Research Material-225

Japanese Science and Technology Indicators 2013

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Research Unit for Science and
Technology Analysis and Indicators

National Institute of Science and Technology Policy
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ABSTRACT

"Science and Technology Indicators" is a basic resource for understanding Japanese science and technology activities based on objective, quantitative data. It classifies science and technology activities into five categories, R&D Expenditure; R&D Personnel; Higher Education; The Output of R&D; and Science, Technology, and Innovation. The multiple relevant indicators show the state of Japanese science and technology activities. Structure of the chapter of "Output of R&D" was changed in the Japanese Science and Technology Indicators 2013. A detailed explanation of the concept of the counting method is provided, and the adjusted number of top 1% highly cited papers in the world, which provides a qualitative perspective of the output, was newly analyzed. An international comparison was made on the number of patent applications using patent families. The "Science, Technology and Innovation" chapter has been enhanced with the addition of an indicator, i.e. transition in the export value of medium high technology industry.

Changes in various indicators are registered in the Japanese Science and Technology Indicators 2013 compared with the previous year. Total research and development expenditure in Japan, which has continued to decline in recent years, showed a 1.6% increase over the previous year. The number of newly-hired researcher has been trending downward since peaking in 2009. The number of people enrolling in undergraduate, masters and doctoral programs declined both in 2011 and 2012.

Looking at the number of papers produced in Japan, Japan was third according to the fractional counting method (degree of contribution in the production of papers in the world). As for the adjusted number of the top 10% and top 1% highly cited papers in the world, Japan ranked sixth and seventh, respectively. In the number of patent families, which is the indicator for international comparison of the number of inventions, Japan ranked number one in the world.

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Statistical Reference

Numerical data of the graphs provided in the report can be downloaded from the following URL:
http://www.nistep.go.jp/research/science-and-technology-indicators-and-scientometrics

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Summary

"Japanese Science and Technology Indictors" is a basic resource for systematically ascertaining Japan's S&T activities based on objective and quantitative data. It presents S&T activities in Japan using numerous related indicators by classifying such activities into categories; namely, "R&D expenditure," "R&D personnel," "higher education," "the output of R&D," and "science, technology and innovation."

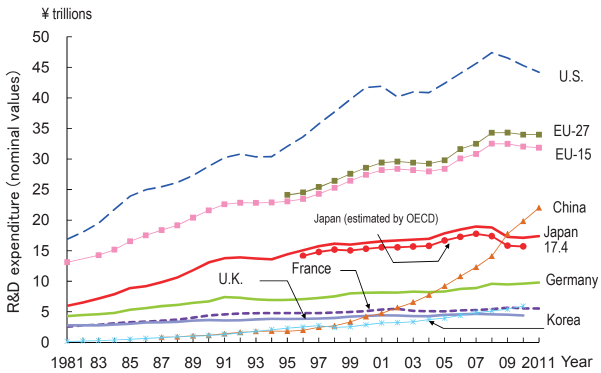
"Japanese Science and Technology Indicators 2013" shows changes in various indicators that are revealed through comparisons with last year's edition. This Summary focuses primarily on indicators that showed changes as well as newly added indicators.

Chapter 1: R&D expenditure

(1) International comparison of R&D expenditure

Total R&D expenditure for all of Japan amounted to 17.4 trillion yen in 2011. This was an increase of 1.6% from the previous year and indicates that the continuing decline that began in FY 2008 has ended. It is thought that this was largely the result of recovering R&D expenditure in the business enterprises sector, which had seen a significant decrease in 2009.

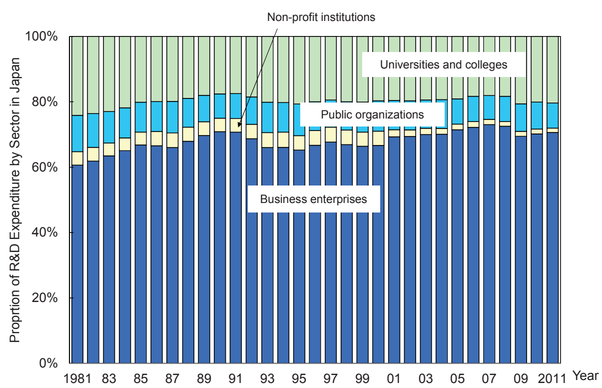
Chart 1: Trend in total R&D expenditure in selected countries



(2) Changes in usage shares of R&D expenditure by sector in Japan

Looking at usage shares of R&D expenditure by sector in Japan, beginning in the mid-1990s, the business enterprises sector had an increasing share while the public organizations sector had a decreasing share. The share of business enterprises fell from its preceding level in 2009 but has shown a recovery in the most recent two years.

Chart 2: Trends in the proportion of R&D expenditure by performing sector in selected countries



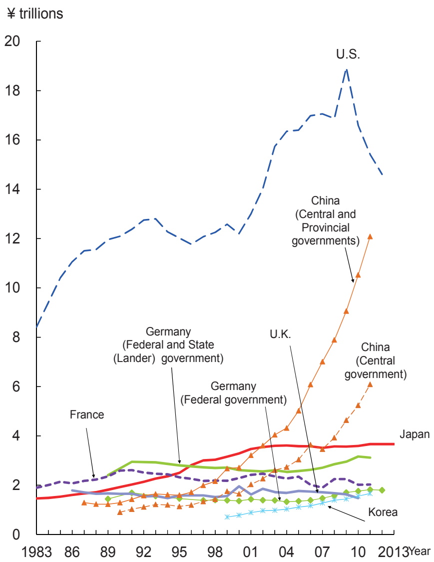
(3) GBAORD (Government Budget Appropriations for Science and Technology) of selected countries

Japan's total GBAORD (initial budget) amounted to 3.7 trillion in 2012. When viewed over the long term, Japan's GBAORD is growing; however, the rate of this growth has been slowing since the early 2000s.

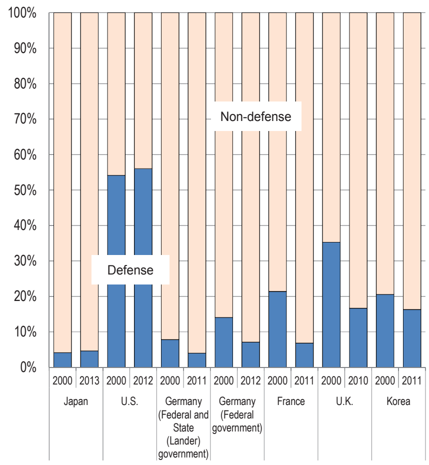
An examination of GBAORD that classifies it into defense-related expenditure (national defense) from other expenditure (civilian) reveals that nearly the entirety of Japan's GBAORD goes to the civilian sector.

Chart 3: Trend in the GBAORD (OECD purchasing power parity equivalent) of the selected countries

(A) Total GBAORD



(B) Percentages of GBAORD for the non-defense and defense sectors

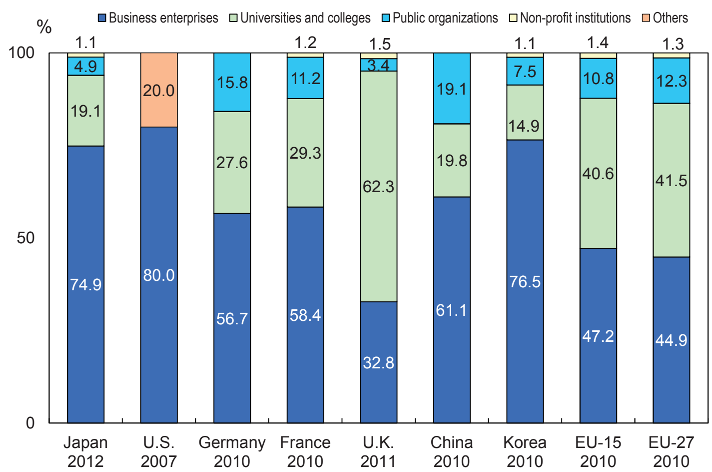


Chapter 2: R&D personnel

(1) Trends in the proportion of the number of researchers by sector in each selected country

Looking at percentages of researchers in the selected countries by sector, researchers in the business enterprises sector exceed 70% in Japan, the U.S., and Korea. On the other hand, in the U.K., the universities and colleges sector accounts for the largest share with a percentage exceeding 60%.

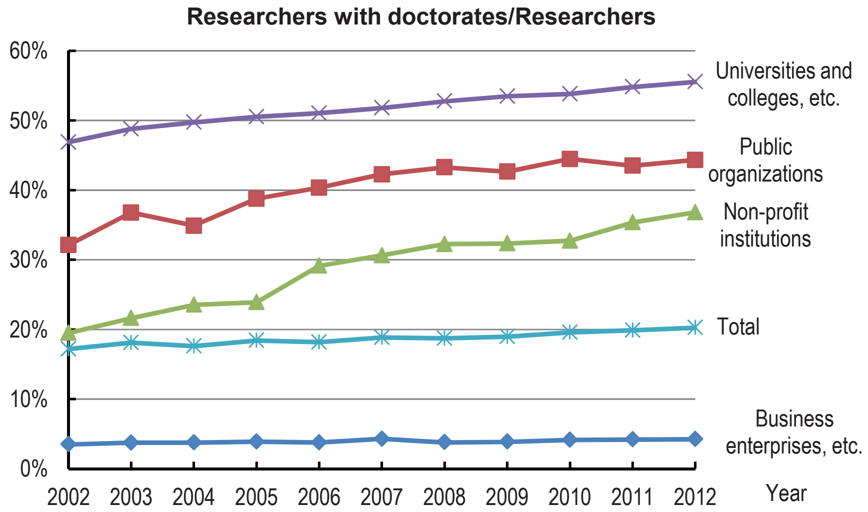
Chart 4: Breakdown of the number of researchers by sector in selected countries



(2) Changes in percentages of doctorate holders among Japanese researchers

In 2012, the percentage of researchers with doctoral degrees among all researchers in Japan was 20.3%. By sector, the percentage was highest in the universities and colleges sector, standing at 55.5% in 2012. On the other hand, the business enterprises sector's figure of 4.2% shows a trend that is flat, with little change since 2002.

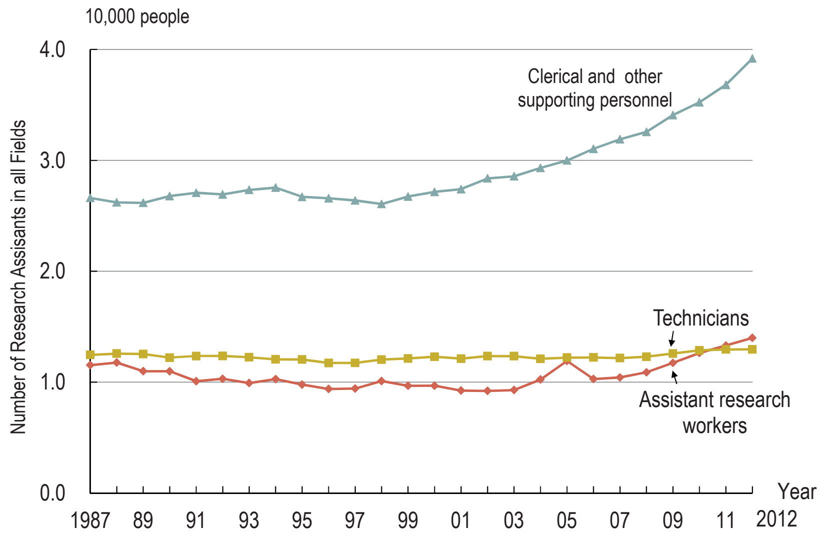
Chart 5: State of researchers with doctorates in each sector (HC)



(3) Research assistants in Japan's universities and colleges sector

Research assistants serve an important role as participants in R&D together with researchers. Looking at research assistants in Japan, a breakdown with particular focus on the universities and colleges sector shows that the number of "administrators and others" began rising upon entering the 2000s and the number of "assistant research workers" began rising from the second half of the 2000s.

