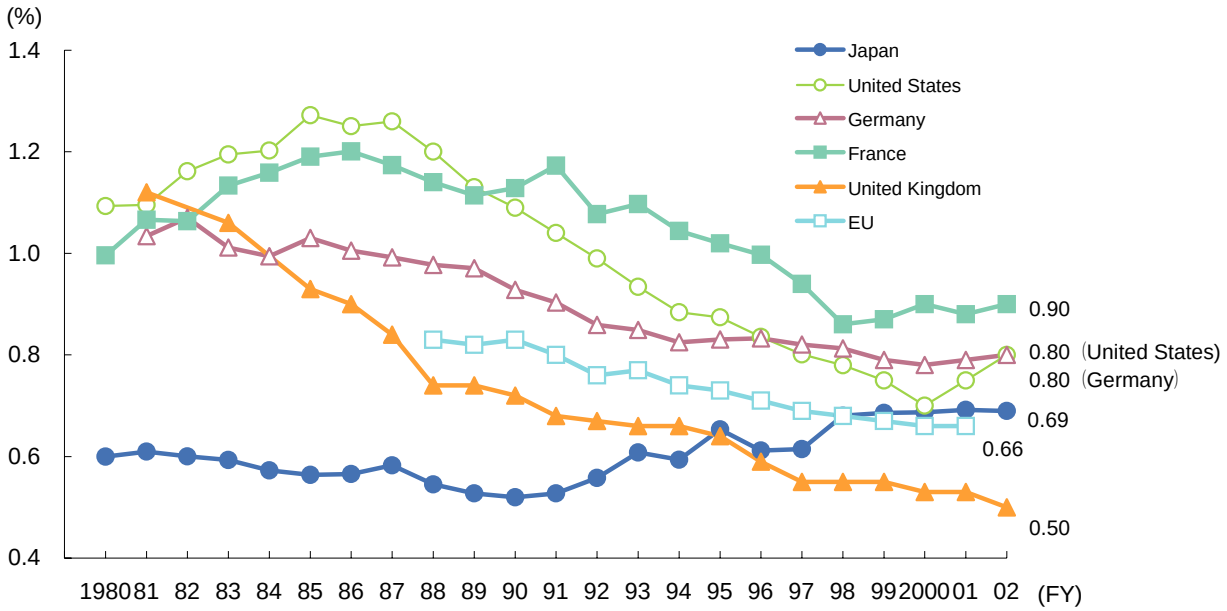


Figure 2-1-9 Trends in the proportion of government-financed R&D expenditures to gross domestic product (GDP) in selected countries

Notes :1. For comparison, statistics for all countries include research in social sciences and humanities.
2. Japan added industries as new survey targets in FY1996 and FY2001.
3. U.S. figures are for calendar years, and figures for 2001 is provisional.
4. French data for FY2002 is provisional.

Source: Same as in Figure 2-1-3.

(See Appendix 3. (1))

2.1.2.2 Share of R&D expenditures by performance

Industry spends approximately two-thirds of total R&D expenditures in all selected countries, demonstrating just how large a role private-sector companies play in research and development. Among the selected countries, government research institutions' share of R&D expenditures was highest in France (Figure 2-1-10).In the selected countries, the trends in real R&D expenditures by type of organization reveals that industry has contributed the most greatly in all countries to growth in R&D expenditures (Figure 2-1-11).In Japan, a look at the contribution by type of organization to year-on-year growth of R&D expenditures (in real terms) shows that R&D expenses at private companies have a large effect on trends in Japan's R&D expenses. For the degree of contribution, private companies made a positive contribution from FY1995 to FY1998, but then fell into a negative contribution for FY1999. Private companies returned to a positive contribution in FY2000 (Figure 2-1-12).

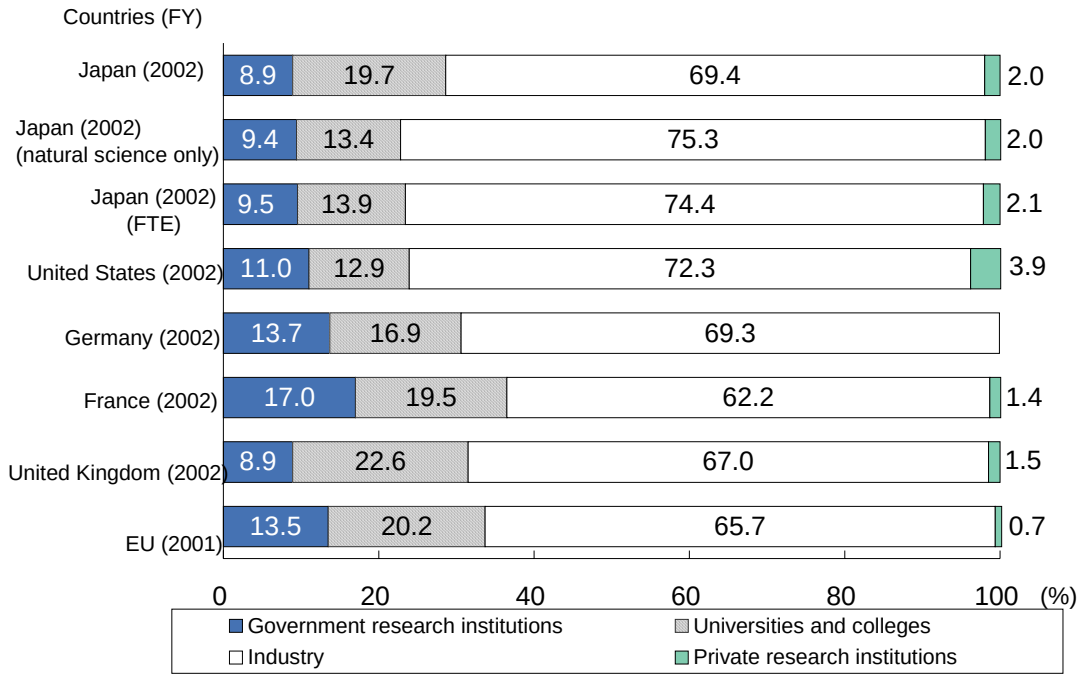


Figure 2-1-10 Share of R&D expenditures by performance sector in selected countries

Notes: 1. For comparison, statistics for all countries include research in social sciences and humanities. The figures for Japan show also the amount for natural sciences only and FTE value.
2. Figures for Japan's FTE value are prepared from the Statistics Bureau data.
3. U.S. figures are for calendar years and provisional. French figures are provisional. In addition, Germany's re-search expenditures at "private research institutions" are included in "government" research institutions.
4. EU figures are Eurostat estimates.

Source: France — OECD. "Main Science and Technology Indicators"
Others — Same as in Figure 2-1-3.

(See Appendix 3. (2), (5))

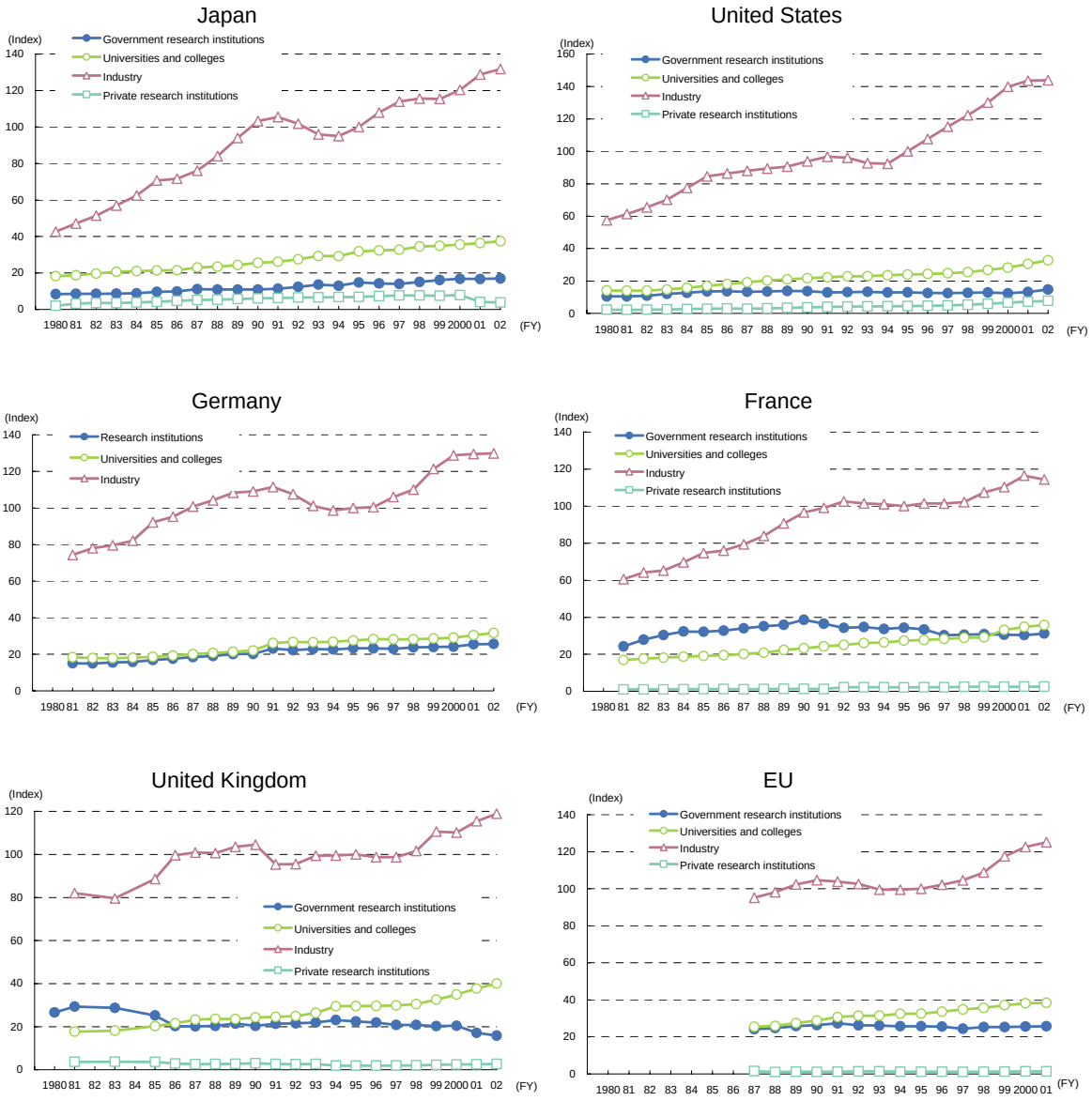


Figure 2-1-11　R&D expenditures growth (in real terms) by sector in selected countries

Notes: 1. All countries include social sciences and humanities for purposes of international comparison. In addition, industry's real research expenditures for FY1995 are set at 100.

2. U.S. data are for calendar years, and data for FY2001 is provisional.

3. FY2002 data for France is provisional.

4. Since no differentiation has been made between "government research institutions" and "private research institutions" in Germany, they are listed simply as "research institutions."

5. Japan added some industries as new survey targets in FY1996 and FY2001.

6. EU figures are Eurostat estimates.

Source: France ─ OECD. "Main Science and Technology Indicators"

Others ─ Same as in Figure 2-1-3.

(See Appendix 3. (15))

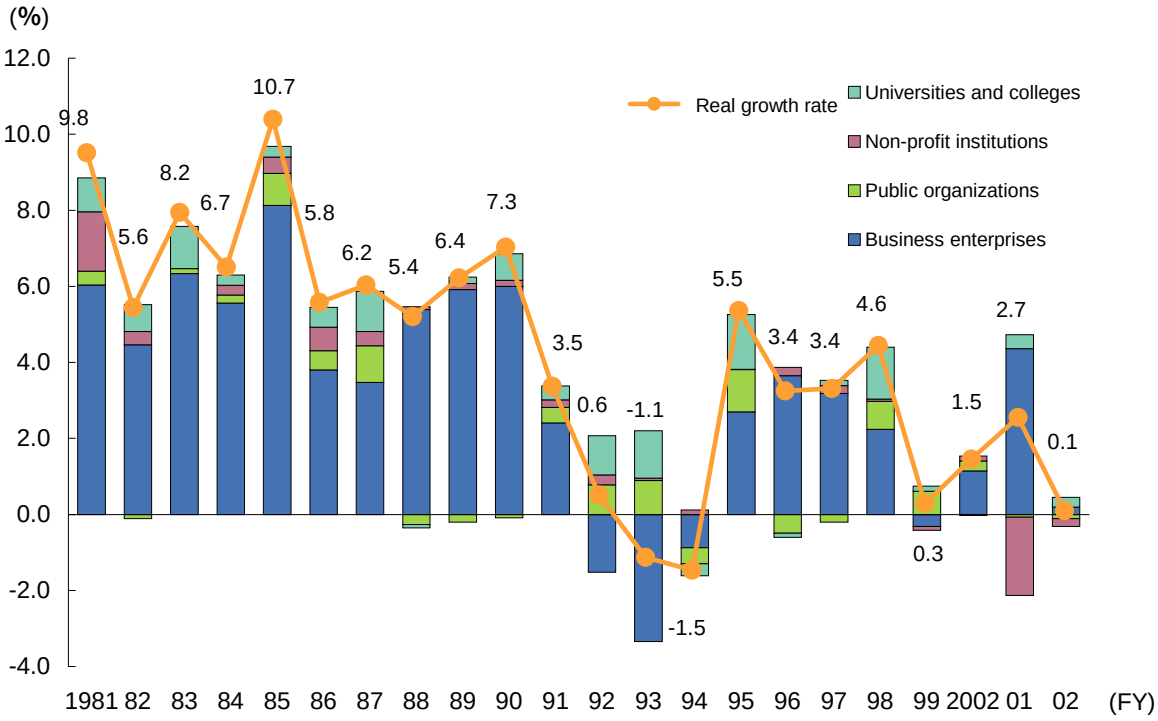


Figure 2-1-12 The contribution by organization to the year-on-year growth rate in Japan's real R&D expenditures

Notes: 1. The deflation referring for each sector is based on FY1995.

2. Japan added some industries as new survey targets in FY1996 and FY2001.

3. Survey coverage categories were changed in FY2001; figures up to FY2000 are for the following categories:

Up to FY2000	FY2001
Companies	Business Enterprises
Private research	Non-profit institutions
Government research institutions	Public organizations

Source: Statistics Bureau. "Report on the Survey of Research and Development"

(See Appendix 3. (5), (15))

2.1.2.3 R&D Expense Flows

Japan's R&D expense flows between sources of funding and sectors of performance reveal that about 48% of government funding goes to universities, about 42% to government research institutions, and about 10% to the private sector. In private-sector funding, by contrast, about 98.6% goes to the private sector, with about 1.0% to universities and about 0.4% to government research institutions.

Comparing flows of R&D expenditures between the financing and performance sectors shows that in Japan there is a lesser flow of R&D expenditures between sectors (government, industry, universities and colleges) than exists in other countries. The ratio of private sector R&D expenditures funded by government is high in the United States and in France. The United Kingdom is characterized by a large proportion of R&D expenditures being borne from abroad (Figure 2-1-13).

On the reason why R&D expenses flow from government to the private sector, and from the private sector to universities, are so low in Japan, it can be pointed out that research and development in Japan often relies more on private-sector activities than it does in other countries. The large flows from government to the private sector in the United States, France, and elsewhere are due to the large flows of aerospace research and defense research funds. Moreover, a major reason for the large flow of research funds from foreign countries into the United Kingdom is likely the existence in that country of many foreign-capitalized corporations with research and development centers in operation, which would therefore be sending R&D funds to the United Kingdom from their own home countries.

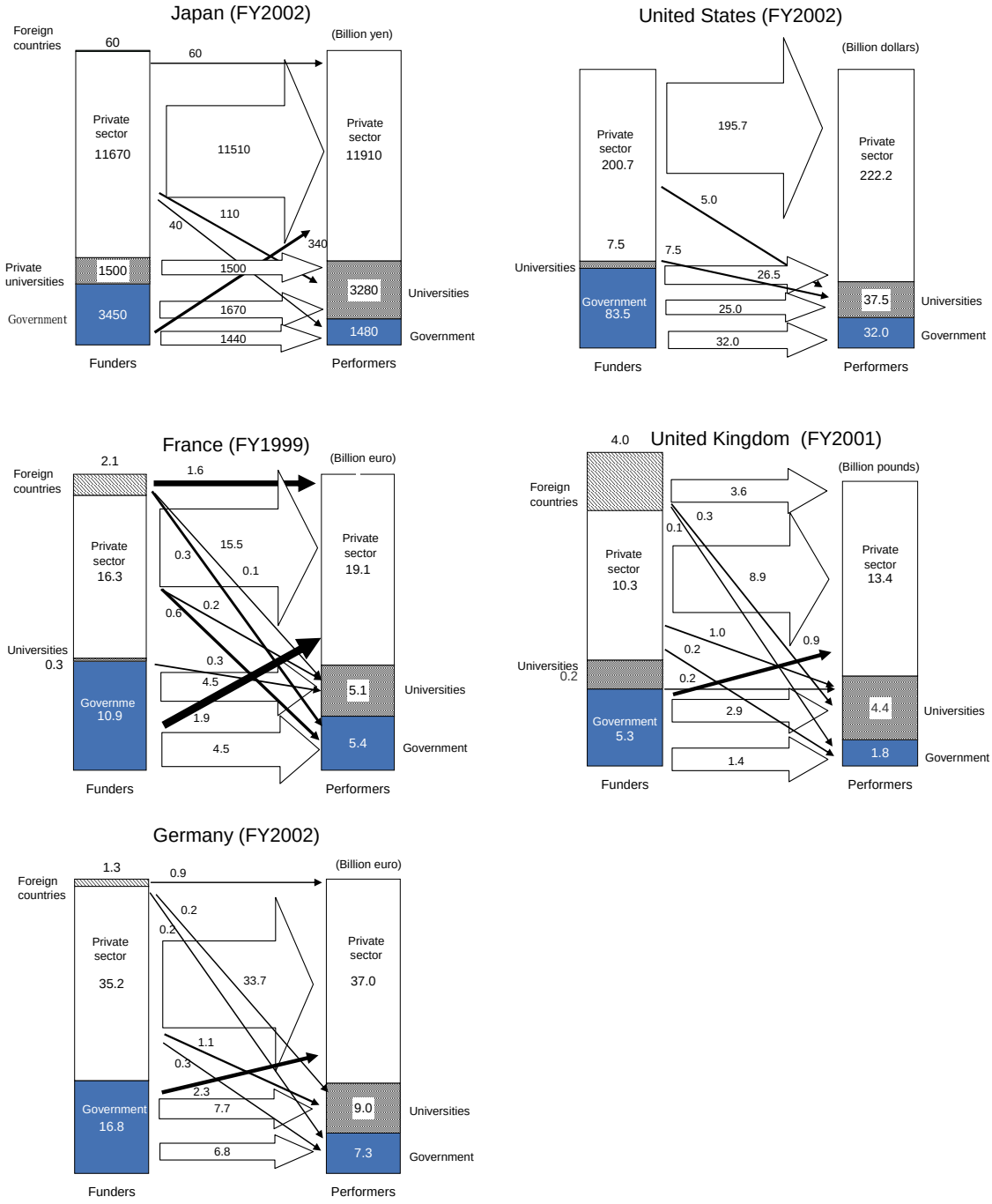


Figure 2-1-13 R&D expense flows in selected countries

Notes: 1. For comparison, statistics for all countries include research in social sciences and humanities.