Chart 6: Breakdown of research assistants by academic field of study in the universities and colleges sector



Chapter 3: Higher education

(1) Number of students newly enrolled in universities and graduate schools

The number of new enrollments in doctoral programs increased greatly upon entering the 1990s. The same was true for the number of new enrollments in graduate school master's programs. Subsequently, the number of students newly enrolling in doctoral programs began falling after peaking in 2003. The number of students newly enrolling in master's programs flattened out around the middle of the 2000s and then began a continuing decline following a peak in 2010. On the other hand, the number of students newly enrolling in undergraduate programs has been level since around the year 2000.

Looking at FY 2012, the number of newly enrolled undergraduates in Japan decreased by 1.2% versus the previous year, to about 605,000. The number of students newly enrolled in master's programs totaled 75,000. This figure represented a decrease of 5.5% compared to the previous fiscal year. And the number of people newly enrolled in doctoral programs fell by 0.8% compared to the previous year to 16,000.

Chart 7: The numbers newly enrolled for undergraduate studies

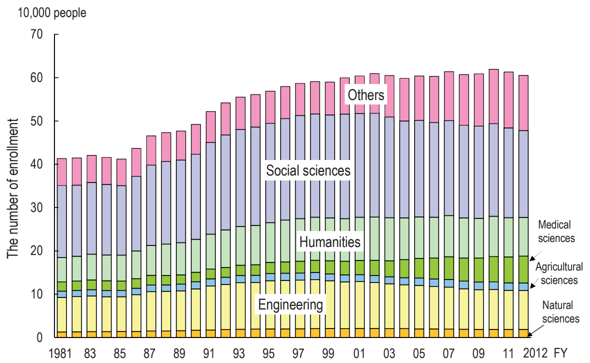


Chart 8: The number of new enrollments in graduate school (master's program)

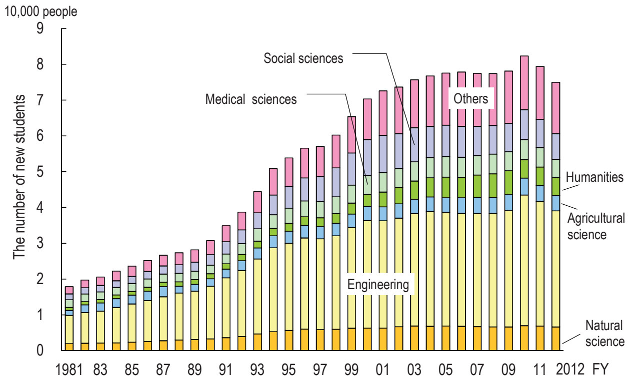
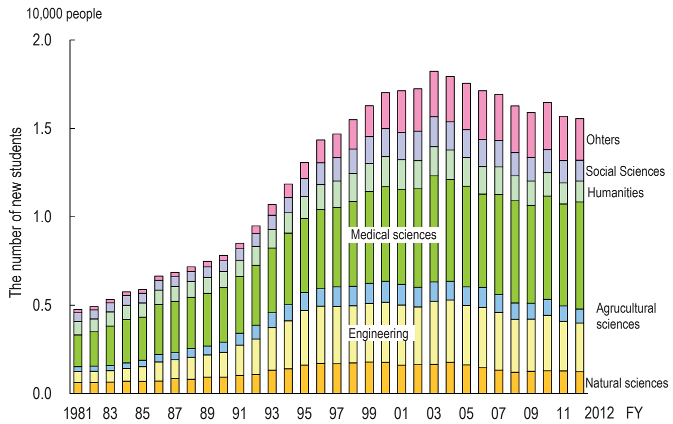


Chart 9: The numbers of new enrollments in graduate school (doctoral program)



(2) Career options for students in Natural sciences and Engineering

Looking at the career paths of students in "Natural Sciences and Engineering," when viewed over the long term, the percentage of "persons who proceed with higher education" is increasing while that of "persons who entered employment" is decreasing. However, during the two most recent years, the percentage of "persons who proceed with higher education" has declined slightly, while that for "persons who enter employment" has risen slightly. In 2012, the percentage of "persons who entered employment" was 48.5%. For graduates of master's programs in natural sciences and engineering, the percentage of "persons who enter employment" has consistently been around 80%; it stood at 84.3% in 2012. And for graduates of doctoral programs in natural sciences and engineering, the percentage of "persons who entered employment" has been increasing since the second half of the 2000s. In 2012, this percentage reached a high of 73.7%.

Beginning in 2012, "persons who entered employment" are being classified into "persons who enter indefinite-term employment" and "persons who enter fixed-term employment." Looking at graduates of undergraduate programs in natural sciences and engineering under this new classification, 97.7% of "persons who enter employment" are "persons who enter indefinite-term employment." Moreover, looking at graduates of master's programs in natural sciences and engineering, 99.1% are "persons who enter indefinite-term employment." On the other hand, in the case of graduates of doctoral programs in natural sciences and engineering, the share of "persons who enter indefinite-term employment" stands at 72.8%, which is low when compared to the same category for undergraduate course graduates and master's program graduates. It is thought that this result comes from the fact that the figure for "persons who enter fixed-term employment" among graduates of doctoral courses includes postdocs and fixed-term researchers.

Chart 10: Career options of "Natural sciences and Engineering" college graduates

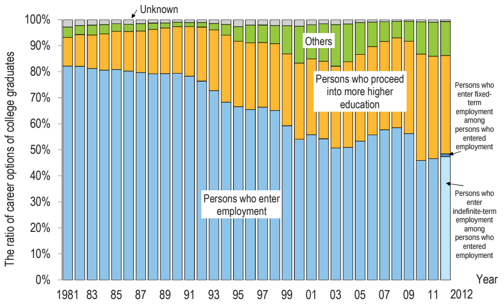


Chart 11: Career options of persons who complete master's programs in "Natural sciences and Engineering"

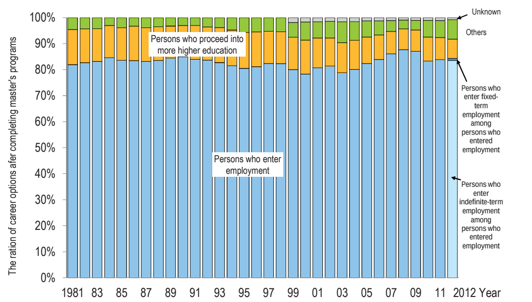
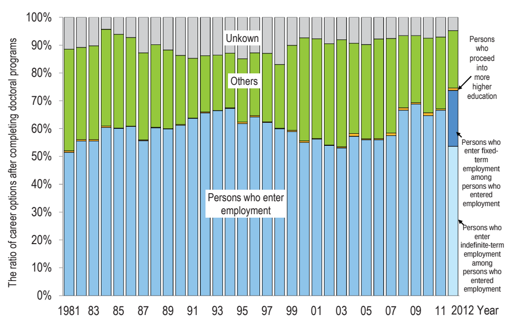


Chart 12: Postdoctoral career options in natural sciences and engineering



Person who enters employment: Person who takes a job for the purpose of receiving routine income.
Person who enters indefinite-term employment: A person who obtains employment for a period that is not determined or limited
Person who enters fixed-term employment: A person who obtains employment with a set employment period of at least one year and with prescribed working hours of around 30 to 40 hours per week
Person who proceeds with higher education: Person who advances to university, etc. Excludes people who enroll in a special vocational school, school in a foreign country, etc.
Unclear: Deceased/unknown
The others: Do not fall under above mentioned categories

Chapter 4: The output of R&D

(1) Numbers of papers, adjusted top 10% papers, and adjusted top 1% papers in the selected countries

For science papers that can be measured as output of R&D activity, a comparison of "degree of contribution to the production of papers" of the selected countries using fractional counting shows that Japan ranked second internationally in terms of average of number of papers for 2000-2002 but third behind the U.S. and China for 2010-2012. As for number of highly cited adjusted top 10% papers, Japan ranked fourth in terms of average for 2000-2002 but sixth in terms of average for 2010-2012. And looking at number of even more highly cited adjusted top 1% papers, Japan ranked fourth in terms of average for 2000-2002 but seventh in terms of average for 2010-2012. Thus, Japan's relative position in the world is trending downward in terms of both paper quantity and quality.

Chart 13: Number of papers, number of adjusted top 10% papers, and number of adjusted top 1% papers by country/region: Top 10 countries/regions (Fractional counting)

(A) 2000 - 2002 (Average)

All fields	2000 - 2002 (Average)			All fields	2000 - 2002 (Average)			All fields	2000 - 2002 (Average)		
	The number of papers				The number of adjusted top 10% papers				The number of adjusted top 1% papers		
	Fractional counting				Fractional counting				Fractional counting		
Country/Region	The number of papers	Share	World rank	Country/Region	The number of papers	Share	World rank	Country/Region	The number of papers	Share	World rank
U.S.	210,237	26.9	1	U.S.	32,532	41.7	1	U.S.	3,957	50.7	1
Japan	66,637	8.5	2	U.K.	6,266	8.0	2	U.K.	658	8.4	2
U.K.	55,075	7.0	3	Germany	5,389	6.9	3	Germany	500	6.4	3
Germany	52,399	6.7	4	Japan	4,767	6.1	4	Japan	367	4.7	4
France	37,652	4.8	5	France	3,676	4.7	5	France	309	4.0	5
China	29,868	3.8	6	Canada	2,857	3.7	6	Canada	254	3.3	6
Italy	27,176	3.5	7	Italy	2,373	3.0	7	Netherlands	180	2.3	7
Canada	24,906	3.2	8	Netherlands	1,907	2.4	8	Italy	179	2.3	8
Russia	21,528	2.8	9	China	1,788	2.3	9	Switzerland	161	2.1	9
Spain	19,346	2.5	10	Australia	1,699	2.2	10	Australia	139	1.8	10

(B) 2010 - 2012 (Average)

All fields	2010 - 2012 (Average)			All fields	2010 - 2012 (Average)			All fields	2010 - 2012 (Average)		
	The number of papers				The number of adjusted top 10% papers				The number of adjusted top 1% papers		
	Fractional counting				Fractional counting				Fractional counting		
Country/Region	The number of papers	Share	World rank	Country/Region	The number of papers	Share	World rank	Country/Region	The number of papers	Share	World rank
U.S.	258,421	21.6	1	U.S.	37,733	31.5	1	U.S.	4,480	37.4	1
China	137,624	11.5	2	China	10,965	9.1	2	China	979	8.2	2
Japan	64,579	5.4	3	U.K.	8,013	6.7	3	U.K.	862	7.2	3
Germany	61,731	5.1	4	Germany	7,992	6.7	4	Germany	802	6.7	4
U.K.	58,502	4.9	5	France	4,909	4.1	5	France	451	3.8	5
France	44,022	3.7	6	Japan	4,809	4.0	6	Canada	412	3.4	6
India	40,627	3.4	7	Canada	4,279	3.6	7	Japan	394	3.3	7
Italy	40,310	3.4	8	Italy	4,138	3.5	8	Italy	363	3.0	8
Korea	37,226	3.1	9	Spain	3,442	2.9	9	Australia	323	2.7	9
Canada	36,777	3.1	10	Australia	3,359	2.8	10	Netherlands	296	2.5	10

Note: "Number of adjusted top 10% (top 1%) papers" refers to a number of papers that is obtained by extracting those papers whose number of times cited enters the top 10% (1%) in each field for each year and then adjusted so that it is 1/10 (1/100) of the number of papers in terms of real numbers.

1) The paper database is not only updated with information on papers for the most recent available years but also corrections and additions pertaining to past papers. Accordingly, simple comparisons between this survey material and the previous Japanese Science and Technology Indicators 2012 cannot be drawn when analyzing papers.
2) Additionally, while the Summaries of materials up to Japanese Science and Technology Indicators 2012 presented results based on whole counting, starting from this year's edition, results will be presented based on fractional counting.