2. U.S. figures are for calendar years and provisional.

3. In Germany, data from private research institutions are included in the government figures, and in the other countries are included in the private sector.

Source: France ─ OECD. "Basic Science and Technology Statistics"

Other countries ─ Same as in Figure 2-1-3.

(See Appendix 3. (2))

2.1.3 R&D Expenditures per Researcher

Because of differences in how researchers are targeted, in survey methods used, and in exchange rates, simple comparisons between countries of R&D expenditures per researcher may not be precise. Nevertheless, a look at statistics for five major countries shows Japan ranked first when the yen was converted to the IMF exchange rate, and ranked last when the OECD's purchasing power parity conversion rate was used (Figure 2-1-14).

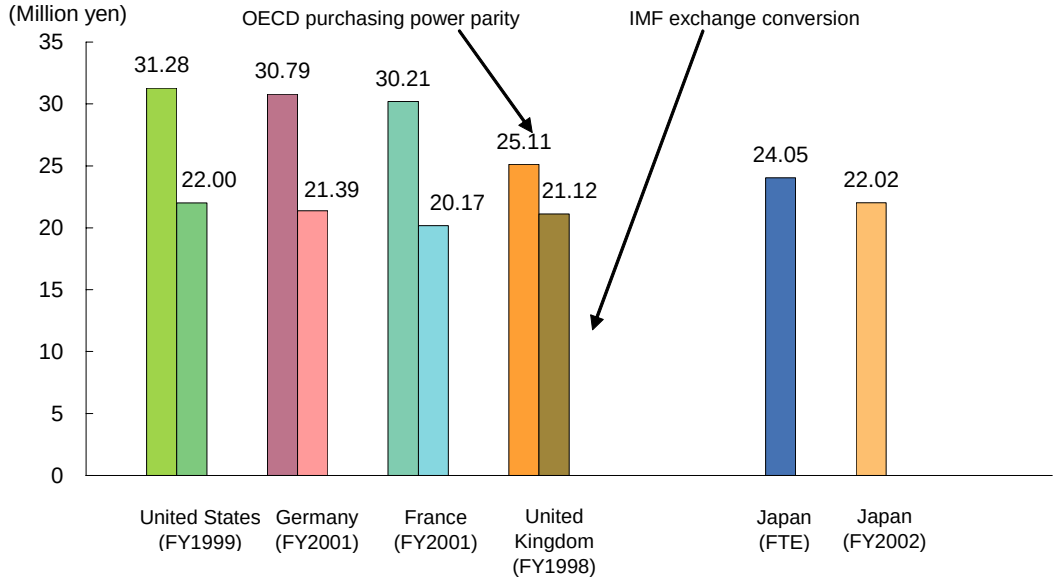


Figure 2-1-14 R&D expenditures per researcher

Notes: 1. For comparison, figures for all countries include social sciences and humanities. The figure for Japan includes the FTE value.
2. R&D expenditures for the U.S. are for calendar year.

Source: Numbers of researchers in France and UK -- OECD "Main Science and Technology Indicators"
Others -- Same as in Figure 2-1-3.

(See Appendix 3. (1))

Japan's R&D expenditures per researcher have been hovering around 22 million yen in recent years.

For R&D expenditures per researcher by type of organization in FY2002, public organizations and non-profit institutions with high ratios of non-personnel R&D expenditures also registered high R&D expenditures per researcher, while universities and colleges, where the ratio of non-personnel R&D expenditures were low, registered lower expenditures per researcher (Figure 2-1-15).

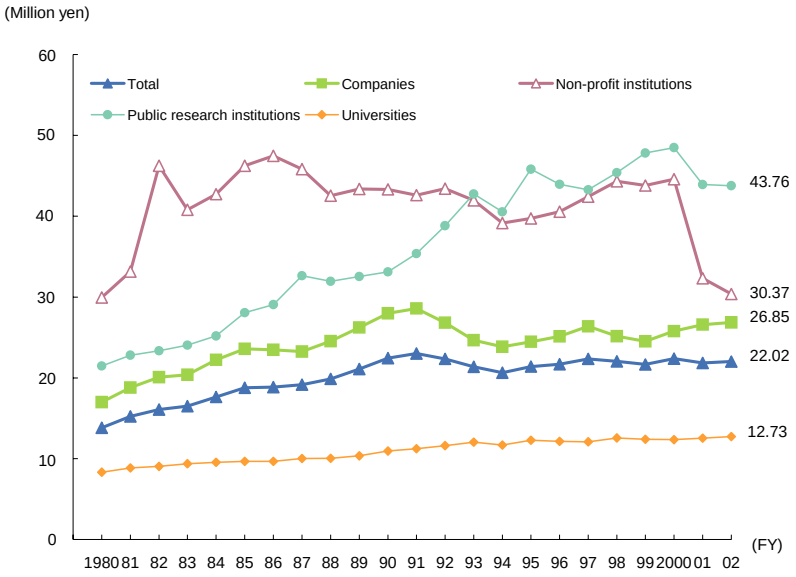


Figure 2-1-15 (1) Trends in R&D expenditures per researcher (in nominal terms)

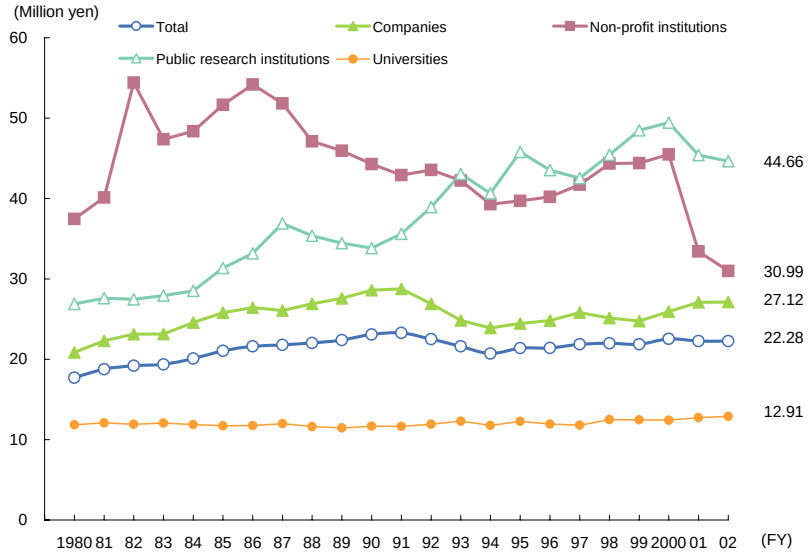


Figure 2-1-15 (2) Trends in R&D expenditures per researcher (in real terms)

Note: 1. Survey coverage categories were changed in FY2001; figures up to FY2000 are for the following categories

Up to FY2000	FY2001
Companies	Business enterprises
Private research institutions	Non-profit institutions
Government research institutions	Public organizations

2. Figures in real terms are converted in constant FY1995.

Source: Statistics Bureau. "Report on the Survey of Research and Development"

If we limit the R&D expenditures per researcher at universities and colleges to those invested in those teachers, then the national universities with particularly high non-personnel R&D expenditures have the highest expenditures per researcher, followed by private universities and other public universities. By specialty (academic field), the rankings were, in order, physical science, engineering, agricultural sciences, and health sciences (Figure 2-1-16).

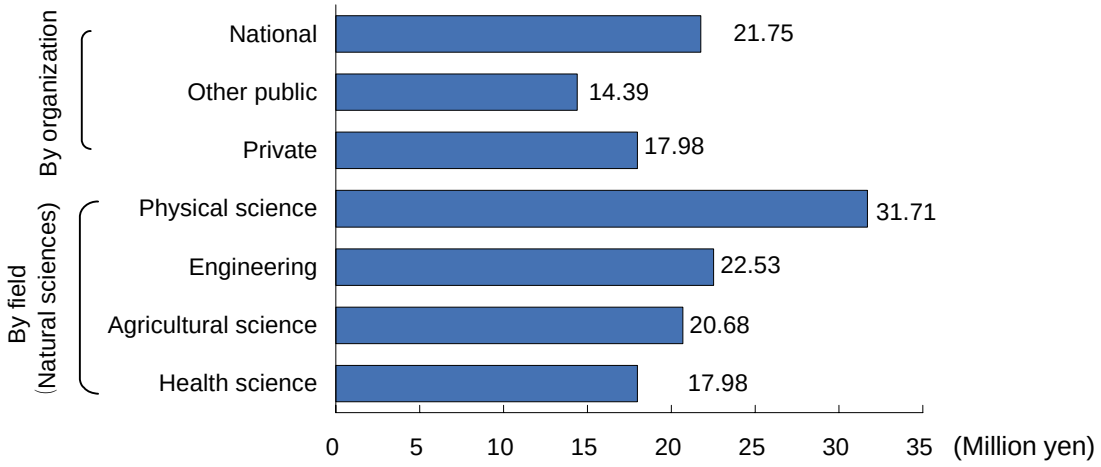


Figure 2-1-16 R&D expenditures per researcher at universities and colleges (FY2002)

Notes: 1. Figures by organization include the humanities and social sciences.
2. Figures are for faculty members only, out of all researchers.
3. The number of researchers is as of March 31, 2003.

Source:Statistics Bureau. "Report on the Survey of Research and Development"

2.1.3.1 R&D expenditures per Researcher, by Type of Industry

For the R&D expenditures per researcher at companies by type of industry, the top five industrial categories were led by the telecommunications industry, with its high purchase rates of large machinery, equipment, facilities, and other tangible fixed assets, and followed by the broadcast industry, the pharmaceutical industry, the transportation industry, and academic research institutions
(Figure 2-1-17).

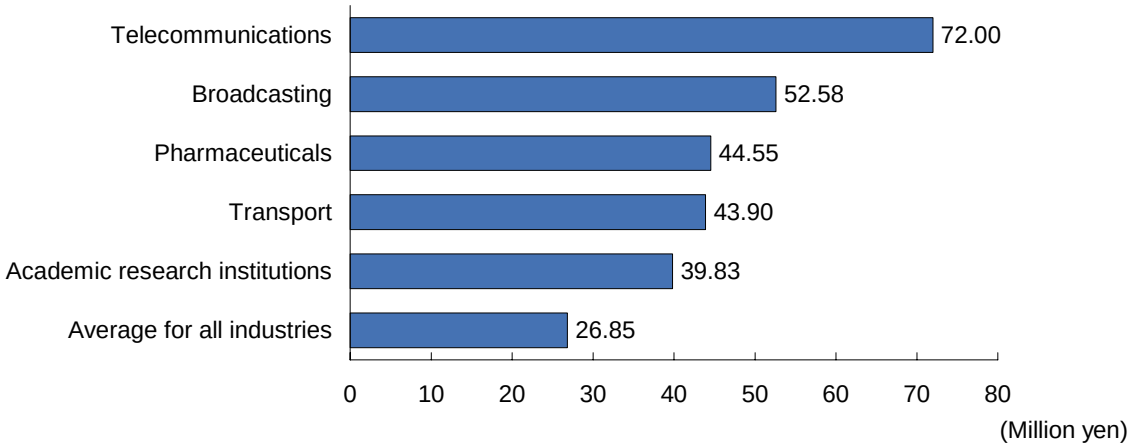


Figure 2-1-17 R&D expenditures per researcher, by industry (top five industrial categories) (FY2002)

Note: The number of researchers is as of March 31, 2003.

Source: Statistics Bureau. "Report on the Survey of Research and Development"

2.1.4 R&D Expenditures by Character of Work

Classification into basic research, applied research, and development[8], may differ from country to country. Although it is difficult to make a comparison due to differences in distinctions between the three among the countries concerned, R&D expenditure data by character of work generally reflects the R&D activity of each country. Recent statistical data for Japan, the United States, Germany and France shows that France and Germany spend more on basic research, and that Japan spends less on basic research (Figure 2-1-18).

8 ・Research classification: “Report on the Survey of Research and Development” by the Statistics Bureau defines research by type of characteristics as follows:
・Basic research: Basic or experimental research conducted with no direct consideration for specific applications or uses, in order to form hypotheses or theories, or to obtain new knowledge about phenomena or observable reality.
・Applied research: Research that utilizes knowledge discovered through basic research to confirm the feasibility of commercialization for a specific objective, and research that searches for new applications for methods that have already been commercialized.
・Experimental development: Research that utilizes knowledge obtained from basic research, applied research, or actual experience for the objective of introducing new materials, devices, products, systems, processes, etc., or of making improvements to those already existing.

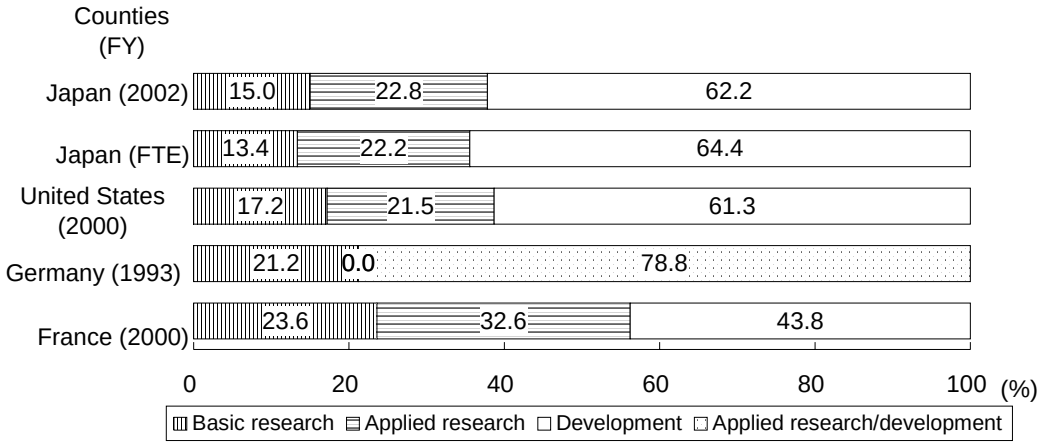


Figure 2-1-18 R&D expenditures by character of work in selected countries

Notes: 1. Figures for Japan's FTE value are prepared from Statistics Bureau data.
2. U.S. figures are for calendar years and provisional.
3. There is no distinction in Germany between applied research and development.

Source: Japan, U.S. ─ Same as in Figure 2-1-3.
Germany, France ─ OECD. "Basic Science and Technology Statistics"

(See Appendix 3. (3))

A look at the trend for the share held by basic research in selected countries shows that Japan's allotment for basic research began rising in FY1991, but then turned downward in FY1996 and rose again in FY1998. The United States, while showing some minor fluctuations, has generally increased its share of basic research since FY1986 (Figure 2-1-19).In Japan, research expenses in the different types of organizations, classified into companies, research institutions, and universities and colleges, are clearly differentiated in structure. For companies, development plays an extremely important role due to their corporate business functions, and this trend has become even more intensified in recent years. On the other hand, universities and colleges place emphasis on basic research and applied research. Non-profit institutions and public organizations, meanwhile, both exhibit intermediate trends (Figures 2-1-20, 21).

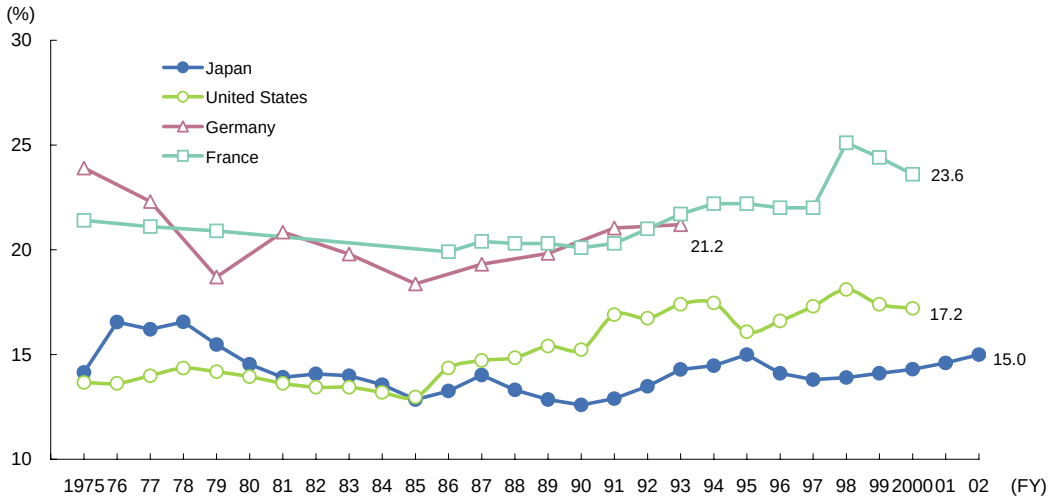


Figure 2-1-19 Trends in the proportion of basic research expenditures in selected countries

Note: United States figures are for calendar years.

Source: Japan, United States ─ Same as in Figure 2-1-3.

Germany, France ─ OECD. "Basic Science and Technology Statistics"

(See Appendix 3. (3))

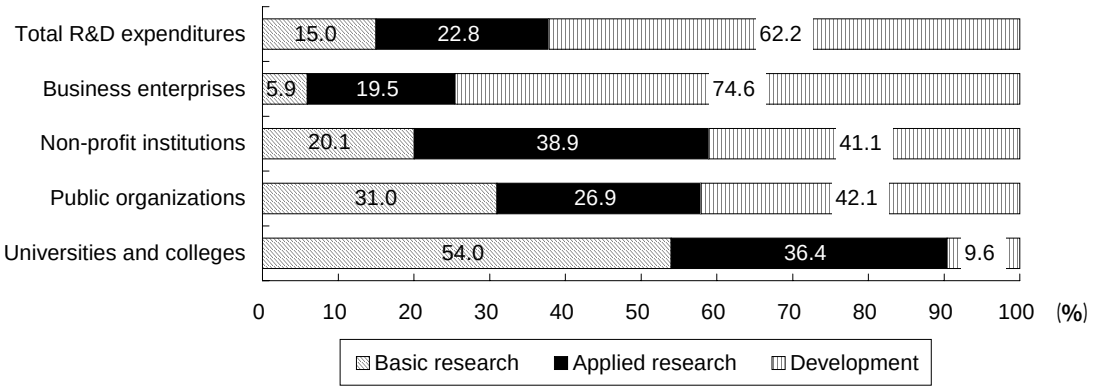


Figure 2-1-20 Composition of R&D expenditures by character of work by sector in Japan (FY2002)

Note: The figures are for the composition of R&D expenditures by character of work in the natural sciences (physical science, engineering, agricultural science, and health science).

Source: Statistics Bureau. "Report on the Survey of Research and Development"

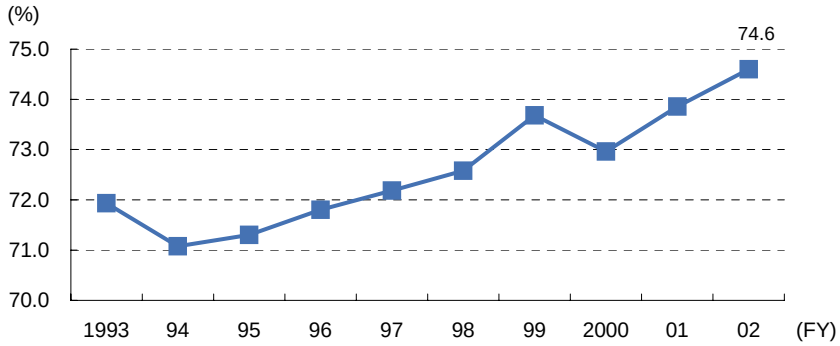


Figure 2-1-21 Trend in the share of development expenditures out of total research expenditures of companies

Note: The share of research expenditures is only for the natural sciences.

Source: Statistics Bureau. "Report on the Survey of Research and Development"

2.1.5 R&D Expenditures by Industry

2.1.5.1 R&D Expenditures by Industry

While the statistical survey range varies from country to country, making simple comparisons difficult, it is plain that research expenses in the service industry have been increasing in all countries since the mid-1980s, in response to the shift of industrial structure from manufacturing to services in major countries. The figures for services are particularly high in the United States and the United Kingdom (Figure 2-1-22).

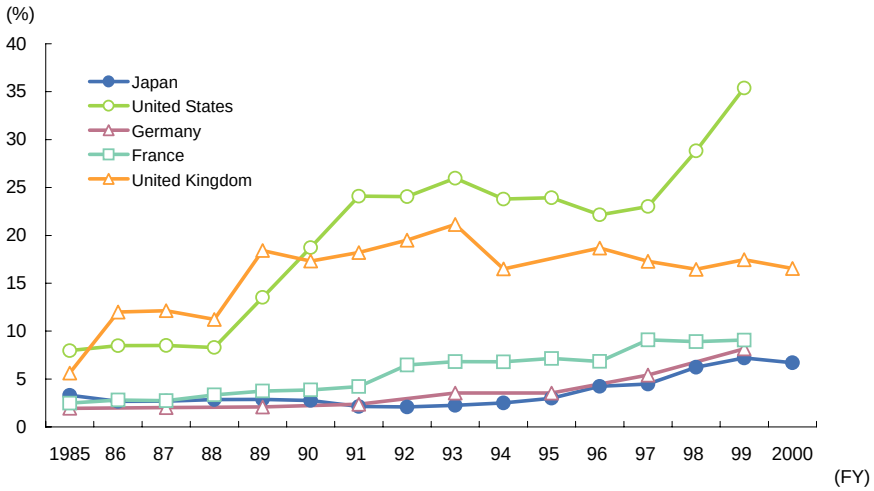


Figure 2-1-22 Share of services industry in total R&D expenditures

Notes: 1. For purposes of international comparison, the figures for each country include the humanities and social sciences.

2. Japan added some industries as new survey targets in FY1996.

Source: OECD. "Basic Science and Technology Statistics"

2.1.5.2 R&D Expenditures by Type of Manufacturing Industry

For the top six R&D expenditure manufacturing industry sectors in major countries, all countries showed high ratios for the telecommunications, electronics and electrical instrument industry, the automobile industry, and the pharmaceuticals industry, which are all subject to severe competition internationally. For the total share of the top three industries, the information and telecommunications machinery and equipment industry, the automobile industry, and the pharmaceuticals industry accounted for 48.4% of the total in Japan; in the United States, the chemical industry, the precision instrument, and the automobile industry accounted for 49.7%; in Germany, the automobile industry, the telecommunications, electronics and electrical instrument industry, and the chemicals industry other than pharmaceuticals accounted for 54.5%; in France, the automobile industry, the pharmaceuticals industry, and the telecommunications, electronics and electrical instrument industry accounted for 45.6%; and in the United Kingdom, the pharmaceuticals industry, the aerospace industry, and the telecommunications, electronics and electrical instrument industry accounted for 53.7% of the total. In all major countries, therefore, R&D expenses are concentrated in the top-ranking industries (Figure 2-1-23).

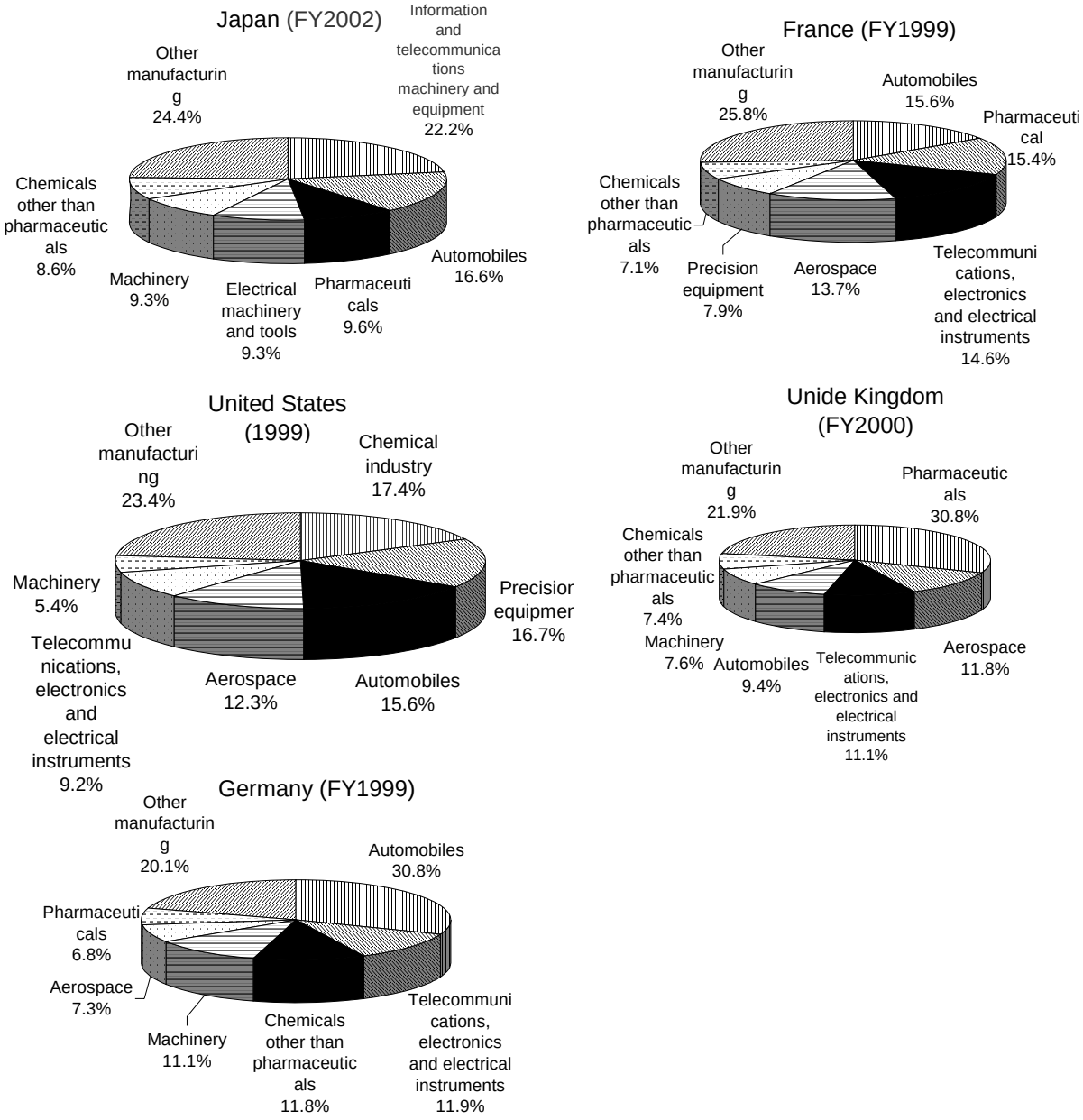


Figure 2-1-23 Manufacturing industry research expenditures in selected countries, by Industry

Source: Japan ─ Statistics Bureau. "Report on the Survey of Research and Development"

Other countries ─ OECD. "Basic Science and Technology Statistics"

2.1.6 R&D Expenditures in Japan by Sector

The following section gives R&D expenditures in Japan by sector[9] on the basis of the Survey of Research and Development (2001) conducted by the Ministry of Internal Affairs and Communications.

2.1.6.1 Business Enterprises[10]

According to the survey, the business enterprises that engaged in research in FY2002 numbered 14,300 companies, with the manufacturing industry accounting for the vast majority of these, at almost 77% of all industry types. Within the manufacturing sector, the machinery, electrical machinery, and food industries held the largest shares.

Also, the total of R&D expenses incurred by companies in FY2002 rose by 1.1% from the previous fiscal year to 11.5768 trillion yen, accounting for about 69% of Japan's total R&D expenditures.

By source of funding for R&D expenditures, companies accounted for almost all of the total, dwarfing the government funding of about 2% of the total.Moreover, for R&D expenses incurred by companies excluding public corporations and incorporated administrative agencies, classified by company capitalization, those with a capitalization of 10 billion yen or more accounted for about 75% of the total, a result that showed R&D expenditures were concentrated in larger corporations. Furthermore, growth rates since FY2001 show that companies with a capitalization of 10 billion yen or more have experienced increases while companies with a capitalization of less than 100 million yen have witnessed year-on-year declines (Table 2-1-24).

Table 2-1-24 R&D expense growth rates and component ratio, by size of company capitalization

Capitalization	R&D expenditures (Million yen)	Growth rate over the previous year (%)	Component ratio (%)
Less than 100 million yen	294,236	-31.3	2.6
100 million to 1 billion yen	651,930	0.8	5.7
1 billion to 10 billion yen	1,977,659	-1.2	17.2
10 billion yen or more	8,573,031	3.4	74.6
Total	11,496,856	1.2	100.0

Source: Statistics Bureau. "Report on the Survey of Research and Development"

9 Research Performing Sector: Research activities in Japan in this paper are provided by business enterprises, public organizations, non-profit institutions, and universities and colleges. These classifications are based on the "Report on the Survey of Research and Development" compiled by the Statistics Bureau. The following defines some of these organizations.

10 Business enterprises: Corporate companies (Capital: 1 million or more yen (FY1974 or before), Capital: 300 million yen or more (between FY1975 and FY1978), Capital: 5 million yen or more (between FY1979 and FY1993), Capital: 10 million yen or more (FY1994 and after)) and profit-oriented public corporations. The public corporations and independent administrative institutions specializing in research are excluded, and are included in the research institutions defined below.

2.1.6.2 Non-profit Institutions[11]

In FY 2002, the government and the private sector were sources for nearly equal shares of funding for non-profit institutions. The total R&D expenditures at non-profit institutions were 332.7 billion yen, accounting for about 2% of Japan's total R&D expenditures (Figure 2-1-25).

2.1.6.3 Public Organizations[12]

The government was the source for nearly all R&D expenditures at public organizations in FY2002, with private-sector funding accounting for only about 3%.

Total R&D expenditures at government research institutions increased by 0.1% over the previous fiscal year to 1.4832 trillion yen, representing about 9% of Japan's total R&D expenditures. When looking at expenditures by type of institution, national government-owned and publicly-owned research institutions witnessed year-on-year declines despite increases at public corporations and incorporated administrative agencies (Figure 2-1-25).

2.1.6.4 Universities and Colleges[13]

By source of funding for R&D expenditures at universities and colleges in FY2002, the government accounted for about 50% of the total. The total R&D expenditures at universities and colleges increased by 1.5% over the previous fiscal year to 3.2823 trillion yen, accounting for about 20% of Japan's total R&D expenditures .

For trends in R&D expenditures by type of university, national and private universities registered year-on-year increases. Likewise, all fields of study within the natural sciences registered year-on-year increases (Figure 2-1-26).

11 Non-profit institutions: Corporations, groups, etc., such as incorporated foundations or incorporated bodies that do not seek private profit.

12 Public organizations: National and local government-owned research institutions and public corporations and independent administrative institutions whose primary business is research and development

13 Universities and colleges: Departments of universities and colleges (including graduate schools), junior colleges, colleges of technology, research institutions attached to the universities and colleges and inter-university research institutes, National Institution for Academic Degrees and Center for National University Finance.

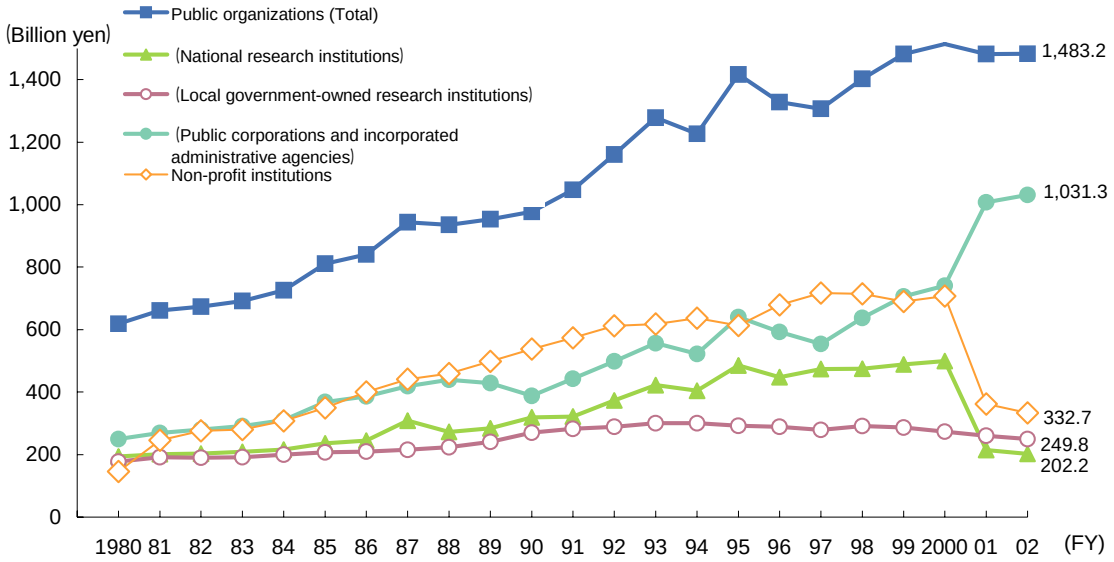


Figure 2-1-25 Trends in R&D expenditures for non-profit institutions and public Organizations

Note: Survey coverage categories were changed in FY2001; figures up to FY2000 use values for the following organizations:
Public organizations: Government research institutions (within which, “Public corporations and independent administrative institutions” uses the values for “Public corporations” up to FY2000)
Non-profit intstitutions: Private research institutions
Source:Statistics Bureau. "Report on the Survey of Research and Development"
(See Appendix 3. (5))

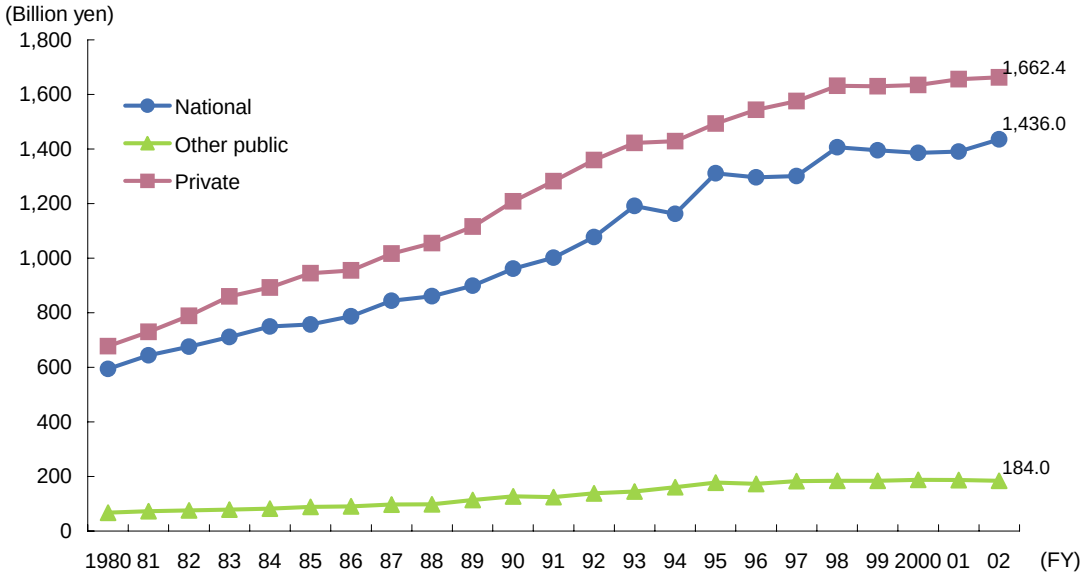


Figure 2-1-26 (1) Trends in R&D expenditures at universities and colleges, by type of university