For details, please see Chapter 4 Section 1 of the main text.

(2) International comparison of patent applications using patent families

For the Japanese Science and Technology Indicators 2013, NISTEP conducted its first full-scale analysis based on patent families. This approach is intended to improve the potential for international comparison of patent application numbers.

In terms of number of patent families (average for 2006-2008), Japan ranked number one in the world and the U.S. ranked number two. "Number of patent families" is an indicator that counts patents for which applications with the same content are made to multiple countries as being part of a single patent family in order to eliminate duplications. It is calculated for each inventor country/region. Germany ranks third behind Japan and the U.S., with Korea, France, China, and Taiwan following.

Chart 14: Number of patent families for each country/region: The top 10 countries/regions

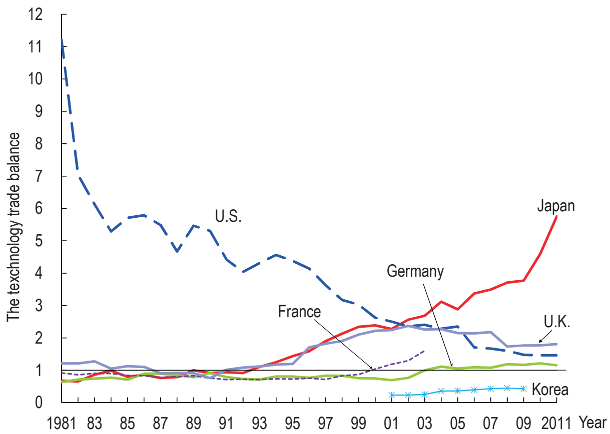
Country/Region	2006 - 2008 (Average) Number of patent families Whole counting: The number of papers	Share	World rank
Japan	61,399	29.0	1
U.S.	47,556	22.4	2
Germany	30,724	14.5	3
Korea	18,466	8.7	4
France	11,082	5.2	5
China	9,506	4.5	6
Taiwan	9,318	4.4	7
U.K.	8,752	4.1	8
Italy	5,668	2.7	9
Canada	5,600	2.6	10

Chapter 5: Science, technology and innovation

(1) International comparison of technology trade

Looking at technology trade balance ratio (technology exports/technology imports), which is an indicator of a country's international technological competitiveness, Japan's ratio continues to grow and reached 5.8 in 2011. The amount of technology exports for Japan has shown an export surplus since 1993. It should be mentioned that the particularly strong growth of Japan's ratio in recent years is due to a decrease in its technology imports.

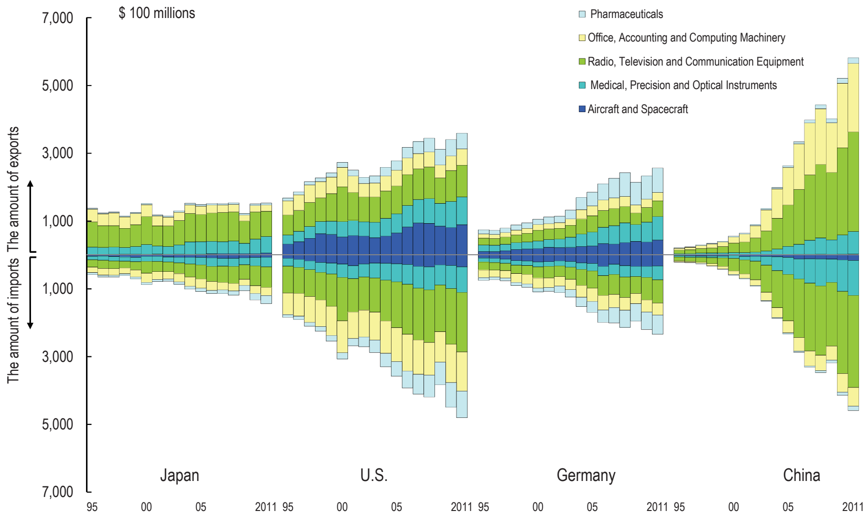
Chart 15: Technology trade balance ratios of the selected countries



(2) High-technology industry trade

Looking at high-technology industry trade, Japan's exports have remained flat while its imports have been trending upward since the second half of the 2000s. Meanwhile, China has seen rapid growth in terms of both exports and imports. China's exports surpassed those of the U.S. in the second half of the 2000s. The U.S. is also seeing growth in both its exports and imports; however, its imports far exceeded its exports in the 2000s. Germany's exports and imports are also growing. All of the countries showed decreased high-technology industry trade amounts in 2009.

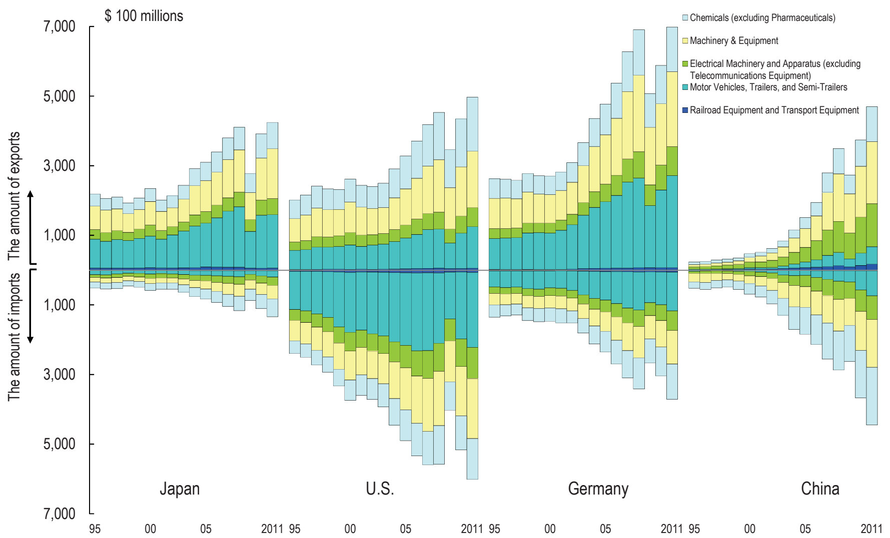
Chart 16: The change in the trade amount of high technology industry in main countries



(3) Medium high-technology industry trade

Germany has the highest exports in medium-technology industry trade, followed by the U.S. Japan also has a presence, although China's exports exceeded those of Japan in the most recent available year. All of the countries showed decreased medium high-technology industry trade amounts in 2009. One factor behind this is thought to be the effect of the Lehman Brothers' bankruptcy. This effect was more strongly pronounced in medium high-technology industry trade than in high-technology industry trade.

Chart 17: The change in the trade amount of medium high technology industry in main countries



Characteristics of the Japanese Science and Technology Indicators

The Japanese Science and Technology Indicators is published each year to present the most recent values at the time of publication. It is a collection of items that allow time-series comparisons as well as comparisons among the selected countries based on data that are updated each year in principle.

Use of statistical data announced by each country

Wherever possible, statistical data announced by each country are used as the sources of data for indicators appearing in Japanese Science and Technology Indicators. Every effort has been made to clarify each country's method of collecting statistics and how it differs from other countries' methods.

Independent NISTEP analysis of paper and patent databases

Paper data were independently aggregated and analyzed by NISTEP using journal data in Thomson Reuters Web of Science. The aggregation method is provided and explained in detail.

Of indicators pertaining to patents, patent family data were independently aggregated and analyzed by NISTEP using journal data in PATSTAT (the patent database of the European Patent Office). The aggregation method is provided and explained in detail.

Presentation of topical indicators in "columns"

In addition to base indicators, those indicators having topicality or are expected to have particular importance in the future are presented in the form of "columns."

Use of "reminder marks" for international comparisons and time-series comparisons

The reminder marks "attention to international comparison" [Attention to international comparison] and "attention to trend" [Attention to trend] have been attached to graphs where they are required. Generally, the data for each country conform to OECD manuals and other materials. However, differences in methods of collecting data or scope of focus do in fact exist, and therefore attention is necessary when making comparisons in some cases. Such cases are marked "attention to international comparison." Likewise, for some time series data, data could not be continuously collected under the same conditions due to changes in statistical standards. Cases where special attention is required when reading trends of increases and decreases are marked "attention to trend." Specifics for such points requiring attention are provided in the notes of individual charts.

Downloading statistical data (numerical data of graphs provided in the report)

Numerical data of the graphs provided in the report can be downloaded from the following URL:
http://www.nistep.go.jp/research/science-and-technology-indicators-and-scientometrics

Main parts

Chapter 1: R&D expenditure

In this chapter, the status of R&D expenditure in Japan and other selected countries, which is a basic index for R&D activities, is reviewed. R&D expenditure is the expenditure used for conducting R&D operations in an organization. It is widely used as quantitative measurement data regarding R&D inputs. This chapter also examines data on R&D expenditures from various angles, including each country's total R&D expenditures, their breakdown by sector and type, cost-sharing structures, and so on. The contents of this chapter also include mention of a part of the government budget appropriations or outlays for R&D (hereinafter referred to as GBAORD).

1.1 International comparison of each country’s R&D expenditure

Key points

○Japan's total R&D expenditure was approximately 17.4 trillion yen in FY 2011. This is an increase of 1.6% from the previous year and suggests that the three-year decline that began in FY 2008 has ended. The ratio to GDP was 3.67%, an increase of 0.1 percentage point from FY 2010.

○If the R&D expenditures of OECD member countries and regions are ranked in terms of percent of GDP in 2010, Japan stands at number four (six in the case of Japan (estimated by the OECD)).

○Looking at the flow of R&D expenditure from funding sectors to the performing sectors of each country, “government” funding flows to “public institutions” and “universities and colleges” in many countries. Countries in which there is a larger flow to the university sector are Japan, Germany, France and the U.K. In almost all the countries, the flow from government to the business enterprises sector is small, but it is large in the U.S.

○The U.K. has a large share of funding from the foreign countries sector. It is relatively large in France and Germany as well. It should be noted that all three countries are characteristic in that there is considerable flow of R&D expenditure from “foreign countries” to “business enterprises.”

○In terms of proportion of total R&D expenditure by sector, “business enterprises” accounts for the largest proportion in all countries. The proportion is approximately 70% for Japan, the U.S., and Germany and approximately 60% for France and the U.K. In China, the share of “private enterprises” is growing and has accounted for approximately 70% in recent years. The proportion of “private enterprises” in Korea is approximately 80%.

1.1.1 R&D expenditure trends in each country

First of all, the total R&D expenditure in selected countries is examined in order to provide an overview of their sizes and trends. A precise comparison of R&D expenditures among different countries is difficult because surveying methods for R&D expenditures differ by country; however, the comparison of the data in each country over time is considered to represent the trend of the country.

For a comparison of R&D expenditures in each country, currency conversion is necessary. But, because of the conversion, the comparison inevitably falls under the influence of each country’s economic conditions. In principle, therefore, converted values are used for the international comparison of each country’s R&D expenditure, and the value of each national currency is used for examining the change of R&D expenditure over time in the corresponding country.

Japan’s R&D expenditures are shown with two types of values. One of such values was obtained from the Survey of Research and Development conducted and published by the Ministry of Public Management, Home Affairs, Posts and Telecommunications.

And the other values were obtained from materials published by the OECD[1]. The difference between

(1) The Organization for Economic Co-operation and Development (OECD) is the organization in which countries supporting democracy and market economy engage in activities for the purpose of 1) economic development, 2) aid to developing countries and 3) expansion of multilateral free trading. OECD is currently composed of 34 member countries, and gath-

both the values is how to obtain labor costs in the university and college sector. Strict separation of expenditures for research and for education in the university and college sector is difficult. Thus, in the Survey of Research and Development, expenditures in the university and college sector include faculty personnel expenses for non-research work (education). On the other hand, the OECD provides a total amount for R&D expenditure that is arrived at by converting personnel expenditure of Japan's universities and colleges to a full-time basis (for details, see R&D expenditure for the universities and colleges sector in Section 1.3.3). In this chapter, the status of R&D investment in each country is studied using the data estimated by the OECD (referred to as "Japan (estimated by the OECD)") and others.