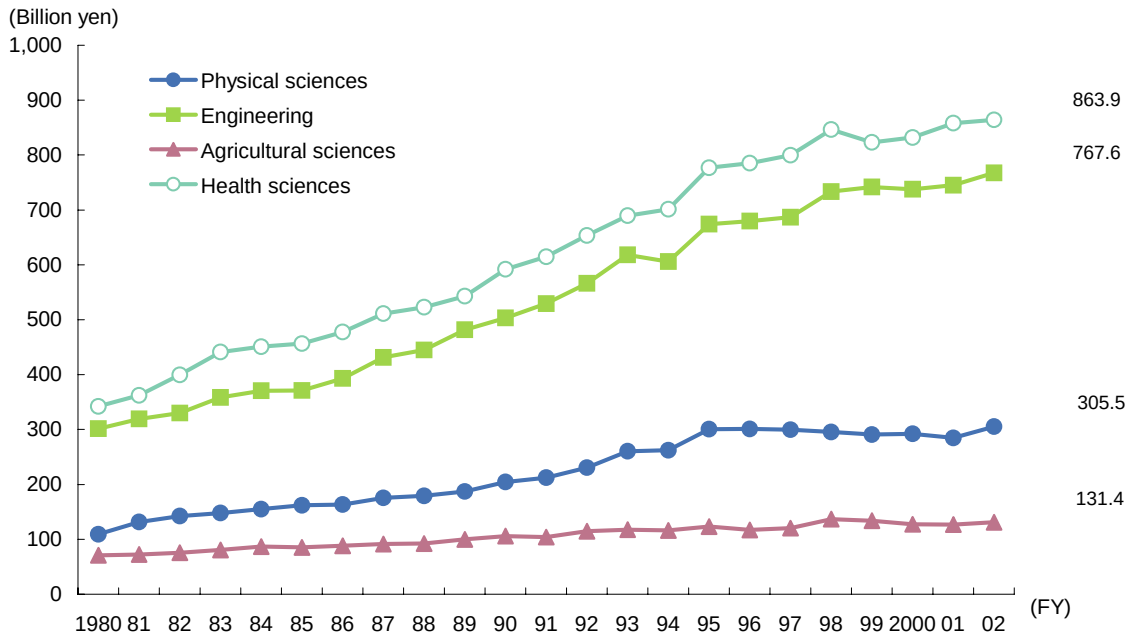


Figure 2-1-26 (2) Trends in R&D expenditures at universities and colleges, by field

Note: The figures by type of university include the humanities and social sciences.
Source: Statistics Bureau. "Report on the Survey of Research and Development"
(See Appendix 3. (5))

2.1.7 R&D Expenditures in Japan by Type

R&D expenditures break down into labor costs, materials, expenditures on tangible fixed assets (land and buildings, machinery, instruments, equipment and others), and lease fees (newly established in the FY2001 survey) and other expenses.

An examination of Japan's R&D expenditures by type reveals that total labor costs decreased by 0.1% over the previous fiscal year to 7.3996 trillion yen. The total expenditures for materials decreased by 3.9% over the previous fiscal year to 2.7502 trillion yen. The total expenditures for tangible fixed asset purchases also decreased, registering a 3.0% decrease over the previous fiscal year to 1.7526 trillion yen. On the other hand, the total expenditures for lease fees increased by 6.2% over the previous fiscal year to 177.2 billion yen. The share of other expenses required for research, such as books and journals, utilities, travel, and telecommunications, etc., increased by 7.2 % over the previous fiscal year to 4.5955 trillion yen (Figure 2-1-27).

Moreover, the trends in the composition of expenditures reveal that while labor cost has long held the largest share of overall expenditures, that share has been declining in recent years. Tangible fixed asset purchase expenditures are also declining. The shares of materials cost and other expenditures have remained almost the same (Figure 2-1-28).

Company R&D expenditures by category rose with the exception of tangible fixed asset purchase expenditures and lease fees (Figure 2-1-29).

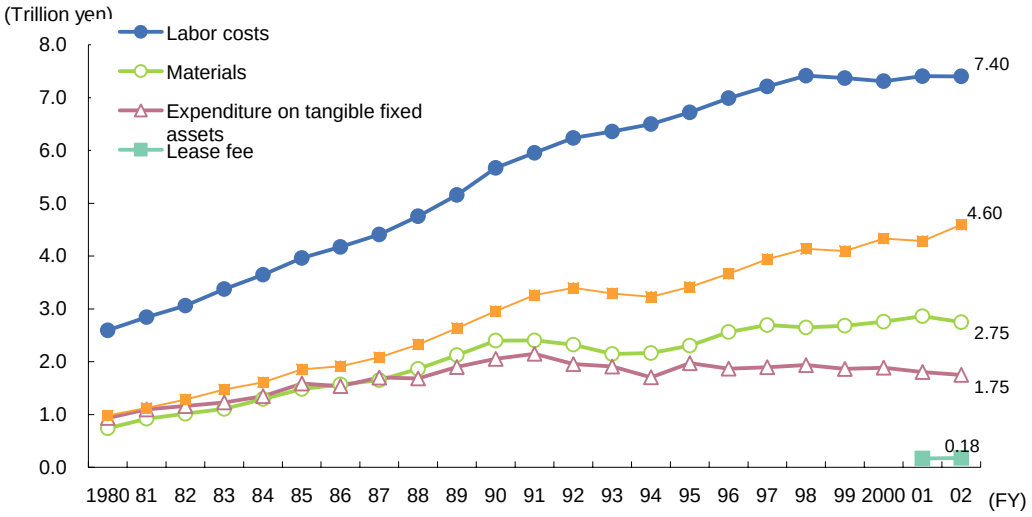


Figure 2-1-27 Trends in R&D expenditures by type

Notes: 1. The humanities and social sciences are included.

2. Lease fee was added as an expenditure in FY2001.

3. Some Industries were added as new survey targets in FY1996 and FY2001.

Source: Statistics Bureau. "Report on the Survey of Research and Development"

(See Appendix 3. (6))

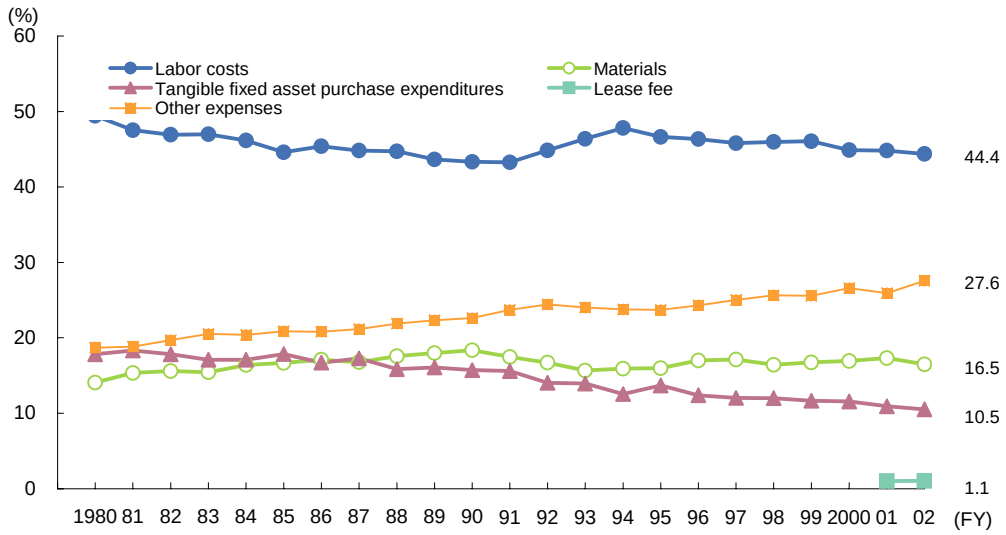


Figure 2-1-28 Trends in R&D expenditures by constituent elements

Notes: 1. The humanities and social sciences are included.

2. Lease fee was added as an expenditure in FY2001.

3. Some Industries were added as new survey targets in FY1996 and FY2001.

Source: Statistics Bureau. "Report on the Survey of Research and Development"

(See Appendix 3. (6))

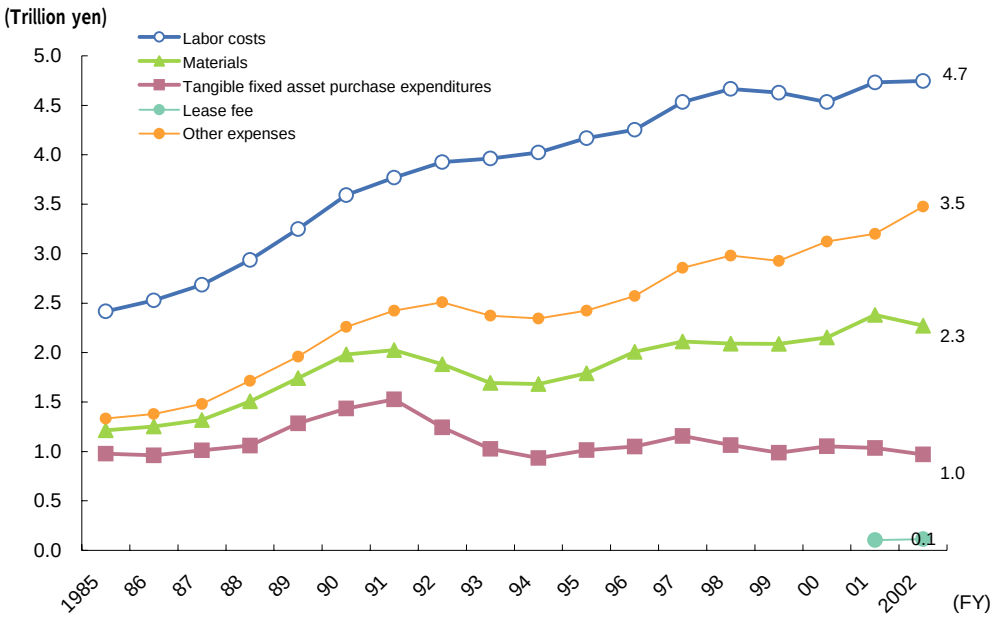


Figure 2-1-29 Trends in R&D expenditures at business enterprises, by type

Notes: 1. Lease fee was added as an expenditure in FY2001.
2. The software industry and wholesale trade were newly added to the scope of the survey in FY1996 and FY2001, respectively.

Source: Statistics Bureau. "Report on the Survey of Research and Development"
(See Appendix 3. (6))

Non-profit institutions and public organizations had lower ratios than any other institutions on expenditures for labor costs, while their tangible fixed asset purchase expenditures showed higher ratios. When looking at expenditures by type of institution, local government-owned institutions were characterized by exceptionally high labor costs. On the other hand, public corporations and incorporated administrative agencies have higher ratios of expenditures for the purchase of tangible fixed assets, because they include those requiring large-scale facilities and equipment for nuclear and space R&D (Figure 2-1-30).

Universities and colleges had a higher share of labor costs than other institutions, accounting for about 65% of expenditures, while raw material costs were the lowest in share. When looking at expenditures by the field of study within the natural sciences, all areas had lower than average shares of labor costs, while the physical sciences and engineering in particular tended to require larger than average shares of total costs for tangible fixed assets (Figure 2-1-31).

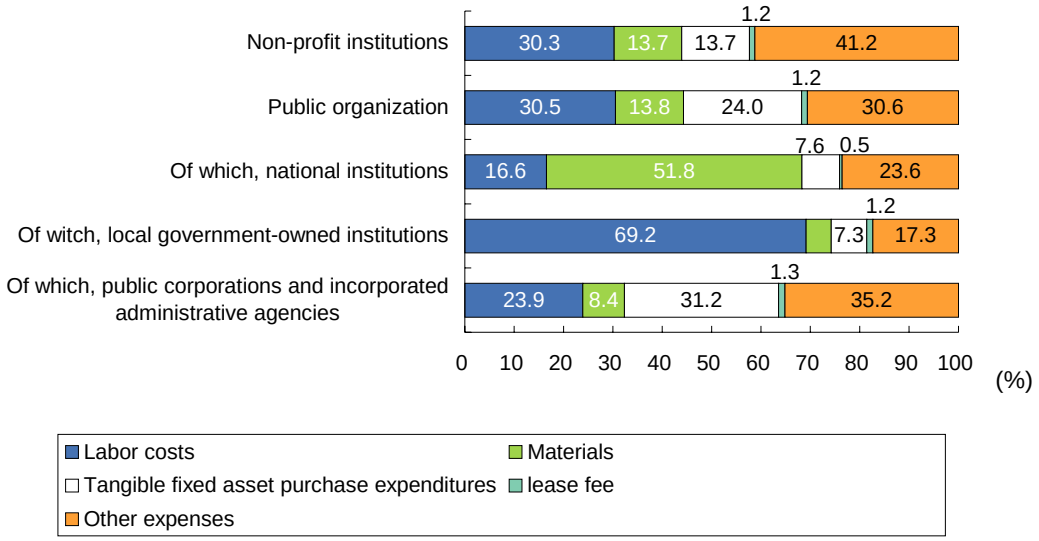


Figure 2-1-30 Composition of research expenditures at non-profit institutions and public organizations by type (FY2002)

Source: Statistics Bureau. "Report on the Survey of Research and Development"
(See Appendix 3. (6))

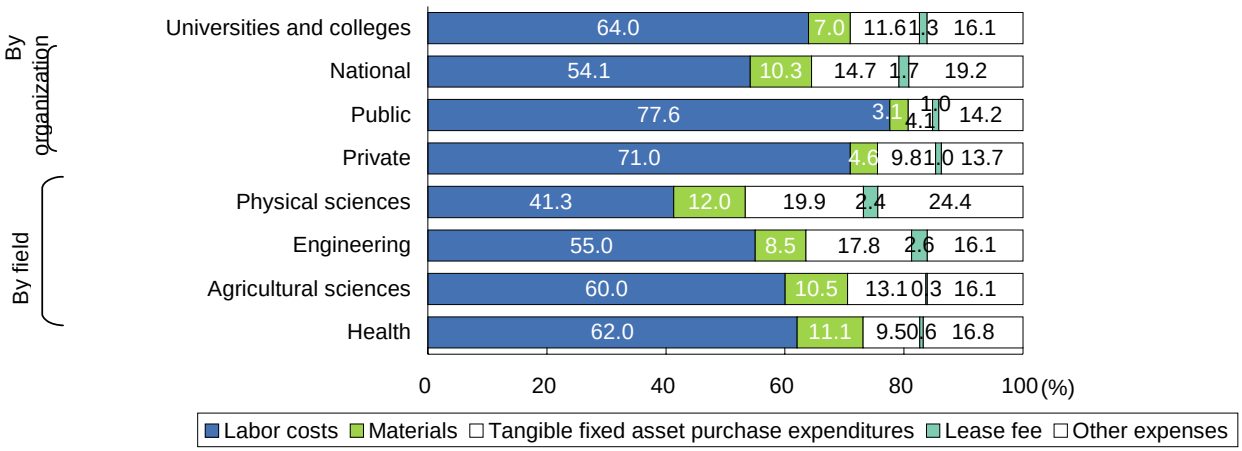


Figure 2-1-31 Composition of R&D expenditures at universities and colleges, by type (FY2002)

Note: The figures for all universities and colleges and those by organization include the humanities and social sciences.
Source: Statistics Bureau. "Report on the Survey of Research and Development"
(See Appendix 3. (6))

2.2 Research Personnel

Statistics on research personnel, along with those on R&D expenditures, are another effective indicator of the extent of research activities. Personnel engaged in R&D[14] can be classified as researchers and support personnel (assistant research workers, technicians, and clerical and other supporting personnel).

2.2.1 Researchers

2.2.1.1 Number of Researchers

Countries use different methods for determining the number of researchers. The Frascati Manual defines researchers as "professionals engaged in the conception or creation of new knowledge, product processes, methods, and systems, and in the management of the projects concerned." But this definition is quite vague, and countries that follow the Frascati Manual also specify their own definitions of the term "researcher" for counting researchers.

For this reason, there are differences between countries in methods for measuring the number of researchers, and international comparisons are difficult. In comparison between Japan and the United States, the number of researchers counted in the Report on the Survey of Research & Development conducted by the Statistics Bureau of Japan's Ministry of Internal Affairs and Communications is not exactly equivalent to the researchers counted in the U.S. National Science Foundation's National Patterns of R&D Resources. Differences of methods for determining the numbers of researchers are shown in Table 2-2-1, and would appear to be obstructing a fair statistical comparison. The category of researcher at universities and colleges, in Japan, consisting of teachers, doctoral students, medical staff, etc., differs between Japan and the United States in the following ways.

(1) Teaching Staff

In 1995, a year in which it's possible to compare teachers in Japan and the United States, 160,634 teachers at universities and colleges in Japan, including those in the humanities and social sciences, were classified as researchers, while in the United States only the 89,300 university and college teaching personnel who responded that they had obtained a doctoral degree and were primarily engaged in research were classified as researchers—a smaller result than in Japan.

It would appear, then, that the number of teaching personnel in the United States who are involved in research is much larger than in Japan when the same kind of statistics are used. On the other hand, if the same statistical method used in the United States were applied to Japan, the number of Japanese researchers would be smaller.

14 ・Research personnel: "Report on the Survey of Research and Development" compiled by the Statistics Bureau classifies personnel engaged in R&D as follows. (2002 revision)
・Researcher: Persons who hold a university degree (or persons who have equivalent or greater knowledge in their specialty), who are engaged in research activities in their own chosen subject. "Researchers" as used herein, refers only to full-time researchers, and excludes those who also perform other duties in addition to research.
・Assistant research workers: Persons who assist researchers and who are engaged in research activities under their direction and who have the possibility of becoming researchers in the future.
・Technicians: Persons, other than researchers and assistant research workers, who are engaged in technical services related to research activities under the guidance and supervision of researchers and assistant research workers.
・Clerical and other supporting personnel: Excepting those mentioned above, persons who are engaged in miscellaneous activities, clerical work, accounting, etc., relating to research activities. Japanese statistics on persons engaged in R&D are as of April 1 of the appropriate year up to 2001, and as of March 31 for 2002.

Table 2-2-1 Comparison of Japanese and U.S. definitions of researchers

Country	Japan (until 2001)	United States
Companies	• Have university graduate (or higher) qualifications • Two years or more of research experience • Have a research theme in which conducting research • Researchers calculated by FTE	• University graduate level, or have equivalent or higher level of expert knowledge • Engaged in research themes • Researchers calculated by FTE
Private research institutions	• Have university graduate (or higher) qualifications • Two years or more of research experience • Have a research theme in which conducting research • Researchers calculated by FTE	• People who have Ph.D.s, and who state that they are mainly engaged in research and development • Actual number of researchers (head count)
Government research institutions	• Have university graduate (or higher) qualifications • Two years or more of research experience • Have a research theme in which conducting research • Researchers calculated by FTE	• People who have Ph.D.s, and who state that they are mainly engaged in research and development (excluding military-related personnel) • Actual number of researchers (head count)
Universities and colleges	• Teachers, enrolled doctoral students, medical staff, or those who have university graduate (or higher) qualifications • Two years or more of research experience • Engaged in research themes (including teaching staff) • Actual number of researchers (head count) (FTE values are also reported to the OECD)	• People who have Ph.D.s, and who state that they are mainly engaged in research and development, and university graduates engaged in research assistance • Actual number of researchers (head count), excluding graduate students • Graduate students are FTE converted with a 50% coefficient

Note: In Japan, categories were changed during a 2002 survey revision to “Business enterprises,” “non-profit institutions,” and public organizations.” The requirement of “two years or more of research experience” was cut.

Source: Japan ─ Ministry of Internal Affairs and Communications, Statistics Bureau (Statistics Bureau). "Report on the Survey of Research and Development"

United States ─ National Science Foundation. "National Patterns of R&D Resources: 2002 Data Update"

(2) Number of Graduate School Students

A comparison for 1999 reveals that 59,057 people who were studying in doctoral courses, including the humanities and social sciences, in Japan were classified as researchers. This figure is virtually identical to the 1999 figure of 59,007 graduate school students in doctoral courses counted in the Ministry of Education, Culture, Sports, Science and Technology’s “Handbook of Education, Culture, Sports, Science and Technology Statistics (2003 edition).”

In the United States, however, the number of graduate school students receiving remuneration for research assistance work is 91,308 people (NSF, “Science and Engineering Indicators 2002”), which is reduced by the FTE (Full-Time Equivalent) rate coefficient of 50% to arrive at a total of 45,700 researchers. In the United States, therefore, while the count extends beyond doctoral courses to include people in Master’s course programs as well, it is limited to students who are engaged in research assistance work, and is further reduced by a predetermined coefficient. Thus, it is highly probable that the estimate for number of researchers would yield a lower result than Japan’s method of including all students engaged in doctoral course programs.

Therefore, when making comparisons between Japan and the United States, it is important to remember that the measurement of researcher numbers in Japan is overestimated, primarily at the universities. In 2002, the Ministry of Education, Culture, Sports, Science and Technology conducted a “Survey of Full-time Equivalency Data at Universities and Colleges,” the results of which will be used in the future to estimate the number of researchers.

As a result, while there may be differences in the methods of measuring researcher numbers, it

is useful, however, to look at general trends for each country from its own methods. The United States had the largest number of researchers (1999: 1,261,000), followed by Japan, at 757,000 (2002: 646,000 using FTE), and Germany (2001: 264,000) (Figure 2-2-2).

The total number of researchers in Japan increased by 0.75% in FY2002 over the previous year (4.3% using FTE), and was followed by a year-on-year increase of 0.13% in FY2003 (-4.34% using FTE). However, the 2002 survey included revised sections (expansion of surveyed industries, a changed survey date, and an altered definition of researchers, etc.). The annual average rates of increase since 1983 (using FTE) were 4.58% from 1983-1988, 3.91% from 1988-1993, 4.40% from 1993-1998 and 3.01% from 1998-2003.

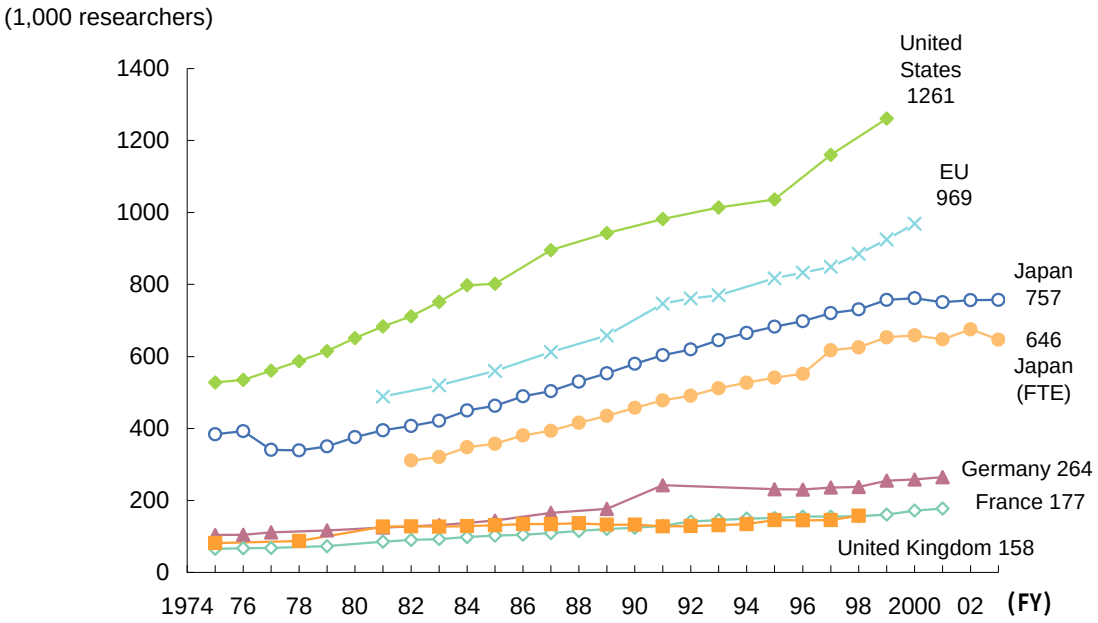


Figure 2-2-2 Trends in numbers of researchers in selected countries

Notes: 1. The figures for all countries include social sciences and humanities.
2. The statistics for Japan also show number of researchers in natural sciences only.
3. Japan's FTE values prior to 1996 are OECD estimates.
4. In Japan, the software industry has been covered in the survey since FY1997 and the wholesale industry since FY2002.
5. U.K. figures through 1983 show total number of researchers in industrial (scientists and researchers) and national institutions (degree-holding researchers and above), and do not include universities and private research institutions.
6. EU (12 countries: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain) figures are OECD estimates.

Source: Japan: Statistics Bureau. "Report on the Survey of Research and Development"
Japan (FTE values), United States, France, United Kingdom, and the EU: OECD, "Main Science and Technology Indicators," Germany: Federal Ministry of Education and Research, "Faktenbericht Forschung"

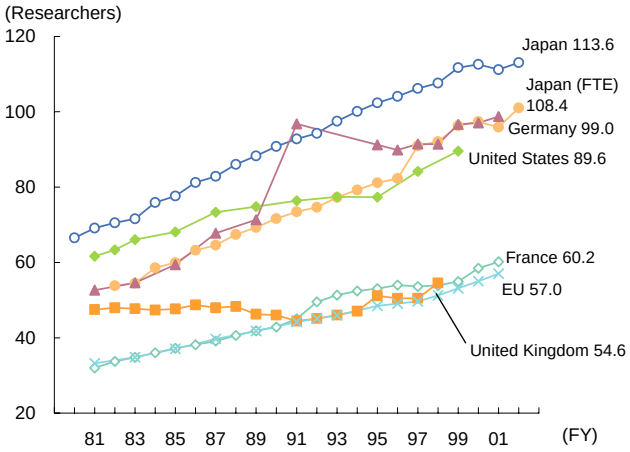
(See Appendix 3. (1))

2.2.1.2 Number of Researchers per 10,000 Population and per 10,000 Laborers

In Japan, the number of researchers per 10,000 people was 59.3 in 2003, while the number of researchers per 10,000 people was 113.6, the highest figures among the advanced nations (Figure 2-2-3).

But the trends in recent years show that the numbers of researchers per 10,000 people and per 10,000 laborers have been stagnant in Japan since about FY2000.

(1)Number of researchers per 10,000 people



(2) Number of researchers per 10,000 labores

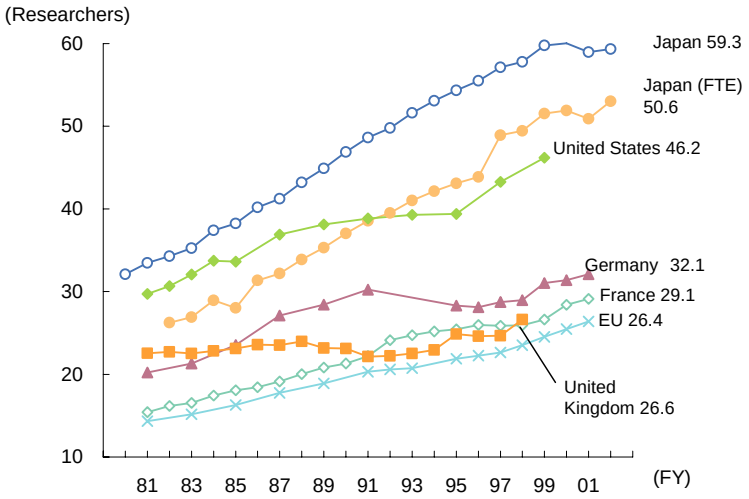


Figure 2-2-3 Trends in numbers of researchers per 10,000 people and 10,000 laborers

Notes: 1. The figures for all countries include social sciences and humanities. The statistics for Japan also show the data for researchers in natural sciences only.

2. Figures for Japan's labor force and number of researchers are as of April 1 of each year.

3. EU figures are OECD estimates.

Source: Number of researchers data: Same as in Figure 2-2-2.

Population and labor force data:

Japan ─ Statistics Bureau. "Population Estimates Series", "Monthly Report on the Labor Force Survey"

Other countries ─ OECD. "Main Science and Technology Indicators," " National Accounts"

(See Appendix 3. (1))

2.2.1.3 Number of Researchers by Sector

As for the number of researchers by type of organization, industry (companies) had the most in Japan at 56.9% of the total, followed by universities and colleges at 37.1% and government research institutions (public institutions) at 4.5%.

The United States has a greater percentage of researchers working in industry, and the percentage of researchers in its government research institutions is low, similar to Japan. In Europe, meanwhile, research personnel are concentrated to a high degree in government research (Figure 2-2-4).

The following sections show the characteristics of researchers in Japan by sector.

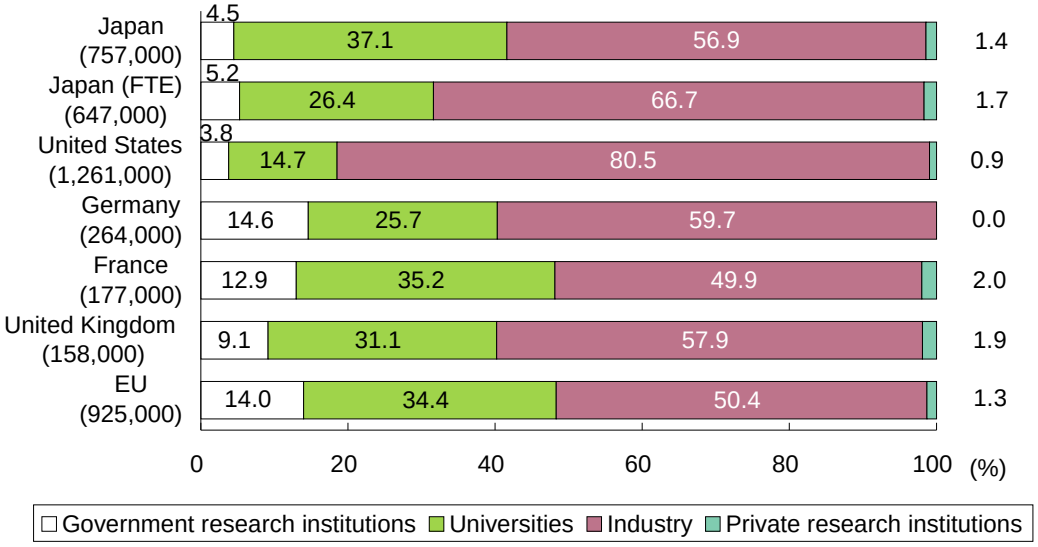


Figure 2-2-4 Share of researchers by sector in selected countries

Notes: 1. For the comparison, statistics for all countries include research in social sciences and humanities. Statistics for Japan, as of March 31, 2002, include the FTE value for public institutions, universities and colleges, companies, and nonprofit organizations.

2. Japan's FTE values are Statistics Bureau data.

3. The data are estimates for Japan in 2003, the United Kingdom in 1998, the United States and the EU in 1999, and Germany and France in 2001.

4. Data for private research institutions in Germany is included in data for government research institutions.

Source: Japan -- Statistics Bureau. "Report on the Survey of Research and Development"

Others -- OECD. "Main Science and Technology Indicators"

2.2.1.3.1 Business Enterprises

In the last five years from 1998 to 2003 (with 2002 using the revised survey), the number of researchers in business enterprises increased by 6.6% (an average annual rate of increase of 1.30%, from 404,000 researchers to 431,000), which, while slowing, is still increasing compared to other organizations. This hints that industry, as well, has come to place great importance on research and development (Figure 2-2-5)

As for the number of researchers by type of industry, the information and telecommunications machinery and equipment industry registered the highest number, followed in order by the automobile industry, the machinery industry, the electronical machinery, equipment and supplier industry, the chemicals industry other than pharmaceuticals (a total of three industries), the electronic parts and devices industry, the pharmaceuticals industry, and the information and telecommunications industry (Figure 2-2-6).

As for the number of researchers out of 10,000 employees, except for academic research institutions, the information and telecommunications machinery and equipment industry had the largest number, at more than 2.8 times higher than the average for all industries, followed in order by the electronic applications and electrical instrument industry, the precision equipment industry, the oils and paints industry, and the general chemicals and chemical fibers industry, in all of which more than one employee in 10 is fully engaged in R&D (Figure 2-2-7).

By field of research, engineering ranks the highest. Next is physical science, followed by health, and finally agricultural sciences. Within the engineering field, researchers are concentrated in “electrical and telecommunications engineering,” and “mechanical engineering, shipbuilding and aeronautical engineering.” Within the physical sciences, chemistry has the majority. These three fields employ more than three-fourths of all Business enterprises researchers (Figure 2-2-8).

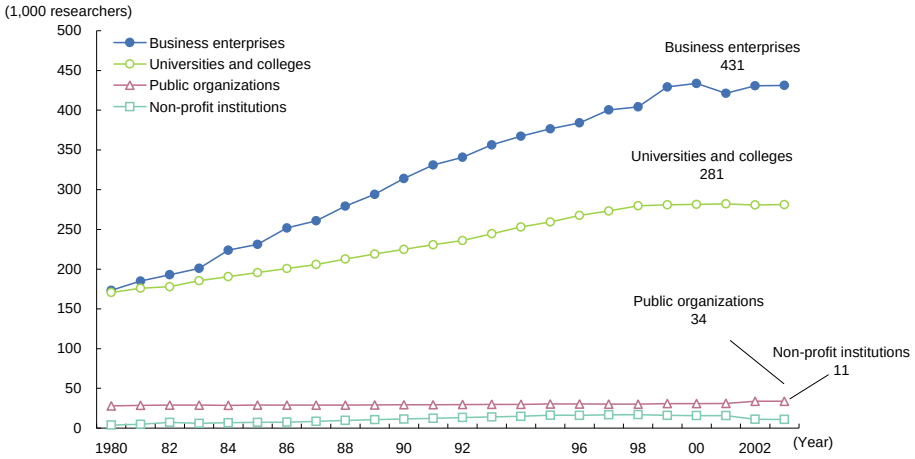


Figure 2-2-5 Trends in numbers of researchers by sector in Japan

Note: 1. Numbers include researchers in the humanities and social sciences and are as of March 31 of each year, except for FY2001, which is as of April 1.

2. Survey categories were changed in FY2002; numbers up to FY2001 are for researchers whose primary duty is research at the following organizations (except at universities and colleges, where the number includes those who conduct research as an additional post).