The total amounts of R&D expenditure in each country are shown in Chart 1-1-1. (A) is nominal values (in yen, of R&D expenditure representing each year's nominal price,) and (B) is real values (in yen, of R&D expenditure on the basis of the standard price values in 2005). (C) and (D) are the nominal values and real values (on 2005 base) represented by the national currencies of each country respectively.

Japan's total R&D expenditure in FY 2011[(2)] was 17.3791 trillion yen. This is an increase of 1.6% from the previous year and suggests that the continuing decline that began in FY 2008 has ended.

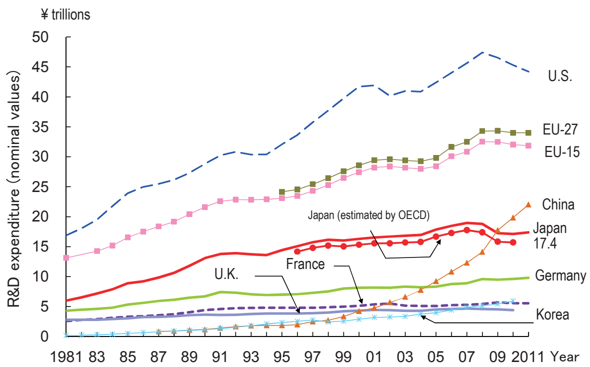
A look at the nominal values of each country for the latest available years (Chart 1-1-1(A)) shows that the U.S. has a much larger value compared to other countries; however, this value has been decreasing since peaking in 2008. China' passed Japan in 2009. Germany shows a continuing long-term growth trend. France, the U.K., and Korea have stayed at the same level since the mid-2000s. The nominal value for the EU has been declining gradually since the mid-2000s.

As for real values (Chart 1-1-1(B)), the value for Japan has been growing since 2009. Though a similar trend is seen for other countries, the value for the U.S. has tended to decline gradually or remain unchanged.

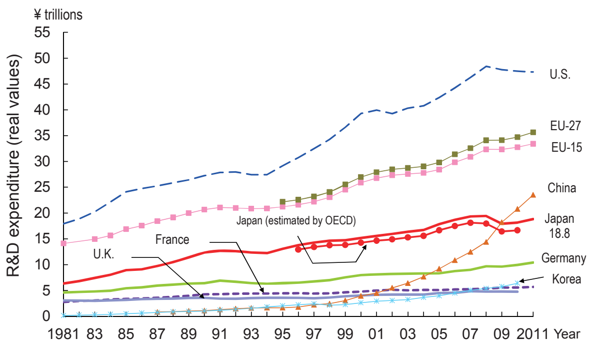
Chart 1-1-1: Trend in total R&D expenditure in selected countries

(A) Nominal values (OECD purchasing power parity equivalent)

Attention to international comparison



(B) Real values
(2005 base: OECD purchasing power parity equivalent)



ers statistics, economic and social data which can be internationally compared, and also conducts prediction and analysis.

(2) Since the period covered to collect yearly total domestic R&D expenditure data differs depending on the country, this report in principle uses the calendar year for international comparison. In the case of Japan, however, fiscal years are used. The term "fiscal year" is used regarding GBAORD.

Chart 1-1-1 (C) shows a comparison of the investment status of each country in terms of the annual average growth rate of R&D expenditure during the first half of the 2000s (2000–2005) and the second half of the 2000s (2005 to the latest available year) on the basis of each national currency.

Comparing the annual average growth rate of R&D expenditure (nominal values) between the first and second halves of the 2000s, the growth rate was higher in the second half for the U.S., Germany, France, China and Korea. On the other hand, countries having poor growth in the second half of the 2000s were Japan and the U.K. Japan, in particular, had a negative annual average growth rate. The rate for the U.S. remained unchanged. Chart 1-1-1 (D) shows annual average growth rates in (real) R&D expenditures on a 2005 base in order to eliminate the influence of price fluctuations. Growth was higher during the second half of the 2000s than in the first half in the U.S., Germany, France and Korea. Japan and the U.K. showed slower growth during the second half of the decade in real terms.

(C) Nominal values (national currency)

National currency	2000	2005	2011	Annual average growth rate	
				'00→'05	'05→'11
Japan (¥ trillions)	16.3	17.8	17.4	1.84%	-0.44%
Japan (estimated by OECD) (¥ trillions)	15.3	16.7	15.7 (2010)	1.73%	-1.20% (2010)
U.S. ($ billions)	269	327	414	4.00%	4.00%
Germany (€ billions)	50.6	55.7	73.7	1.95%	4.76%
France (€ billions)	31.0	36.2	44.9	3.20%	3.65%
U.K. (£ billions)	17.7	22.1	26.4 (2010)	4.50%	3.58% (2010)
China (¥ billions)	89.6	245	861	22.3%	23.3%
Korea (W trillions)	13.8	24.2	43.9 (2010)	11.8%	12.7% (2010)

(D) Real values (2005 base; national currency)

National currency	2000	2005	2011	Annual average growth rate	
				'00→'05	'05→'11
Japan (¥ trillions)	15.2	17.8	18.8	3.30%	0.90%
Japan (estimated by OECD) (¥ trillions)	14.3	16.7	16.7 (2010)	3.19%	-0.02% (2010)
U.S. ($ billions)	303	327	365	1.54%	1.85%
Germany (€ billions)	53.4	55.7	69.7	0.87%	3.79%
France (€ billions)	34.1	36.2	40.5	1.21%	1.89%
U.K. (£ billions)	19.8	22.1	23.4 (2010)	2.18%	1.11% (2010)
China (¥ billions)	105	245	626	18.5%	16.9%
Korea (W trillions)	15.9	24.2	39.0 (2010)	8.66%	10.1% (2010)

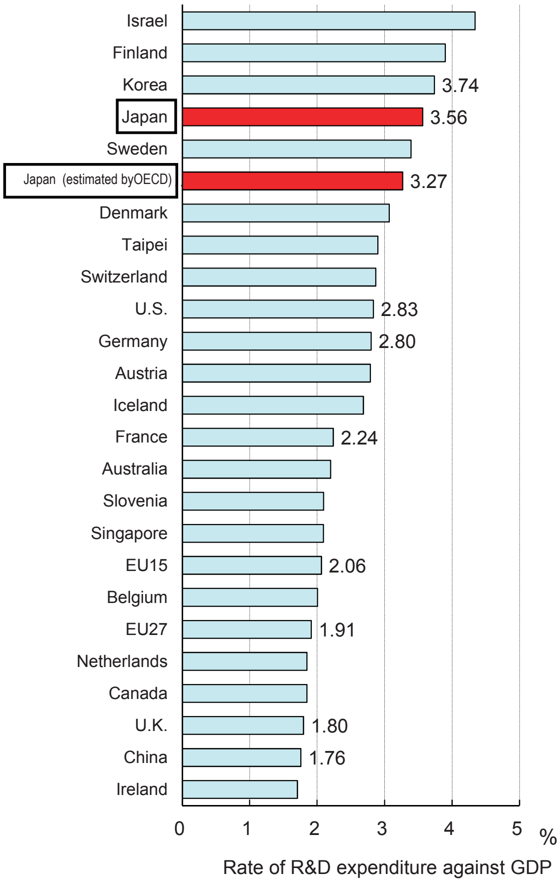
Note:1) The total R&D expenditure is the sum of each sector's expenditure, and the definition of each sector occasionally differs depending on the country. Therefore it is necessary to be careful when making international comparisons. Refer to Chart 1-1-4 for the definition of sectors in each selected country.
2) R&D expenses include the fields of social science and humanities (in the case of Korea, only natural sciences until 2006).
3) The former West Germany until 1990, and the unified Germany since 1991, respectively.
4) Reference statistics E were used for the conversion to obtain purchasing power parity equivalent.
5) Real values were obtained by calculations with a GDP deflator (reference statistics D were used).
6) Value for Japan (estimated by the OECD) represents the total R&D expenditure in which the labor cost comprising a part of R&D expenditure in the university and college sector was converted to FTE. The value was corrected and estimated by the OECD.

Sources: <Japan> Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"
<U.S.> NSF, "NSF, "National Patterns of R&D Resources: 2010–11 Data Update"
<Germany> Bundesministerium für Bildung und Forschung, "Bundesbericht Forschung 2004,2006," "Bundesbericht Forschung und Innovation 2010, 2012"; from 2010: OECD, "Main Science and Technology Indicators 2012/2"
<Japan (estimated by the OECD), France and EU> OECD, "Main Science and Technology Indicators 2012/2"
<U.K> National Statistics website: www.statistics.gov.uk
<China> Ministry of Science and Technology of the People's Republic of China, S&T Statistics Data Book 2011 (website)
<Korea> National Science and Technology Information Service (website)

Next, the "ratio of total R&D expenditure against GDP (gross domestic product)" is shown below for comparison of R&D expenditures in light of the influence of the size of economy (Chart 1-1-2).

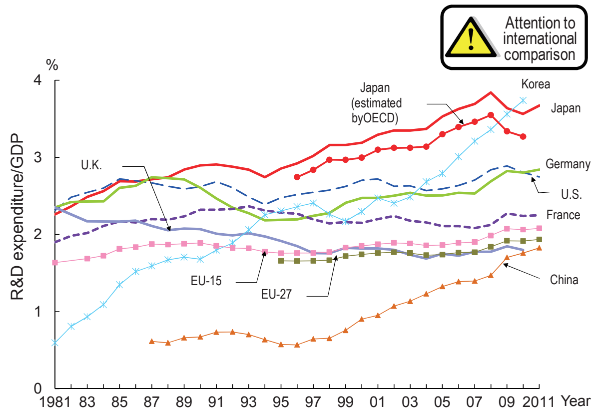
Japan's total R&D expenditure against GDP in 2010 could be described as being relatively high.

Chart 1-1-2: Ratio of the total R&D expenditure against GDP in each country (2010)



Note: 1) The value for Iceland is from 2007; those for Switzerland is from 2008.
2) The value for Israel excludes defense-related expenditure
3) Capital expenditure in the U.S. was almost all excluded.
4) Secretariat estimate or projection based on national sources was used with regard to EU15 and 27.
5) Figures for the Sweden, Austria, U.K. and Ireland are national estimates or projections.
Source: Same as Chart 1-1-3. OECD, "Main Science and Technology Indicators 2012/2"

Chart 1-1-3: Trend in the ratio of the total R&D expenditure against GDP for each country



Note: The "attention to international comparison" and R&D expenditures are the same as those given in Chart 1-1-1.
Source: The details of the R&D values are the same as those given in the notes to Chart 1-1-1. GDP is the same as for reference statistics C.

Additionally, changes in the level of investment each country makes to R&D can be seen from changes in total R&D expenditure against GDP over the years (Chart 1-1-3).

Japan's ratio peaked in 2008 before entering a continuing declining trend. However, in the latest year, 2011, its ratio increased by 0.1 percentage point to 3.67% compared to the previous year. The statistic for Japan (estimated by the OECD) also peaked in 2008. However, it continues to decline, with the ratio for the most recent available year (2010) standing at 3.27%.

The ratio for the U.S. was increasing from the mid-2000s but has been declining in recent years. Germany's ratio has been growing considerably since the mid-2000s. The ratios for France and the EU have remained largely unchanged in recent years. And growth of the U.K.'s ratio has been slowing since the mid-1990s. On the other hand, Korea's ratio continues to grow. The value in Korea surpassed 3% in 2006. Its 2010 figure of 3.74% was higher than Japan's.

In China, where economic development has been remarkable, the ratio has been increasing since 1996. The gap between China and the other selected countries has shrunk markedly.

1.1.2 Trend of R&D expenditure by sector in each country

In order to understand national R&D systems, it is necessary to view by sector the institutions carrying out R&D activities in each country.

However, what is problematic in classification by sector and international comparison are the discrepancies among national R&D systems, methods of survey, and the scope of target organizations in each country. Consequently, comparison should be made in accordance with a correct understanding of the differences among each country.

In order to examine the structure of R&D funding, this section classifies by sector institutions in each country performing R&D activities.

(1) Definition of funding sectors and performing sectors for R&D expenditures

Chart 1-1-4 classifies institutions that perform R&D into four sectors based on the OECD's "Frascati Manual."(3) It shows a simple breakdown of each country's R&D expenditure funding sectors (five sectors) and performing sectors (four sectors). Expressions used in the chart are the same as those used in each country's R&D statistics or in OECD data; however the sector names of the headings are those used in a set of Japanese R&D statistics, the Survey of Research and Development of the Ministry of Internal Affairs and Communications.

Chart 1-1-4: Definitions of funding and performing sectors in R&D expenditure in selected countries
(A) Funding sectors

Country	Business enterprises	Universities and colleges	Governments	Non-profit institutions	Foreign countries
Japan (Up to FY 2010)	• Companies • Special corporations orindependent administrativ ecorporations (for-profit)	• Private universities (including junior colleges, university-affiliated research institutes, etc.)	• National government and local governments • Research institutions (including JSPS, NEDO, JST , etc.) at national, public and semi-governmental corporations and independent administrative agencies (not for profit) • National and public universities (including junior colleges, university- affiliated research institutes, etc.)	• Corporations, organizations, and individuals not included in another category	Foreign organizations
Japan (From FY 2011)	• Companies	• Private universities (including junior colleges, university-affiliated research institutes, etc.)	• National government and local governments • Research institutions (including JSPS, NEDO, JST , etc.) at national, public and semi-governmental corporations and independent administrative agencies (not for profit) • National and public universities (including junior colleges, university- affiliated research institutes, etc.)	• Corporations, organizations, and individuals not included in another category	Foreign organizations
U.S.	• Companies and others	• University & Colleges (organizations which each conduct R&D equivalentto $150,000 or more)	Federal government (however, some R&D funds used by universities and colleges are provided by state governments)	• Other non-profit institutions	
Germany	• Enterprises • Public research institutes (IfG)	***Not considered a funding source**	Government (federal, state and district governments) (Includes federal government commissions and subsidies, and in some cases repayable grants from public organizations. Does not include funds received from the federal government within the economic sector's R&D human resources development program or the industrial and economic sectors' measures on the promotion of cooperative research.)	Domestic organizations that are not part of the economic sector, such as universities and private NPOs (nonprofit organizations)	• Corporate groups • Funds from E.U. promotion programs • Other funds from foreign countries
France	• Enterprises	• National Science and Research Center (CNRS) • Grandes ecoles (not administered by Ministèrede l'éducation nationale (MEN)) • Higher education institutions (administered by Ministère de l'é ducation nationale (MEN))	• Public research institutions • Regional governments	• Non-profit institutions	• Business enterprises (foreign business enterprises belonging to the same corporate group, unrelated foreign companies) • Foreign governments • Foreign nonprofit organizations • Foreign universities • E.U. • International organizations
U.K.	• Enterprises	• Universities	• Central government (U.K) • Decentralized governments (Scotland, etc.) • Research councils • Higher Education Funding Councils * Local governments are not included	• Non-profit institutions	· Foreign countries
China	• Enterprises	***Not considered a funding source**	• Government research institutes * Local governments are not included	• Other non-profit institutions	· Foreign countries
Korea	• Enterprises • Government investment institution (organizations in which the government invests some or all of the funds needed to operate corporations: Korea Agricultural and Rural Infrastructure Corporation, Korea Industrial Promotion	• National or public universities • Private universities	• Government (national and public laboratories, local governments) • Government-contribution research institutions (organizations to which the government provides some or all of the funds needed to operate corporations: Korea Advanced Institute of Science and Technology, Korean Atomic Energy Research Institute, etc.)	• Other non-profit institutions	• Business enterprises (foreign business enterprises belonging to the same corporate group, unrelated foreign companies) • Foreign governments • Foreign nonprofit organizations • Foreign universities • E.U. • International organizations

(3)The Frascati Manual 2002 (Proposed Standard Practice for Surveys on Research and Experimental Development): International standards with regard to the method of surveying R&D statistics are stated in this manual. In 1963, a meeting on surveying research and experimental development (R&D) in Frascati, Italy was held by experts from member countries of the OECD. The summary of the result is the proposed standard practice for surveying research and experimental development. The latest publication was the sixth version (2002). Most surveys of R&D statistics in each country are mainly conducted following this manual.

(B) Performing sectors

Country	Business enterprises	Universities and colleges	Public organizations	Non-profitinstitutions
Japan (Up to FY 2010)	• Companies • Special corporations orindependent administrativecorporations (for-profit)	• Universityfaculties (including advanced researchcources at graduate schools) • Junior colleges • Universityresearch institutes • Others	• National research institutes • Special corporations or independ entadministrative corporations (non- profit) • Public research institutes	• Non-profitinstitutions
Japan (From FY 2011)	• Companies	• Universityfaculties (including advanced researchcources at graduate schools) • Junior colleges • Universityresearch institutes • Others	• National research institutes • Special corporations or independ entadministrative corporations (non- profit) • Public research institutes	• Non-profitinstitutions
U.S.	• Companies and others	• University& Colleges (organizations w hich each conduct R&D equivalentto $150,000 or more)	• Federal government • FFRDCs *** Local governments are not included**	• Other non-profit institutions
Germany	• Enterprises • Public research institutes (IfG)	• Universities • Comprehensive universities • Colleges of education • Colleges of theology • Colleges of art • Universities of applied sciences • Colleges of public administration	• Federal government • Non-profit institutions (institutions w hich each obtain public funds of €160,000 or more) • Legally independent universityresearch institutes • Local government research institutes	
France	• Enterprises • Government investmentinstitution	• National Science and Research Center (CNRS) • Grandes ecoles (not administered by Ministèrede l'éducation nationale (MEN)) • Higher education institutions (administered byMinistère de l'éducation nationale (MEN))	• Scientific and technical research publicestablishment "Etablissement public a caracterescientifique et technologique" (other than CNRS) • Commercial and industrial research publicestablishment "Etablissement public a caractereindustriel et commercial" • Administrative research public establishment"Etablissement public a caractere administratif" (otherthan higher education institutions) • Departments and agencies belonging to ministries *** Local governments are not included**	• Non-profitinstitutions
U.K.	• Enterprises	• Universities	• Central government (U.K) • Decentralized governments (Scotland, etc.) • Research councils *** Local governments are not included**	• Non-profitinstitutions
China	• Enterprises	• Universities	• Government research institutes *** Local governments are not included**	• Other non-profit institutions
Korea	• Enterprises • Government investmentinstitution (organizations in w hich the government invests some or all of the funds needed to operate corporations: Korea Agricultural and Rural Infrastructure Corporation, Korea Industrial Promotion Corporation, etc.)	• Universities and colleges offering majors in thefield of natural scienses and engineering (includingextention campuses and local campuses) • Universityresearch institutes • University hospitals (only if a school of medicineand its accounting are integrated)	• National or public research institutes • Government-contribution research institutions (organizations to w hich the government provides some or all of the funds needed to operate corporations: Korea Advanced Institute of Science and Technology, Korean Atomic Energy Research Institute, etc.) • National or public hospitals *** Local governments are not included**	• Private hospitals • Other non-profit institutions

Note: 1) Detailed information by sector for the U.K. and China was not obtained.
2) EU data are not included because they were available only as totals for each country.
<U.S. > 1) FFRDCs: Federally funded research and development centers
<Germany> 1) IfG: Institutions for co-operative industrial research and experimental development.
2) Funding sectors do not include "universities and colleges".
<China> Funding sectors do not include “universities and colleges.”
Sources: NISTEP, “Metadata of R&D-related statistics in selected countries: Comparative study on the measurement methodology” (Research Material No. 143)
Ministry of Internal Affairs and Communications, “Report on the Survey of Research and Development”
BMBF, “Bundesbericht Forschung und Innovation 2008

(2) Funding sectors and performing sectors for R&D expenditures in selected countries

This section examines the flow of R&D funds from funding sectors to performing sectors in each country, how the funds are distributed, and which sectors use how much of them.

Chart 1-1-5 shows each country's R&D expenditures divided by sector and their flow. Chart 1-1-4 above provides some details of the funding and performing sectors. However, caution is required because there is variation among the countries in terms of systems, survey methods, and the scope of the institutions covered, for both the funding sectors and the performing sectors.

Looking at the flow of R&D funds from funding sectors to performing sectors in each country, the business enterprises sector accounted for a large percentage in each country, but the flow was almost entirely within that same sector. In Germany and

China, however, the flow of R&D funds to the universities and colleges sector was relatively larger.

In the case of the governments sector, many countries had flow to public organizations and universities and colleges. Countries with the largest flows to universities and colleges are Japan, Germany, France, and the U.K. The flow from the governments sector to the business enterprises sector was small in most countries, although it is large in the U.S.

The universities and colleges sector is extremely small as a funding sector. In particular, in Germany and China, universities and colleges are not assumed to form a funding sector. In Japan's case, the only universities included in "universities and colleges" as a funding sector are private universities. The funding share of universities and colleges in Japan is large compared to other countries. The major reason for this is that a certain percentage of personnel expenses for instructors at private universities and colleges is statistically considered to be R&D expenditure.

The percentage of funding provided by the non-profit institutions sector was small in each country.

The foreign countries sector has a relatively large funding share in both the U.K. and France. In both those countries, most of those funds flowed to the business enterprises sector. It should be noted that, in the case of the United States, "foreign countries" is not classified as a funding sector. It is assumed that relevant information is included in other sectors.

Looking at each country, Japan had a large flow of R&D funds from the business enterprises sector to the business enterprises sector. There was almost no flow from that sector to other sectors. There was a large flow from the governments sector to the universities and colleges sector and to the public organizations sector as well. As a funding sector, the universities and colleges sector refers to private universities. All those funds flow to the universities and colleges sector as the performing sector. This flow means that R&D expenditure in private universities is almost entirely self-funded.

In the U.S., there was a large flow of R&D funds from the business enterprises sector to the business enterprises sector. There was also a large flow from the governments sector to the public organizations sector. The flow from that sector to the business enterprises sector was also large, exceeding the size of the flow to the universities and colleges sector.

In Germany, as in the other countries, the flow between the business enterprises sectors was the mainstream. Compared with the other countries, however, Germany had one of the larger flows of R&D funds to the university and college sector and the public organizations/non-profit institutions sector. It had the largest flow from the business enterprises sector to the universities and colleges sector of any of the selected countries. The share of funds accounted for by the foreign countries" sector was also among the largest.

Likewise in France, the flow from business enterprises was the largest, followed by governments. In particular, France is characteristic in that the funding share of governments is the largest compared to the other countries at 37.0%. The foreign countries sector's share of funding was also relatively large. Most of those R&D funds flowed to the business enterprises sector.

A characteristic of the U.K. is that, while business enterprises has the largest share among the funding sectors with 44.0% and governments is also large with 32.3%, foreign countries has an exceptionally large of 17.7%. Most R&D funds from the foreign countries sector flowed to the business enterprises sector, but a large share also went to the universities and colleges sector.