Up to FY2001	FY2002
Companies	enterprises
Private research institutions	Non-profit institutions
research institutions	Public organizations
Universities and colleges	Universities and colleges

Source: Statistics Bureau. "Report on the Survey of Research and Development"
(See Appendix 3. (8))

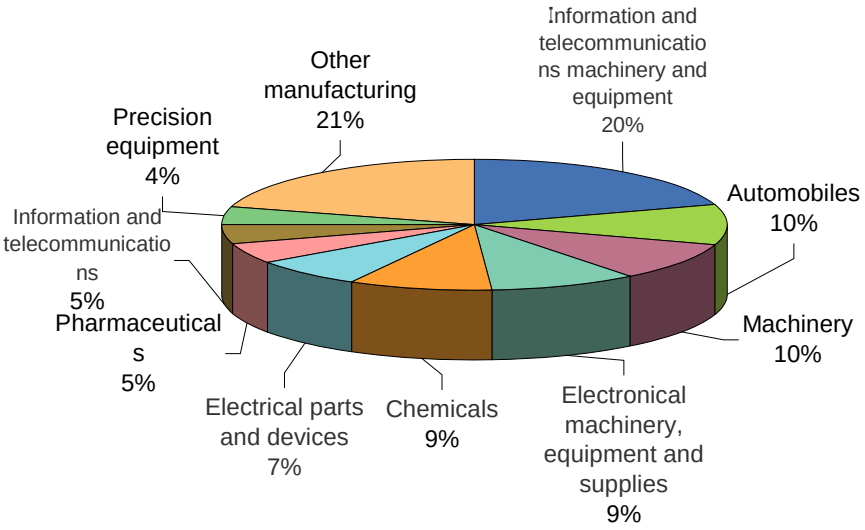


Figure 2-2-6 Researchers at business enterprises, by type of industry (2003)

Source: Statistics Bureau. "Report on the Survey of Research and Development"

(See Appendix 3. (9))

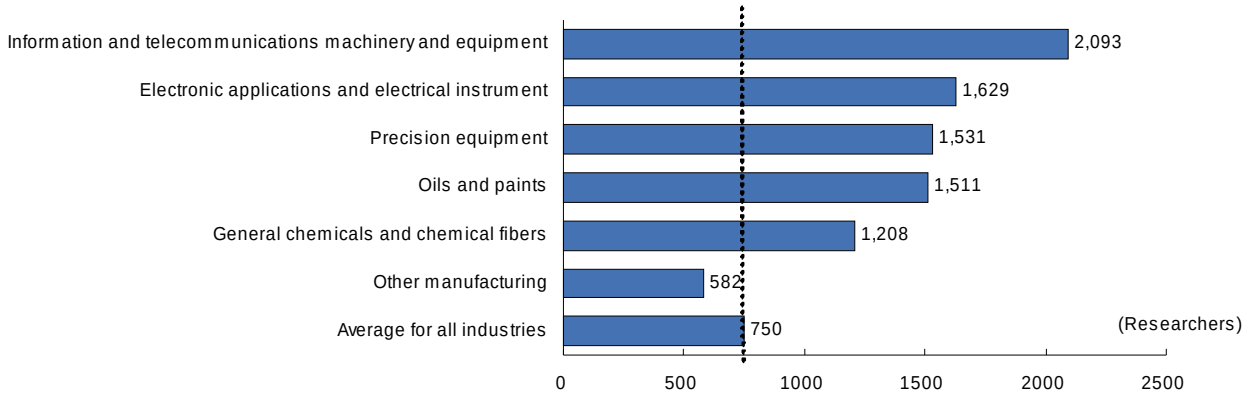


Figure 2-2-7 Number of researchers per 10,000 employees at business enterprises (top five industrial categories except academic research institutions) (2003)

Notes: 1. Regarding researchers per 10,000 employees, the data for number of employees and number of researchers are as of March 31, 2003.

2. Academic research institutions (5,697 researchers per 10,000 employees) are not shown on graph.

Source: Statistics Bureau. "Report on the Survey of Research and Development"

(See Appendix 3. (9))

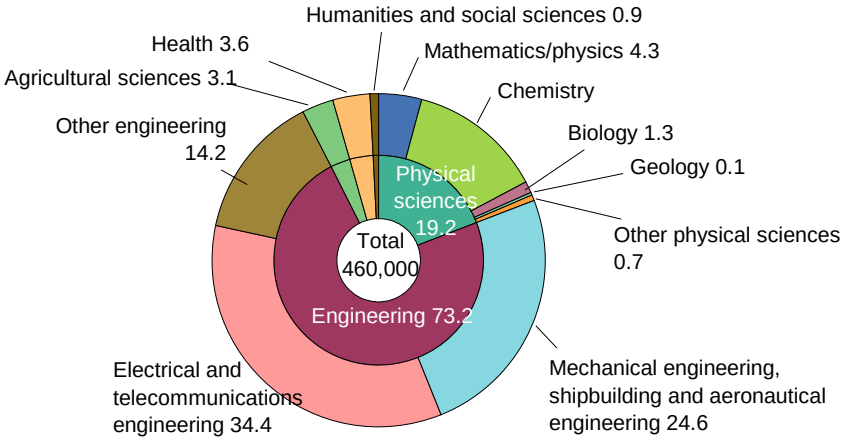


Figure 2-2-8 Composition of number of business enterprises researchers by field of research (2003)

Note: Figures are their shares in percentages to total company researchers.

Source: Statistics Bureau. "Report on the Survey of Research and Development"

2.2.1.3.2 Non-profit Institutions and Public Organizations

A chronological comparison of the number of researchers is made difficult by the transformation of national experimental research institutions into incorporated administrative agencies, in addition to the revision of the Statistics Bureau's "Survey of Research and Development." However, the number of researchers stands at 11,000 in non-profit institutions and within public organizations, at 3,300 in national institutions, 14,500 in local government-owned institutions, and 16,100 in public corporations and incorporated administrative agencies (Figure 2-2-9).

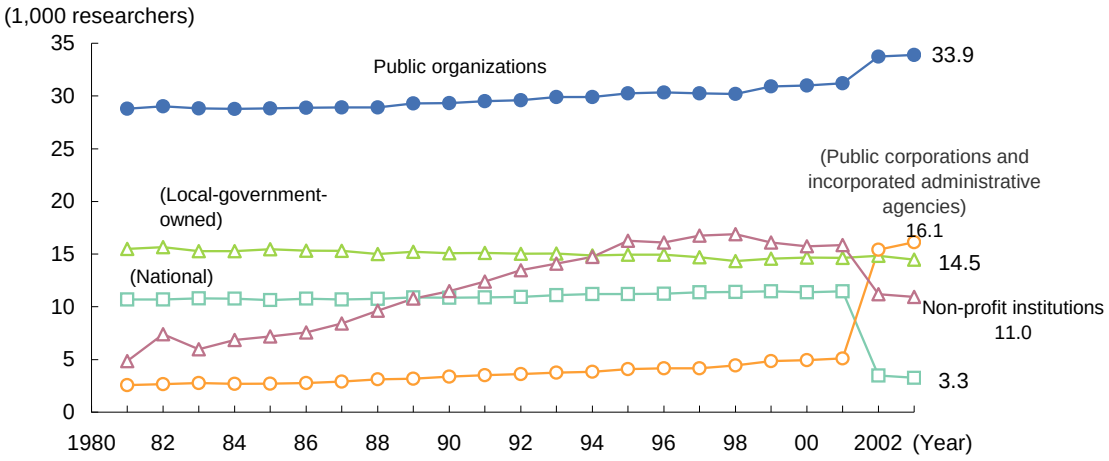


Figure 2-2-9 Trends in the numbers of researchers in nonprofit organizations and public institutions

Notes: 1. Numbers include researchers in the humanities and social sciences and are as of April 1 of each year, ecept for FY2003, which is as of March 31.
2. Survey coverage categories were changed in FY2002; numbers up to FY2001 for non-profit institutions use the values of private research institutions.
3. Values up to FY2001 are for researchers whose primary duty is research.
Source: Statistics Bureau. "Report on the Survey of Research and Development"
(See Appendix 3. (8))

When looking at sector composition, a disproportionately large share of researchers was seen in engineering at non-profit institutions and among public organizations, in health and engineering at national institutions, in agricultural sciences at local government-owned institutions, and in engineering and the physical sciences at public corporations and incorporated administrative agencies (Figure 2-2-10).

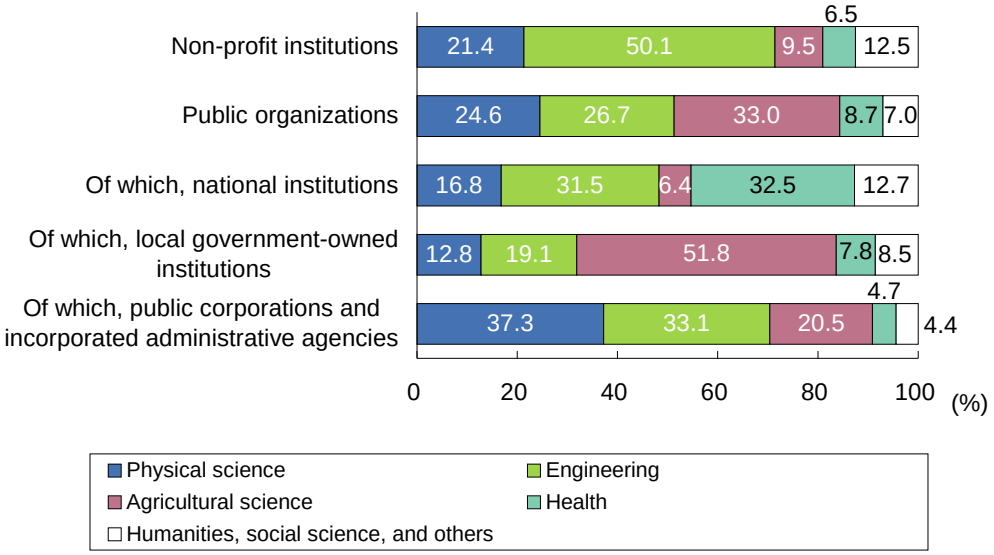


Figure 2-2-10 Composition of researchers in non-profit institutions and public organizations by organization and field (2003)

Note: The number of researchers is as of March 31, 2003.
Source: Statistics Bureau. "Report on the Survey of Research and Development"

2.2.1.3.3 Universities and Colleges

The number of researchers at universities and colleges, including those in the humanities and social sciences, has increased by 0.6% in the last five years (1998-2003, an average annual rate of increase of 0.12%) up to 281,000 researchers from 280,000. Looking at the number of researchers by type of institution in 2003, private universities and colleges have 131,000 researchers, the largest portion of the total researchers at universities and colleges, followed by national universities and colleges (128,000), after which comes local public universities and colleges (22,000) (Figure 2-2-11). However, in terms of researchers whose primary role is research, the order becomes national universities (122,000), followed by private universities (117,000), and then local public universities (18,000).

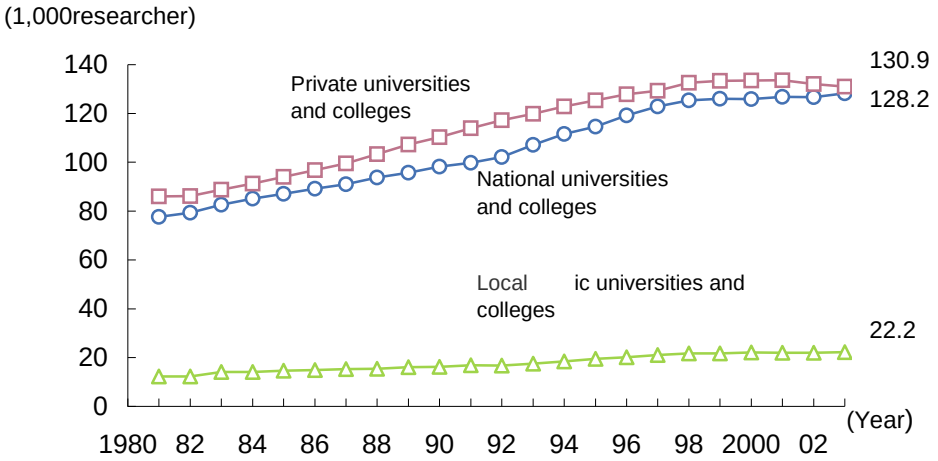


Figure 2-2-11 Trends in numbers of researchers in universities and colleges

Note: Numbers include researchers in the humanities and social sciences and are as of April 1 of each year, except for FY2003, which is as of March 31.

Source: Statistics Bureau. "Report on the Survey of Research and Development"

(See Appendix 3. (8))

Researchers in universities and colleges consist of faculty members, doctoral students, medical staff and others. Looking at the composition of researchers by type of institution, in national universities and colleges, doctoral students make up a large ratio of the researchers, and private universities and colleges have a greater ratio of teachers and medical staffs and a smaller ratio of students for doctoral degrees. The figures for public universities and colleges fall in between those for the national universities and the private universities and colleges (Figure 2-2-12).

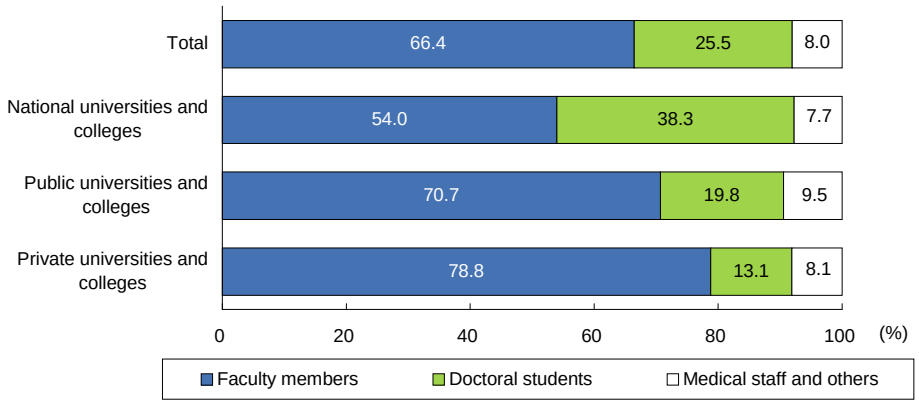


Figure 2-2-12 Composition of researchers in universities and colleges (2003)

Note: Numbers include researchers in the humanities and social sciences as of March 31, 2003.

Source: Statistics Bureau. "Report on the Survey of Research and Development"

By sector composition, a large share of university researchers were health specialists, whether faculty members, doctoral students, or medical staff. Other sectors with relatively high shares of the total were engineering, for teachers, and science, for students in doctorate programs (Figure 2-2-13).

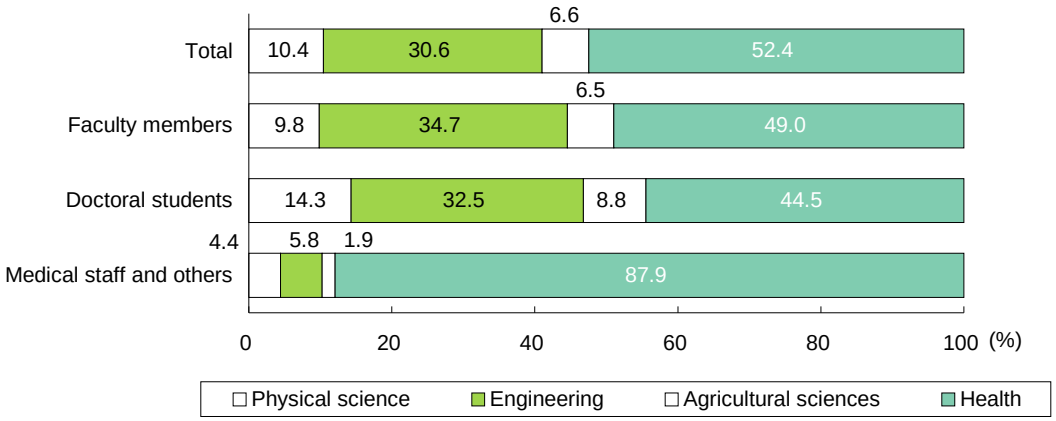


Figure 2-2-13 Share of researchers in the natural sciences at universities and colleges by field (2003)

For the number of researchers by academic field in the most recent five-year period (1998-2003), balanced annual growth rates are seen in the physical sciences (at 0.16%), engineering (at 1.85%), and agricultural sciences (at 1.03%), while the health sciences registered a decline of an average annual rate of 1.47% (Figure 2-2-14).

Looking at specific sectors, the electrical and communications sectors (average annual growth rate of 2.76%) and civil engineering and architecture (average annual growth rate of 2.04%) are showing particularly fast increases in the number of researchers (Figure 2-2-15).

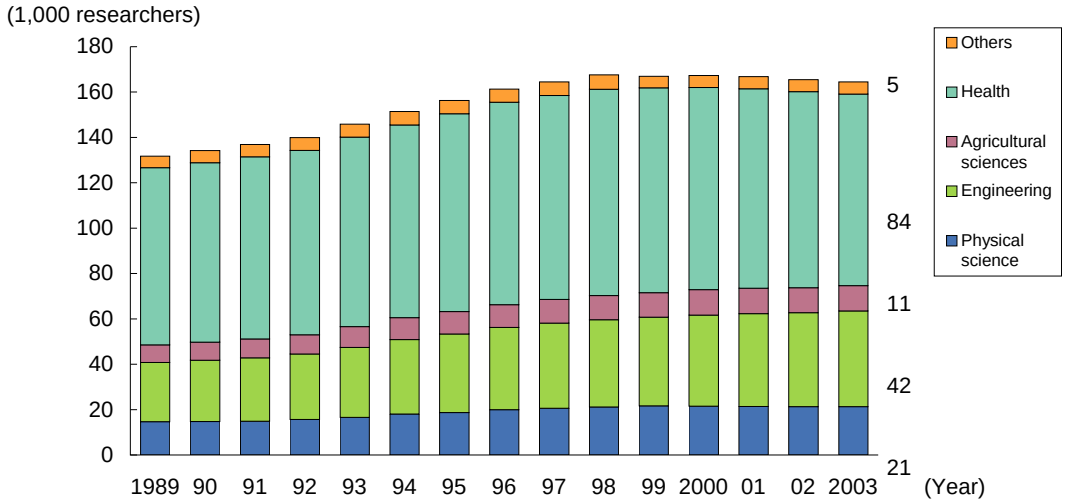


Figure 2-2-14 Trends in the numbers of researchers at universities and colleges (five fields)

Note: The number of researchers is for the natural sciences only and is as of March 31 of each year, except for FY2003,which is as of April 1.