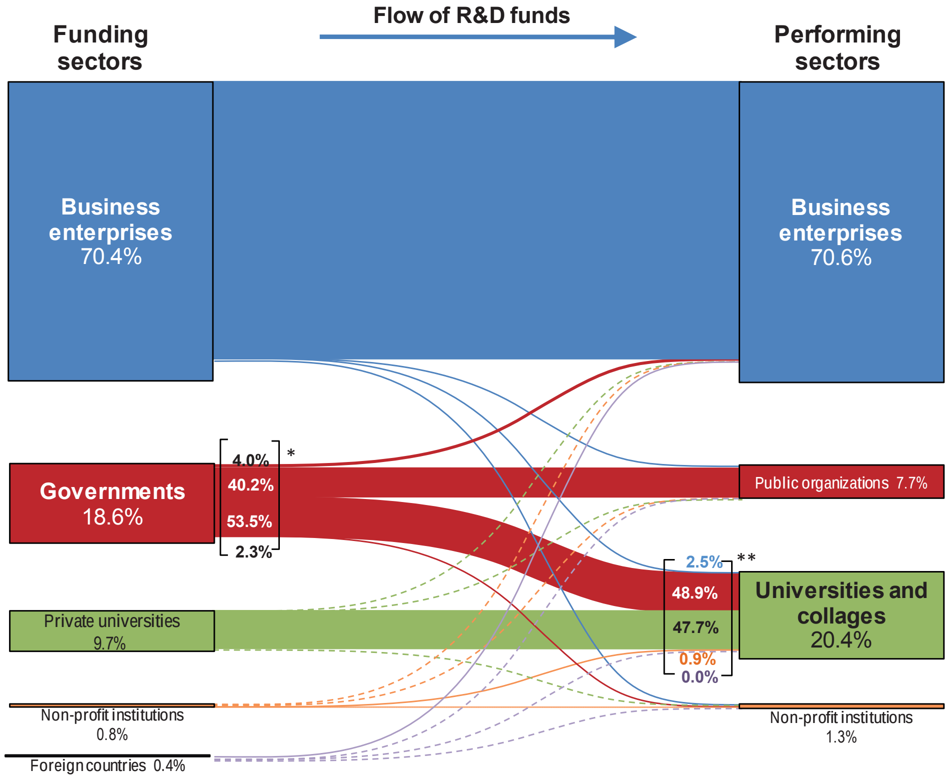
In China, the non-profit institutions sector comes under the classification "Other". At 73.9%, the share of business enterprises is large even when compared to other countries. Although almost all flows to business enterprises, the portion to universities and colleges is also large and funds 35.3% of their R&D expenditure. The largest share of R&D funding borne by the governments sector flowed to the public organizations sector.

In Korea, the business enterprises sector has the largest share at 71.8%. Almost all flows to business enterprises. The governments sector's share was large at 26.7%. About half of that went to the public organizations sector.

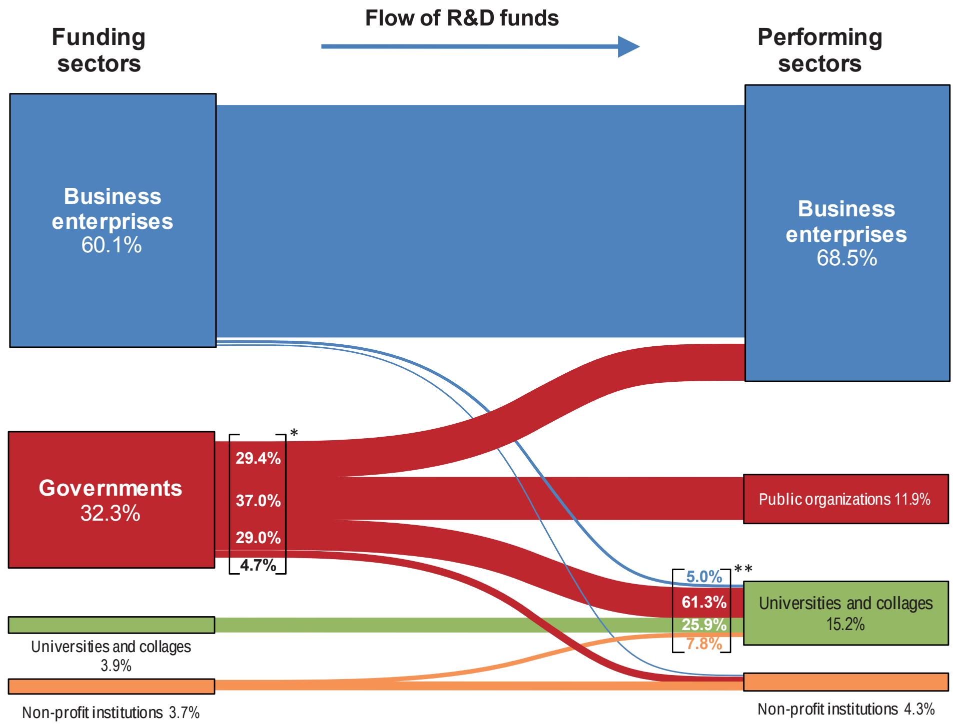
Chart 1-1-5: Flow of R&D funds from funding sectors to performing sectors in selected countries

(A) Japan (FY 2011)

Attention to international comparison

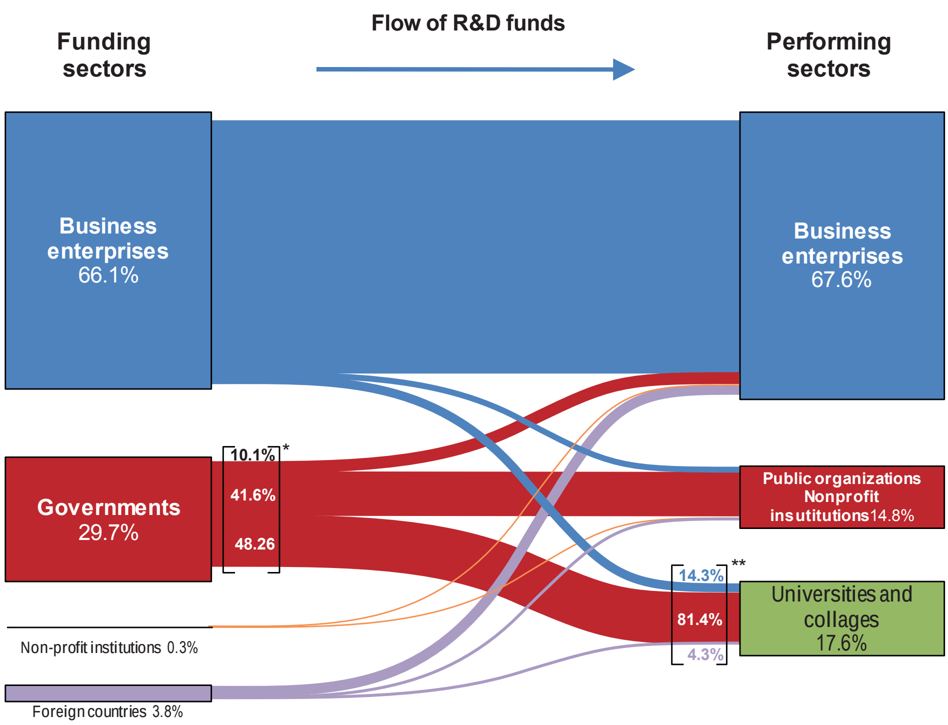


(B) U.S. (2011)

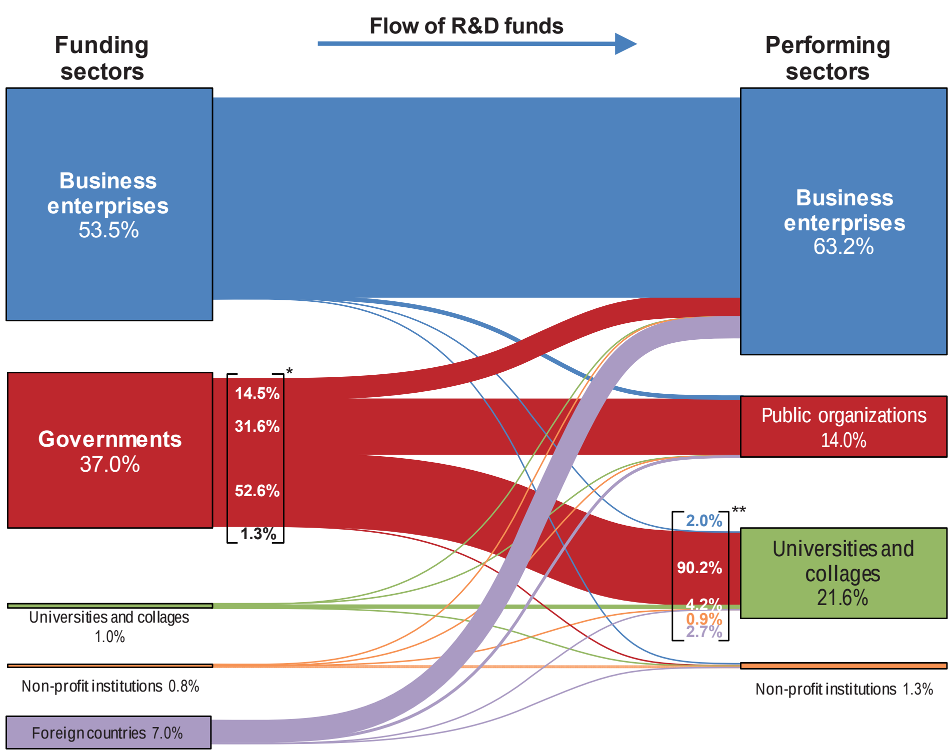


*U.S. funding sectors do not include "foreign countries."

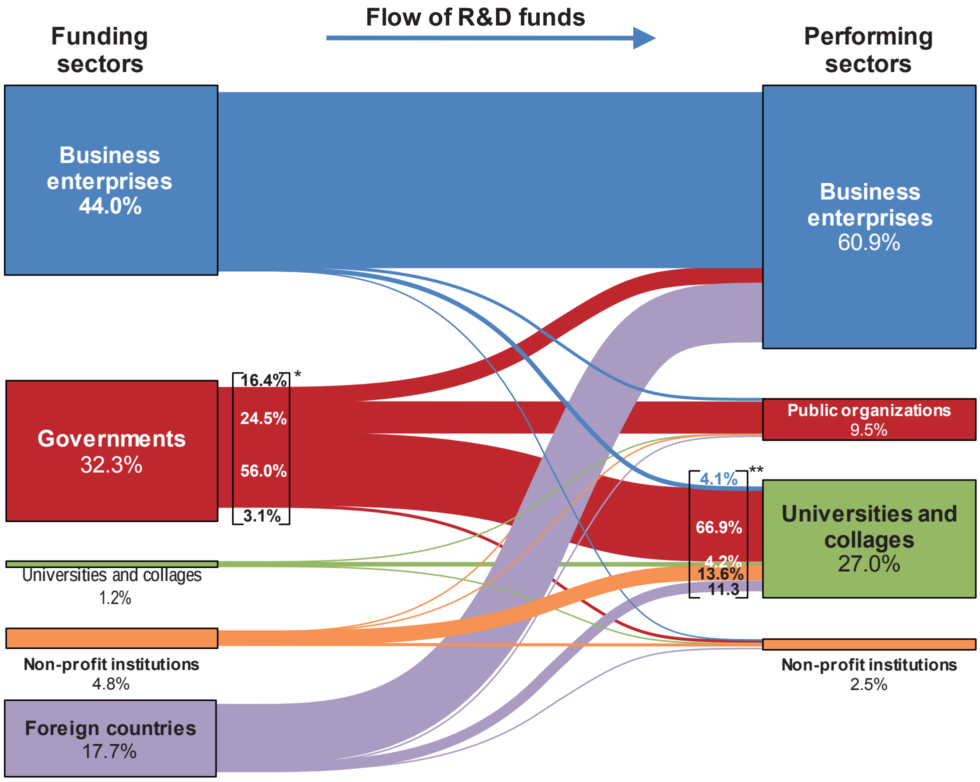
(C) Germany (2009)



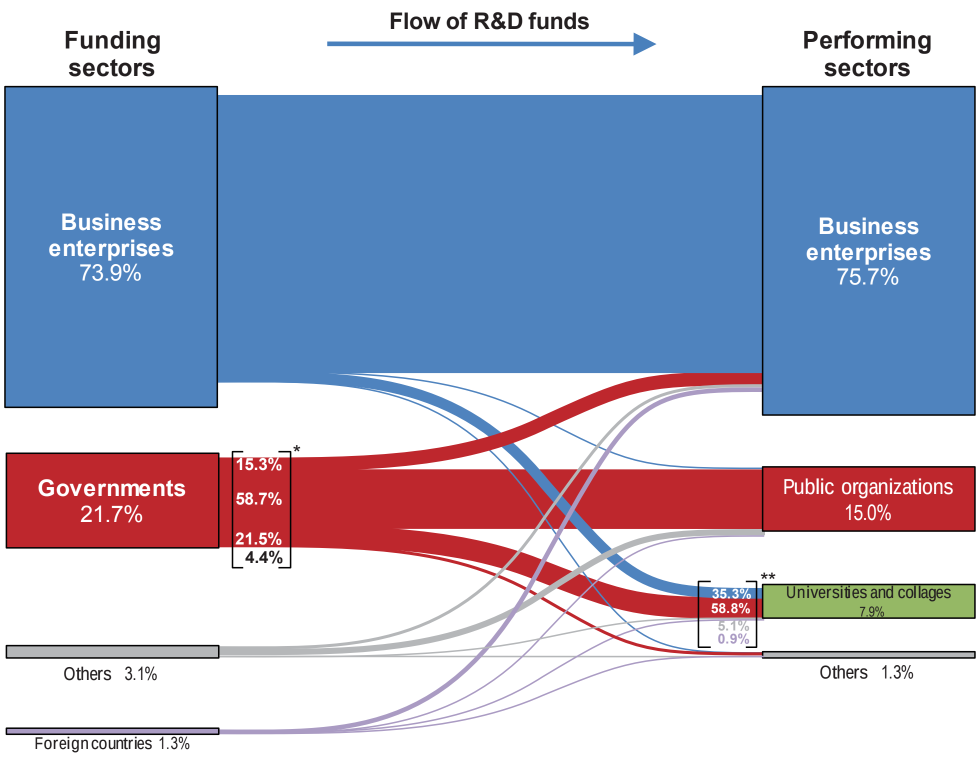
(D) France (2010)



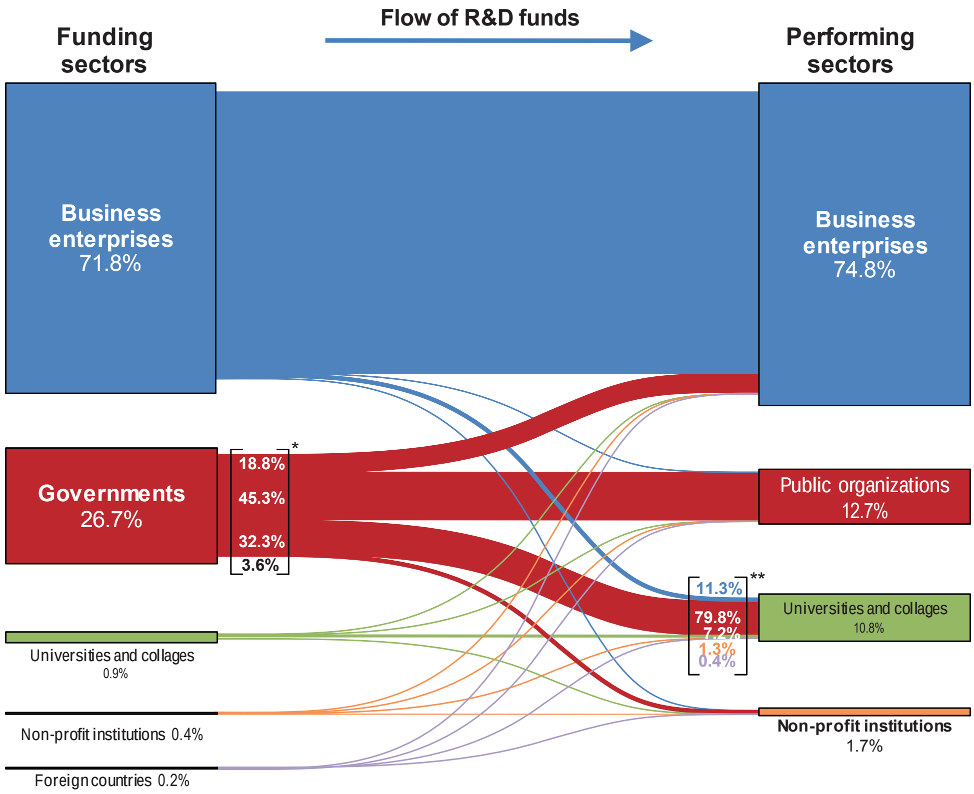
(E) U.K. (2010)



(F) China (2011)



(G) Korea (2010)



Note: See Chart 1-1-4 regarding funding and performing sectors.
*Analyzed in detail in Chart 1-2-5.
**Analyzed in detail in Chart 1-3-15.
Sources: <Japan> Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"
<U.S.> NSF, infobrief NSF 13-313 January 2013"
<Germany>"Bundesbericht Forschung und Innovation2012"
<U.K.> National Statistics website: www.statistics.gov.uk
<France, Korea> OECD, "Research & Development Statistics 2012"
<China>Ministry of Science and Technology of the People's Republic of China, "China Science and Technology Indicators"

(3) Changes in R&D expenditures in performing sectors in selected countries

In Chart 1-1-6, each selected country's total R&D expenditure is classified by sector, and changes in the proportions of each sector are shown. In each country, the business enterprises sector accounted for the largest proportion of total R&D expenditure: 70% in Japan, the U.S., Germany and Korea, and 60% in France and the U.K. On the other hand, the proportion used by the business enterprises sector is increasing in China, recently accounting for about 70%.

As for specific countries and regions, a long-term look at Japan shows that the business enterprises sector continues to increase while the public organizations sector is showing a gradual decrease. However, since 2009, the share of business enterprises has been decreasing while that of the universities and colleges sector is increasing. The significant decrease in the non-profit institutions sector since FY 2001 was due to a change in classification method for statistics.

In the case of Japan (estimated by the OECD), the business enterprises sector is increasing while the universities and colleges sector is showing a gradual decrease.

In the U.S., from a long run perspective, the proportion for the public organizations sector has been on the decrease, while the non-profit institutions sector has been small but increasing. The proportion of R&D expenditure of the universities and colleges sector is showing a gradual increasing trend over the long term.

In Germany, the data of public organizations sector and the non-profit institutions sector are integrated because these have not been classified.

No major fluctuation is seen in this sector's proportion of R&D expenditure over time, and thus it is thought that changes in the business enterprises and universities and colleges sectors are having an impact on conditions. In recent years, the proportion of the universities and colleges sector has been increasing, while that of the business enterprises sector has been decreasing.

In France, the proportion of the public organizations sector is always relatively large. This proportion has been decreasing in the long term and has recently leveled off. At the same time, the proportion of the universities and colleges sector is in an increasing trend.

In the U.K., the proportion of R&D expenditure of the public organizations sector has been decreasing since the 1990s, while that of the universities and colleges sector has been increasing.

In China, the proportion of the public organizations sector is large compared to other (five) countries; however it has been decreasing since 1999. On the other hand, the proportion of the business enterprises sector is rising over time instead.

In Korea, the proportion of the public organizations sector is larger than that of the universities and colleges sector. The proportions of both sectors have remained largely unchanged in recent years.

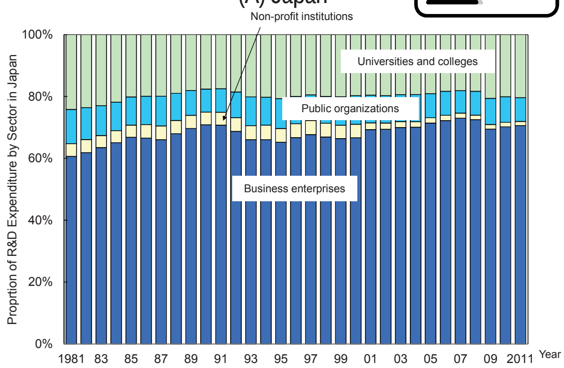
EU-15 and 27 show the same characteristics as the U.K. and France. Specifically, the proportion of the public organization sector is in a long-term decreasing trend, while the proportion of the universities and colleges sector is showing an increasing trend.

Chart 1-1-6: Trends in the proportion of R&D expenditure by performing sector in selected countries

Attention to international comparison

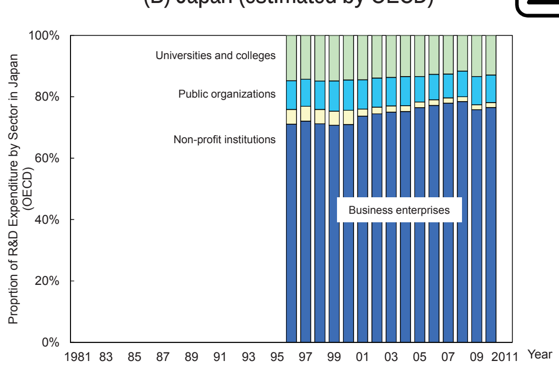
(A) Japan

Attention to trend

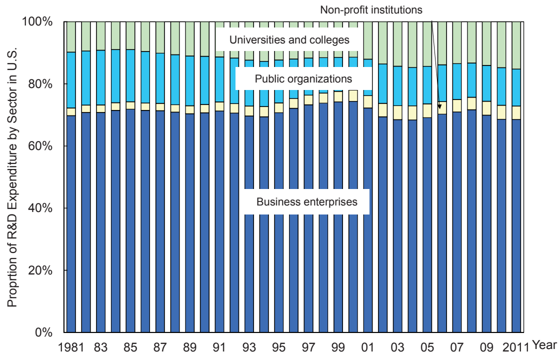


(B) Japan (estimated by OECD)

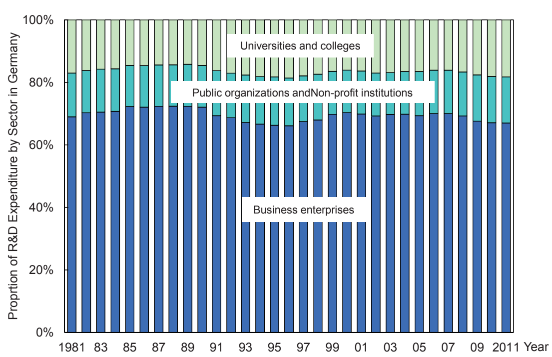
Attention to trend



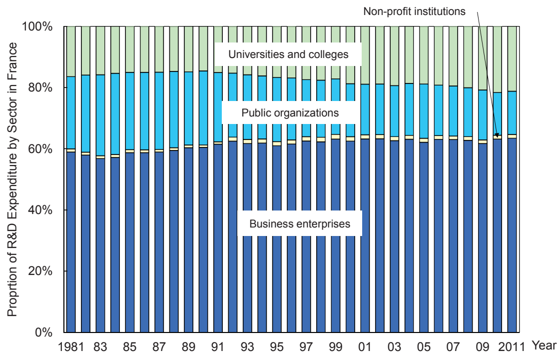
(C) U.S.