Source: Statistics Bureau. "Report on the Survey of Research and Development"

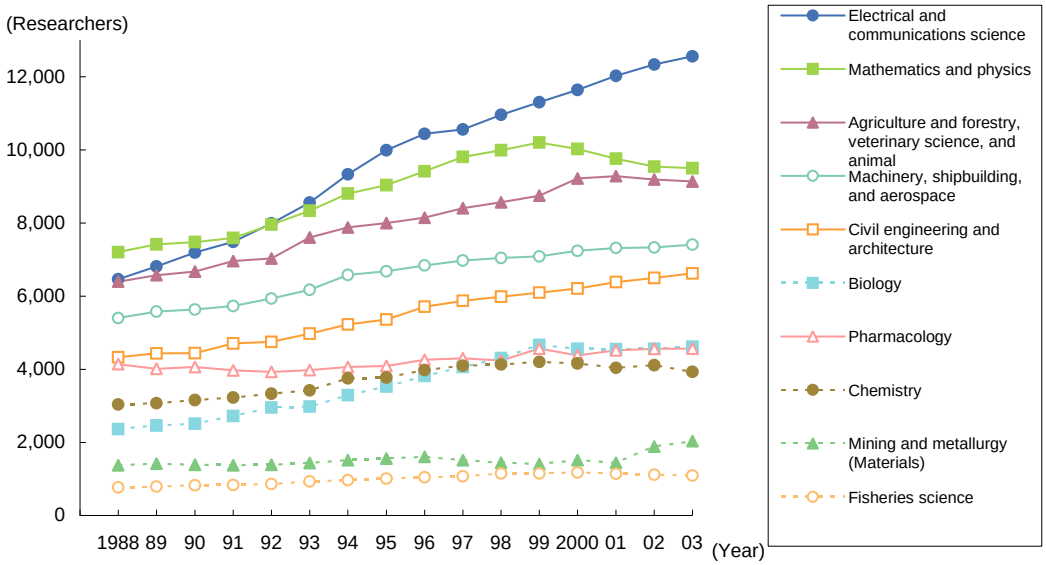


Figure 2-2-15 Trends in the number of researchers at universities and colleges (ten fields)

Notes: 1. The number of researchers is for the natural sciences only and is as of March 31 of each year, except for FY2001, which is as of April 1.

2. “Mining and metallurgy” was changed in FY2002 to “materials,” to which was added materials engineering, raw materials engineering, and materials process engineering, etc.

Source: Statistics Bureau. "Report on the Survey of Research and Development"

2.2.1.3.4 Women Researchers

Women researchers, including those in the humanities and social sciences, have steadily increased year by year, reaching 89,000 in 2003, representing about 11.2% of the total number of researchers (Figure 2-2-16). But looking at all workers, 25.97 million women employees accounted for 41.1% of the total of 63.16 million employees in Japan in 2001, according to the "Labor Survey of the Ministry of Internal Affairs and Communications." It is clear that the ratio of women engaged in the R&D field remains lower than that of women in the labor market in general. The proportion of women researchers by type of organization was 5.9% at companies, etc., 8.8% at non-profit institutions, 11.5% at public organizations, and 19.9% at universities and colleges, clearly demonstrating that universities and colleges provide women researchers more opportunities than elsewhere.

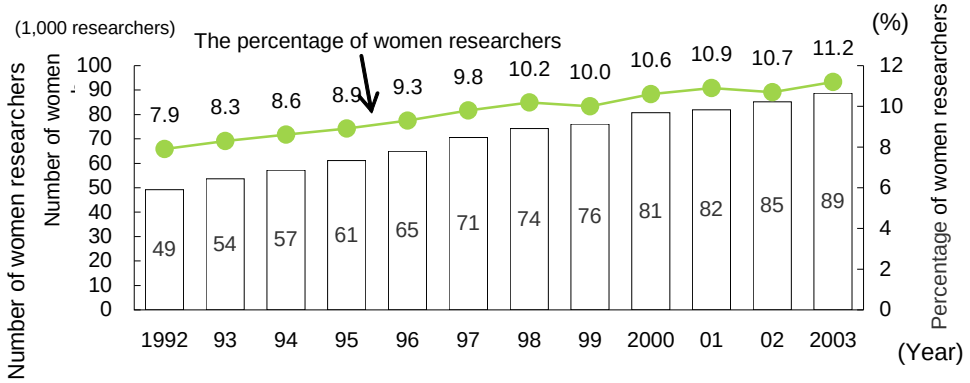


Figure 2-2-16 The percentage of all researchers that are women

Note: Numbers include researchers in the humanities and social sciences and are as of March31 of each year, exceptfor FY2001, which is as of April 1.

Source: Statistics Bureau. "Report on the Survey of Research and Development"

2.2.2 Personnel Engaged in R&D

The definition of personnel engaged in R&D, which includes both regular researchers and research support staff, varies in scope from one country to the next, so that simple comparisons are probably untenable. Nevertheless, in just such a comparison with the selected countries of Europe, Japan had the largest number of personnel engaged in R&D at 968,000, followed in order by Germany, France, and the United Kingdom.

Japan has relatively low numbers of personnel who are engaged in R&D but are not researchers themselves, with 0.28 research support staff for each researcher, a figure that is one-third the standard for European nations (Figure 2-2-17). Moreover, even if Japan's researchers are counted according to the FTE method, the number of people engaged in research is 892,000 (of which researchers number 676,000), and the number of research support staff is slightly higher, yet still low, at 0.32 per researcher.

The number of research and development-related workers in Japan showed a year-on-year decline in FY2000, and a 3.1% decline in the most recent five-year period (1998-2003). The downward trend in the number of research assistants was strengthened in the same five-year period, declining by 21.5%, an annual average of -4.8% (Figure 2-2-18).

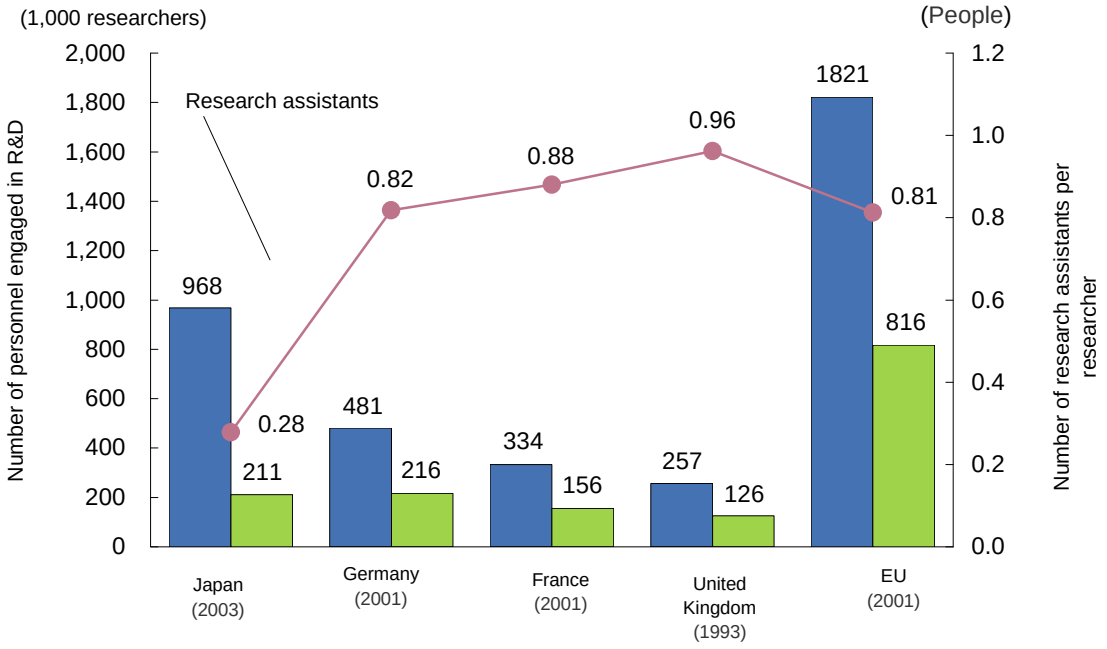


Figure 2-2-17 Number of research assistants per researcher in selected countries

Notes: 1. For comparison, figures for all countries include social sciences and humanities.
2. Figures for EU are OECD estimates.
3. Research assistants refers to people who assist researchers, people who provide technical services that add value to research, and people employed in research administration, which in Japan is referred to as assistant research workers, technicians, and clerical and other supporting personnel.

Source: Japan — Statistics Bureau. "Report on the Survey of Research and Development"
Others — OECD. "Main Science and Technology Indicators"

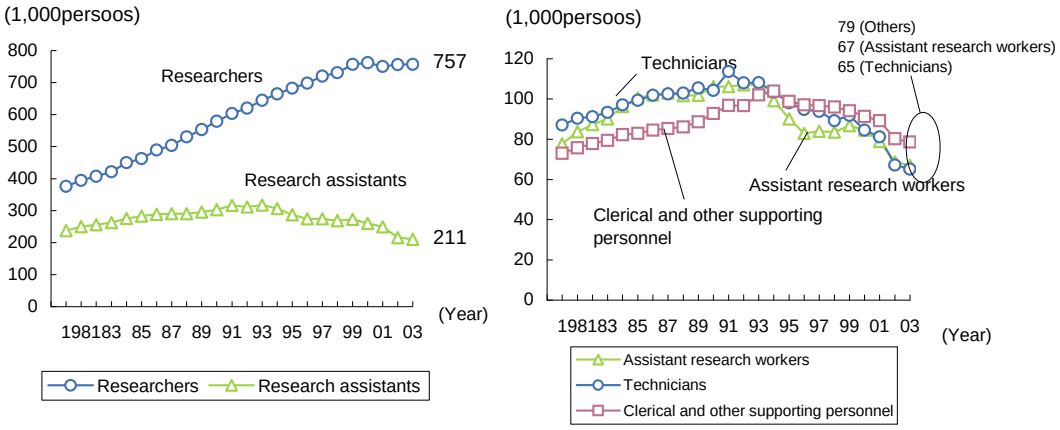


Figure 2-2-18 Trends in persons engaged in R&D in Japan

Note: Numbers include personnel in the humanities and social sciences and are as of March 31 of each year, except for FY2001, which is as of April 1.

Source: Statistics Bureau. "Report on the Survey of Research and Development"

(See Appendix 3. (7))

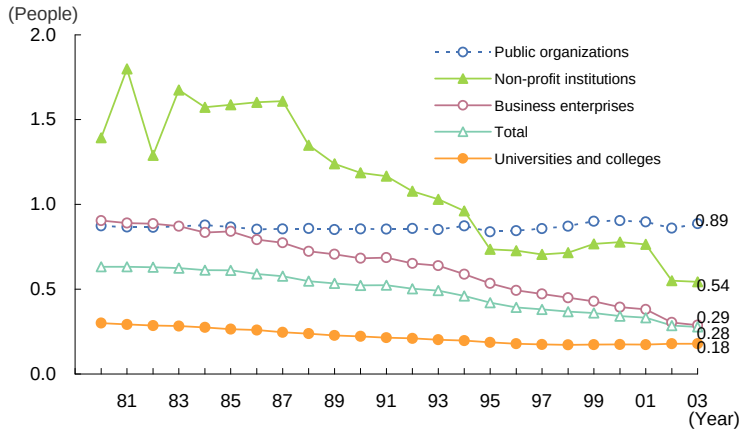


Figure 2-2-19 Trend in the numbers of research assistants per researcher in Japan

Notes: 1. The numbers of researcher and research assistants include those in the humanities and social sciences and are as of March 31 of each year, except for FY2001, which is as of April 1.

2. Survey categories were changed in FY2002; numbers up to FY2001 are for researchers at the following organizations:

Up to FY2001	FY2002
Companies	Business enterprises
Private research institutions	Non-profit institutions
Government research institutions	Public organizations
Universities and	Universities and colleges

Source: Statistics Bureau. "Report on the Survey of Research and Development"

(See Appendix 3. (7))

The percentage of researchers of all personnel engaged in R&D has increased from 73.1 % in 1998 to 78.2% in 2003. On the other hand, the share of assistant research workers decreased from 8.4% to 6.9%. The percentage of technicians decreased from 8.9% to 6.7%. Clerical and other supporting personnel have decreased from 9.6% to 8.1%. In this way, the number of research assistants per researcher continues to decrease. However, promotion of the Science and Technology Basic Plan has curbed the downward trend at public institutions and universities and colleges (Figure 2-2-19).

The composition by organization of the number of personnel engaged in R&D in Japan reveals that all universities and colleges, including both public and private schools, have the lowest number of research support staff per researcher (Figure 2-2-20).

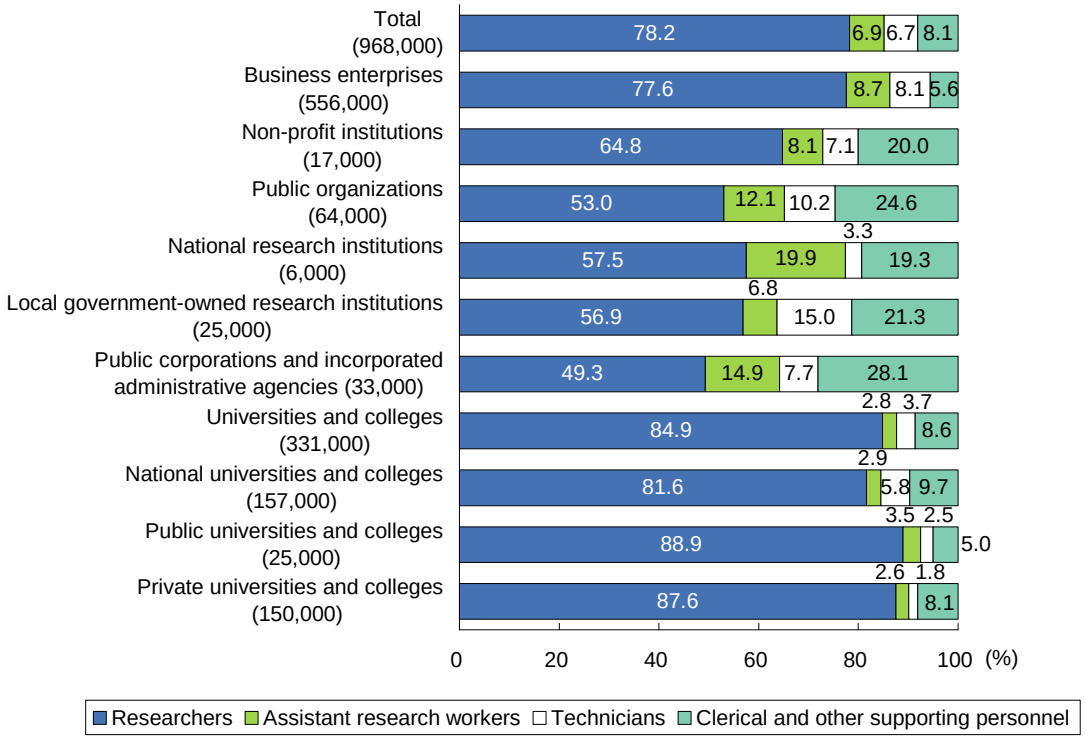


Figure 2-2-20 Composition of personnel engaged in R&D by sector in Japan (2003)

Note: Numbers for all personnel engaged in R&D include those in the humanities and social sciences and are as of March 31, 2003.

Source: Statistics Bureau. "Report on the Survey of Research and Development"

2.2.3 Production and Employment of Research Personnel

2.2.3.1 Overall Degree Trends

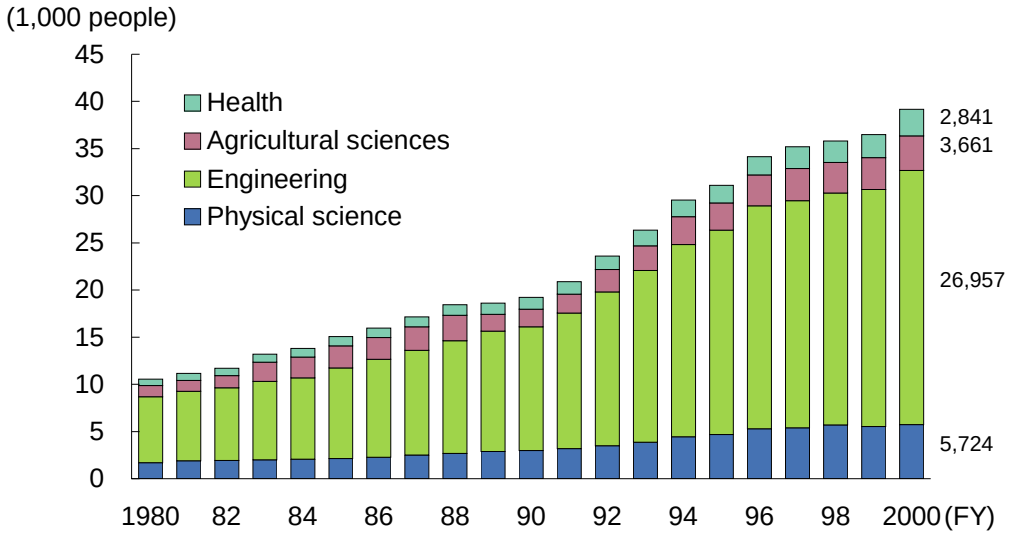
The number of people acquiring a master's degree or doctoral degree in the natural sciences in Japan has been rising alongside an expansion of graduate schools. While the number of doctorates decreased in FY1999, those conferred in FY2000 exceeded those conferred in FY1998. During the five-year period from FY1995 to FY2000, the number of master's degrees conferred rose by 1.26 times (average annual growth rate of 5.1%), and the number of doctorates by 1.12 times (average annual growth rate of 2.3%) (Figure 2-2-21). Looking at degrees by major for FY2000, the engineering field accounted for the largest number of new master's degree holders at 26,957, while the largest number of new Ph.D.s was in the health science field at 7,053.

Master's and doctoral degrees differ from country to country due to differences in culture and educational systems. Social factors such as industrial structure and numbers of students can affect the number of awarded degrees. Thus, it is difficult to compare the data at face value. It is useful, however, to compare trends, and this section describes the degree trends in the natural sciences and engineering in selected countries.

The United States awards the largest number of degrees, a little over three times as many as does Japan. Compared to 1980, the ratio of engineering and health science degrees to total degrees has increased. Japan is second in number of degrees awarded, following the U.S., and has a higher ratio in engineering. The United Kingdom, Germany and France follow in the order named. Of these countries, Germany has a higher ratio in the physical science and health science fields, the U.K. is higher in physical science and engineering, and France has a higher ratio of degrees awarded in health sciences (Figure 2-2-22). Also, if we look at doctorates only, the number in physical science fields in Japan is quite a bit lower than in other selected countries.

The number of graduate school students as a proportion of all university students is also lowest in Japan among selected countries (Figure 2-2-23).

(1) Master's degree



(2) Doctorates

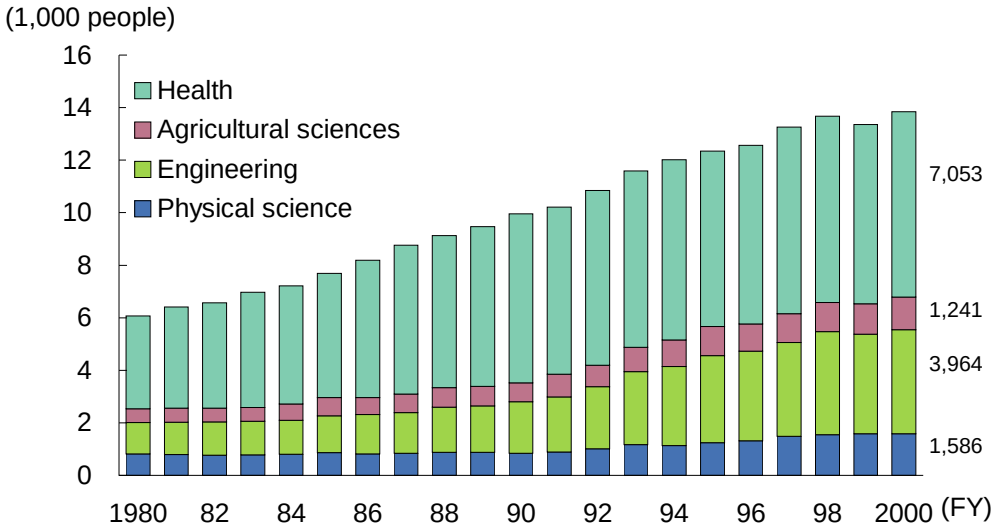
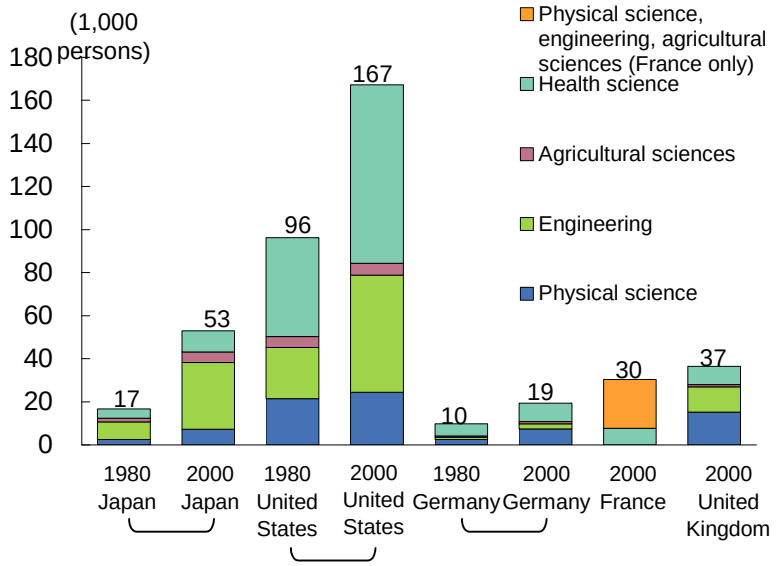


Figure 2-2-21 Degree trends in Japan (natural science)

Note: The figures are awarded degrees in FY2000.

Source: MEXT. "Statistical Abstract of Education, Science and Culture 2004."

(1) Total (awarded at graduate schools)



(2) Doctorates

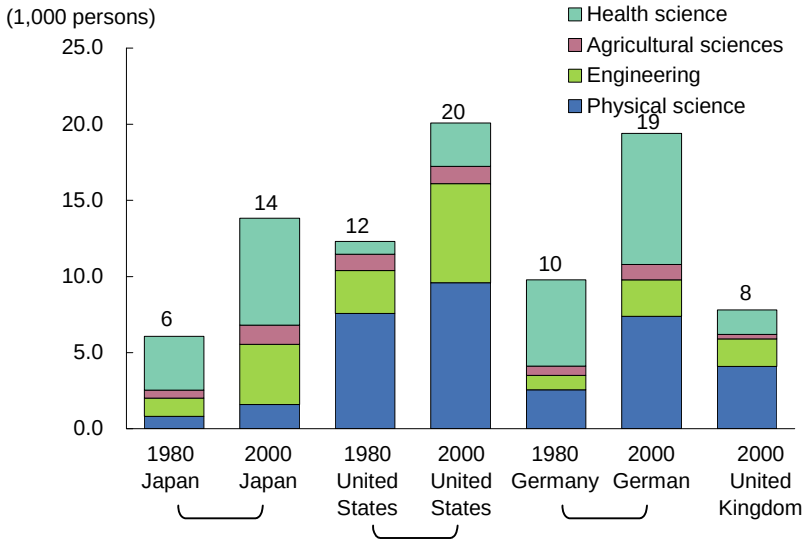


Figure 2-2-22 Number of awarded degrees in selected countries (natural science)

Notes: 1. Totals include master's and doctoral degrees (Germany: only doctorates). U.S. health sciences include first-professional degrees.

2. 1980 data for Germany are for the former West Germany.

3. France does not distinguish between physical sciences, engineering, and agricultural sciences.

Source: MEXT. "International Comparison of Education Indexes 2003, 2004."

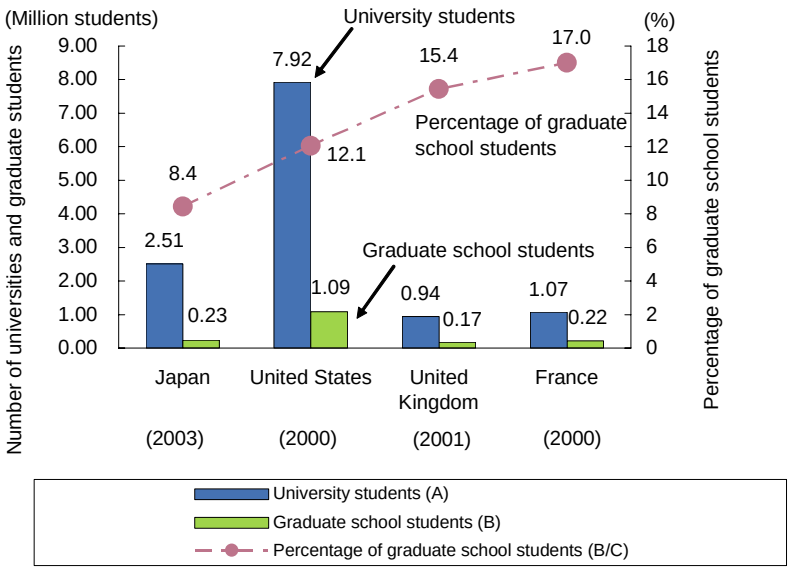


Figure 2-2-23 Number of graduate and university students, and percentage of graduate school students in selected countries

Note: Numbers for the United States and the United Kingdom are for fulltime students.

Source: MEXT. "International Comparison of Education Indexes 2004"

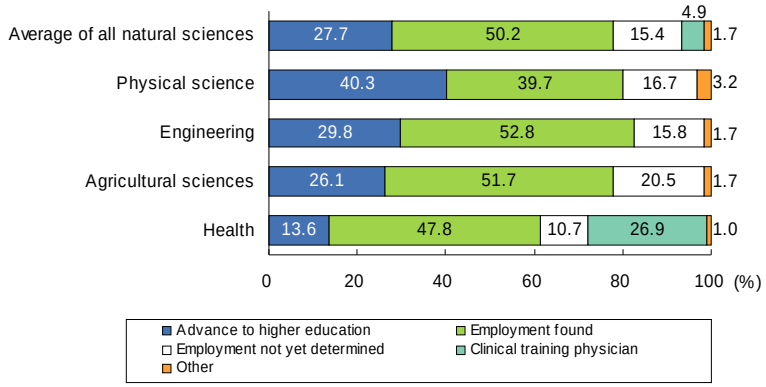
2.2.3.2 Employment of Research Personnel

In order to enable the utilization of the skills of research personnel who have received a university and/or graduate school education, it is important that they be ensured an easy transition into industry or research institutions, etc. following graduation.

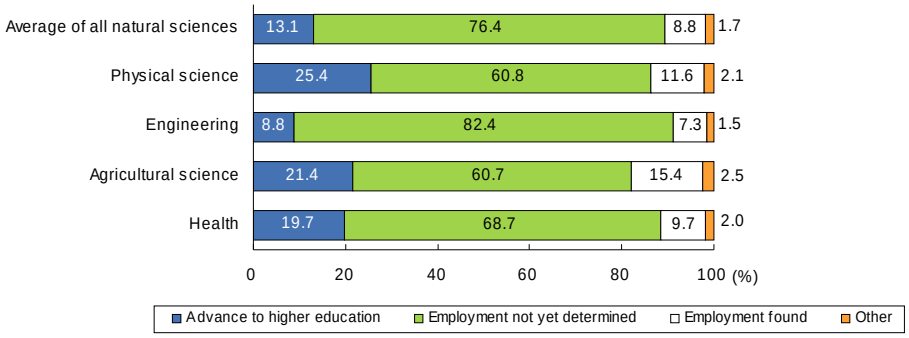
Here, we shall look at the employment situation for Japan's research personnel from the viewpoint of careers chosen by people in the natural sciences after graduating from university, or after completing master's or doctoral courses. At the university graduate stage, 40.3% of science specialists continue on to graduate work, a proportion that is higher than other specialties. After completing master's degrees, the proportion of engineering specialists who continue on with education drops (to 8.8%), with the vast majority (82.4%) turning to employment. After completing doctoral courses, a large proportion (about 40%) of people in physical science and agricultural science fields do not have definite plans for the time after receiving their doctorates (Figure 2-2-24).

If we look at a number of industries to examine their characteristics in terms of which field of the natural sciences their employees tend to come from, manufacturing industries such as the electrical machinery and tools industry, and the transport machinery and tools industry, consist almost entirely of engineering specialists. By contrast, other manufacturing industries, such as the chemicals industry, take people broadly from all four fields: the physical sciences, engineering, agricultural sciences, and health sciences. In addition, while the electrical machinery, tools manufacturing and other manufacturing industries have a high proportion of personnel who have completed master's courses, they also have an exceptionally low proportion of people who have completed doctoral courses (Figure 2-2-25).

(1) Upon university graduation



(2) Upon completion of master's degree



(3) Upon completion of doctor's degree

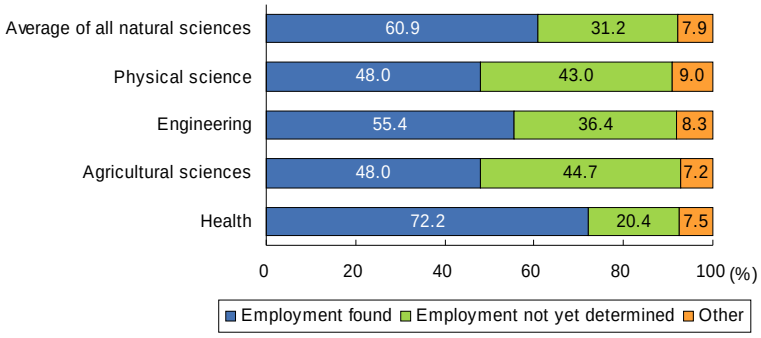
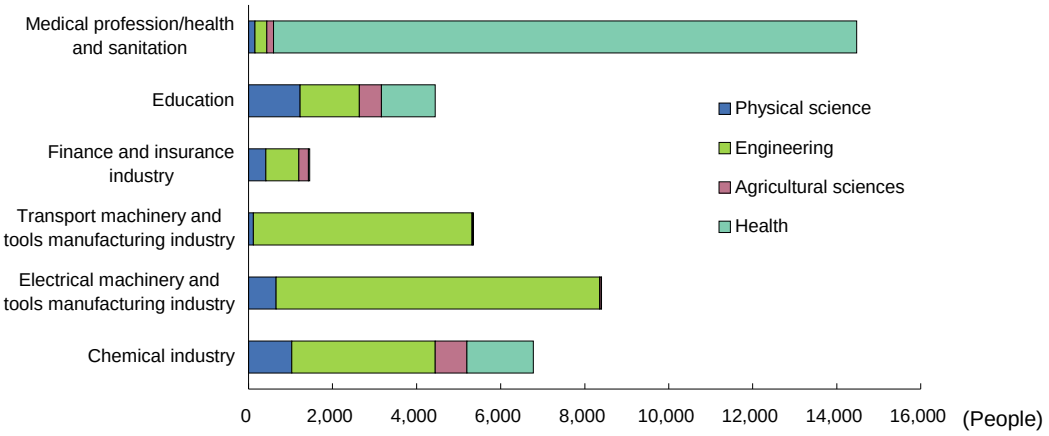


Figure 2-2-24 Trends in career choice, by university degree level (March 2003)

Notes: 1. "Average of all natural sciences" is the average value of physical science, engineering, agricultural science, and health.
2. "Employment not yet determined" refers to people who are employed in a temporary work, engaged in housework, are still at school working as a researcher, have entered a technical school or other type of school, a school in a foreign country, or an employment skills development facility, etc., or are clearly neither engaged in any employment nor enrolled in advanced education.
3. "Other" for those who have completed a master's degree refers to people who are deceased or unidentified.
4. "Other" for those who have completed a doctor's degree refers to people who have advanced to higher education, are engaged in clinical training to be a physician, or who are deceased or unidentified.

Source: MEXT. "Basic Survey Report on Schools 2003."

(1) By academic field



(2) By academic degree

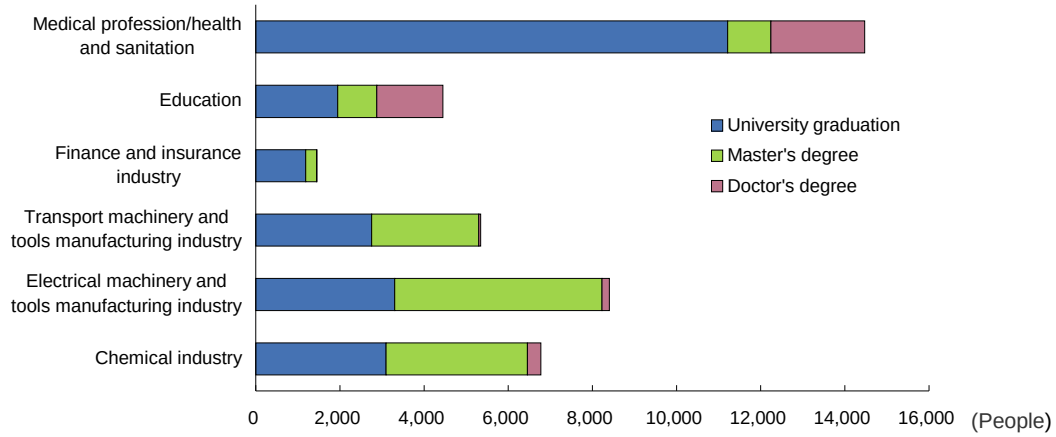


Figure 2-2-25 Employment situation in major industries, by academic field and by degree (March 2003)

Source: MEXT. "Basic Survey Report on Schools 2003"

2.3 Trends Related to Research Performance

The data on numbers of scientific papers, numbers of patents applied for and granted, technology trade balances, and high-tech product trade balances, which indicate the results of R&D activities in science and technology, reflect a nation's activity and level and strength of R&D activities. These statistics are considered to be significant indicators demonstrating levels of R&D and technological strength. This chapter describes these trends in Japan and selected countries.

2.3.1 Scientific Papers

Scientific papers are the results of R&D. It is impossible to make a simple comparison between scientific papers because of the language normally used by the researchers and the language they are written in, etc. However, here is a comparison of the number of scientific papers and the number of citations on the basis of the database[15] compiled by the Institute for Scientific Information.

2.3.1.1 Trends in the Number of Scientific Papers, and Number of Citations, in Selected Countries

Of the scientific papers published in major scientific journals around the world between 1981 and 2002, Japan's share of scientific papers and citations was as shown in Figure 2-3-1. Japan's share of scientific papers in 1981 was fourth in the world, after the United States, the United Kingdom, and Germany.

However, ever since Japan surpassed the United Kingdom in 1992 to obtain the No.2 ranking, Japan has maintained its position at No.2, and has registered the second fastest rate of growth after China among the selected countries.

Moreover, since excellent papers tend to attract large numbers of citations in other papers, the number of citations can be viewed as one indicator of a paper's quality. A look at the number of citations of papers authored by Japanese researchers through the year 2000 by year of publication reveals that Japan's share of total citations has tended to rise over time. Nevertheless, Japan has ranked after the United States, the United Kingdom, and Ger-many in the number of citations ever since 1989, and the ratio to total citations remains much lower than the share of the total number of scientific papers published (Figure 2-3-1).

2.3.1.2 Relative citation impact for scientific papers in selected countries

The Relative Citation Impact (RCI) shows the number of citations per scientific paper from Japan divided by the number of citations per scientific paper for the world as a whole. Japan's RCI value is less than 1.0, putting it in a position relatively lower than other major selected countries. Where the RCI for Japan and the United States has stayed relatively stable since 1981, it has risen in the other major countries, with particularly strong increases seen in recent years for the United Kingdom, Canada, and Germany (Figure 2-3-2).

For Japan's RCI by field, materials science registers the highest RCI value. But no sector exceeds 1.0, and th results are generally low across fields (Table 2-3-3).

15 ISI database: About 8,500 journals are listed in the ISI database, of which about 5,500 are natural science journals, about 1,800 are social science journals, and about 1,200 are arts and humanities journals. The selection standards for the listing of journals are determined according to the following criteria: (1) International editorial conventions, (2) Timeliness of publication, (3) Article title, abstract, and keywords, at the very least, noted in English and (4) Quality sufficiently maintained through the use of peer review or complete implementation of citations.