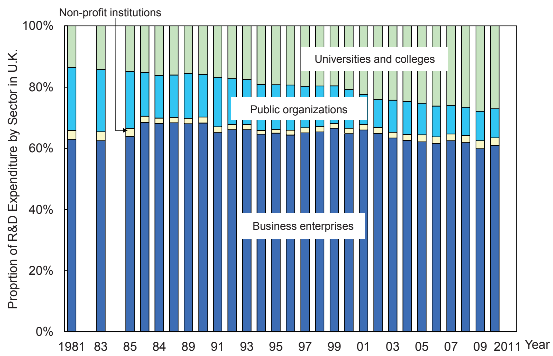
(D) Germany



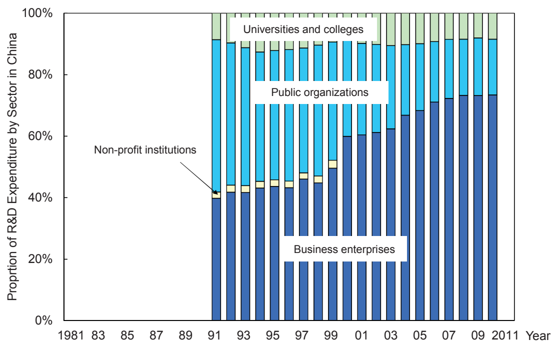
(E) France



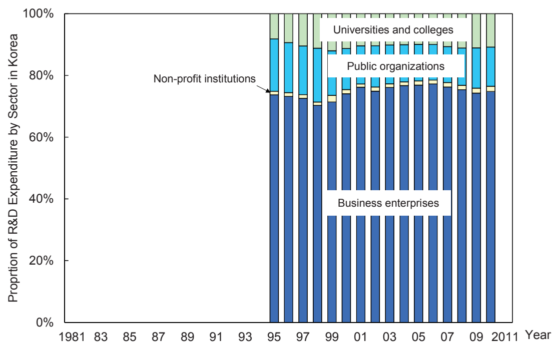
(F) U.K.



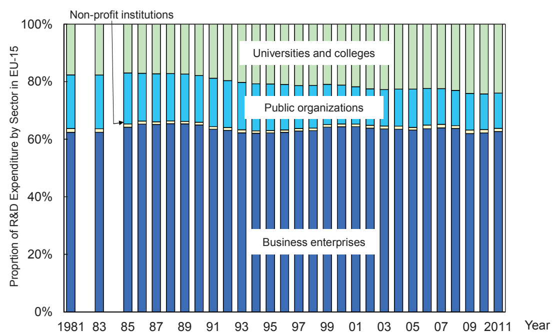
(G) China



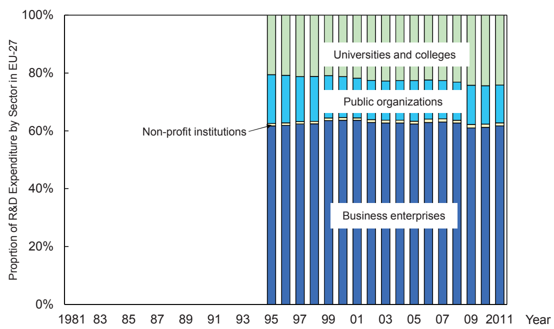
(H) Korea



(I) EU-15



(J) EU-27



Note: 1) The total R&D expenditure is the sum of each sector's expenditure, and the definition of each sector occasionally differs depending on the country. Therefore it is necessary to be careful when making international comparisons. Refer to Chart 1-1-4 for the definition of sectors in each selected country.
2) R&D expenditures include humanities and social sciences (for Korea, only natural sciences until 2006).
3) For Japan (OECD estimate), France, China, Korea and EU, non-profit institution totals minus the business enterprises; public organizations; and universities and colleges.
<Japan and Japan (estimated by the OECD)> In FY 2001, a part of non-profit institutions moved into the business enterprise sector.
<Japan (estimated by the OECD)> From 1996, figures corrected and estimated by the OECD (R&D expenditure in the universities and colleges sector comprising labor costs converted to FTE) are used, so caution is required when viewing changes over time.
<Germany> Former West Germany until 1990, and the unified Germany since 1991, respectively.

Source: <Japan> Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development; OECD, "Main Science and Technology Indicators 2012/2"
<U.S.> NSF, "National Patterns of R&D Resources: 2010–11 Data Update "
<Germany> Bundesministerium für Bildung und Forschung, "Bundesbericht Forschung 2004,2006"; "Bundesbericht Forschung und Innovation 2010, 2012"; OECD, "Main Science and Technology Indicators 2012/2" for 2010 or later
<U.K.> National Statistics website: www.statistics.gov.uk
<France, China, Korea and EU> OECD, "Main Science and Technology Indicators 2012/2"

1.2 Government budgets

Key points

○Japan's total GBAORD amounted to 3.6 trillion in 2013. Growth in Japan's total GBAORD has stagnated since entering the 2000s.

○Japan's total GBAORD is comprised almost entirely of non-defense expenditure, as national defense accounted for less than 5%. On the other hand, in the U.S., the share of GBAORD for national defense exceeds 50%, which makes it larger than the share for the civilian sector.

○A look at the GBAORD of the selected countries (real values, national currencies based on 2005 rates) shows that the countries with higher annual average growth rates in the second half of the 2000s than the first half are Germany and China (central and regional governments). All of the other countries are showing decreases, with the U.S. having the largest. China (central government) and Korea show small decreases.

○The country with the largest ratio of R&D expenditure funded by the government among the selected countries is France, whose ratio was 37.0% in 2010. Japan has the lowest ratio among the seven countries, with a government-funded ratio of 18.6% in 2011 (17.2% in the case of Japan (estimated by the OECD)). The ratios of almost all of the countries were in a decreasing trend until around 2000 and have leveled out since then; however, China's ratio has continued to decrease.

○In 2013, Japan's ratio of competitive funding was 11.5% of GBAORD totaling 3.6 trillion yen. This figure represents a decrease from the 2009 peak.

In this chapter, each country's GBAORD included in the government budget are examined.

In this report, Japan's "government budget appropriations for Science & Technology (S&T)" are treated as the GBAORD. The government appropriations for S&T are composed of (1) funds for promoting science and technology (a part of the general account, with the main purpose of appropriation in the promotion of science and technology) (2) other research expenditure included in the general account, and (3) the government budget appropriation for S&T included in the special account.

1.2.1 GBAORD in each country

An examination of total GBAORD (by OECD purchasing power parity equivalent) of the selected countries' governments (Chart 1-2-1 (A)) shows that Japan had a total of 3.7 trillion yen in 2012[(4)]. When viewed over the long term, Japan's GBAORD is growing; however, the rate of this growth has been slowing since the early 2000s. In the case of the U.S., there has been a declining trend since special funds were allocated in 2009 under the American Recovery and Reinvestment Act of 2009 (ARRA). Germany is seeing a gradual and consistent increase. France and the U.K. have seen stationary or declining trends since entering the 2000s. On the other hand, Germany and Korea have had continuous increases since entering the 2000s, while China has had remarkable increases.

An examination of GBAORD that classifies defense-related expenditure (defense) from other expenditure (non-defense) (Chart 1-2-1 (B)) reveals that nearly the entirety of Japan's GBAORD goes to the non-defense sector, with that going to defense accounting for 5% or less. On the other hand, in the U.S., the share of GBAORD for defense exceeds 50%, which makes it larger than the share for the non-defense sector. Looking at other countries, the share of GBAORD for defense is 10% or less in Germany and France and 10% or more in the U.K. and Korea.

A comparison of the annual average growth rates of total GBAORD for the first half of the 2000s (2000 to 2005) and the second half of the 2000s (2005 to the most recent available year in each country) (Chart 1-2-1 (C)) shows that the countries with higher rates in the second half than the first half are Germany and China. All of the other countries

(4)This section uses "years" for international comparison, although in the case of Japan it is originally "fiscal years."

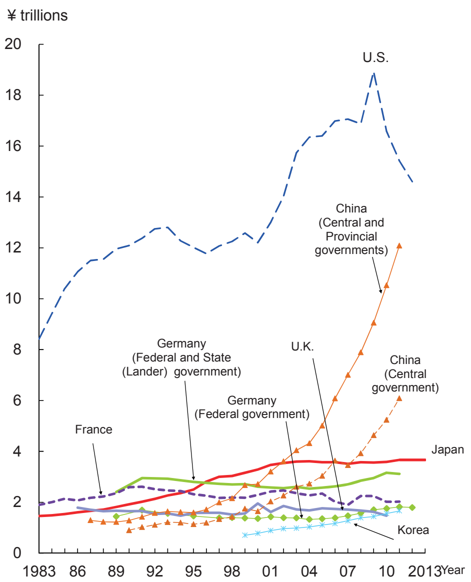
have lower rates in the second half, with the U.S. having the lowest rate.

Moreover, an examination of changes in real values, excluding the effects of price fluctuations (Chart 1-2-1 (D), shows that the countries with higher annual average growth rates in the second half of the 2000s than the first half are Germany and China (central and regional governments). All of the other countries are showing decreases, with the U.S. having the largest. China (central government) and Korea show small decreases.

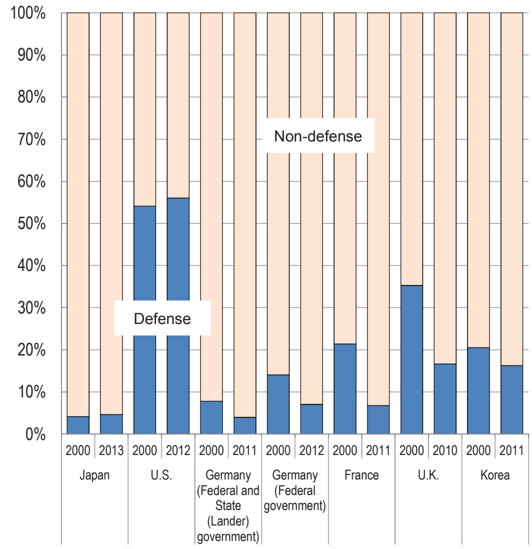
It should be noted that the annual average growth rates for defense-related budgets of many countries showed negative growth in the second half of the 2000s. In terms of nominal value, those countries showing positive growth are the U.S. and Korea only. And in terms of real value, the U.S., Germany (federal and state (Lander government)), and Korea show positive growth.

Chart 1-2-1: GBAORD of selected countries

(A) Trends in total GBAORD
(by OECD purchasing power parity equivalent)



(B) Percentages of GBAORD
for the non-defense and defense sectors



(C) Nominal values (national currency)

National Currencies	Government BudgetAppropriations or Outlays for R&D	2000	2005	2012	Annual Average Growth Rate '00→'05	Annual Average Growth Rate '05→'12
Japan (¥ trillions)	Total	3.29	3.58	3.69	1.72%	0.44%
	Non-defense	3.15	3.43	3.58	1.74%	0.61%
	Defense	0.14	0.14	0.11	1.22%	-4.13%
U.S. ($ billions)	Total	78.7	127	141	9.98%	1.51%
	Non-defense	36.1	52.6	61.8	7.81%	2.26%
	Defense	42.6	74.0	78.8	11.7%	2.17%
Germany (Federal and State (Lander) Governments) (€ billions)	Total	16.3	17.2	23.4('11)	1.16%	5.27% ('11)
	Non-defense	15.0	16.2	22.5 ('11)	1.61%	5.59% ('11)
	Defense	1.27	0.99	0.94 ('11)	-4.80%	-0.92% ('11)
Germany(Federal Govenment) (€ billions)	Total	8.48	9.04	13.8	1.28%	6.26%
	Non-defense	7.29	7.95	12.8	1.90%	7.10%
	Defense	1.19	1.09	0.98	-2.72%	-1.52%
France (€ billions)	Total	13.8	16.7	16.8 ('11)	3.82%	0.11% ('11)
	Non-defense	10.9	13.2	15.7 ('11)	3.95%	3.33% ('11)
	Defense	2.96	3.48	1.14 ('11)	3.39%	-18.2% ('11)
U.K. (£ billions)	Total	8.01	8.66	9.38 ('10)	6.06%	1.61% ('10)
	Non-defense	5.18	6.41	7.82 ('10)	8.78%	4.03% ('10)
	Defense	2.83	2.24	1.56 ('10)	0.03%	-7.01% ('10)
China (Central and Provincial governments) (¥ billions)	Total	57.6	133	490 ('11)	18.3%	24.2% ('11)
	Non-defense	-	-	-	-	-
	Defense	-	-	-	-	-
China (Central government) (¥ billions)	Total	35.0	80.8	247('11)	18.2%	20.5% ('11)
	Non-defense	-	-	-	-	-
	Defense	-	-	-	-	-
Korea (₩ billions)	Total	3.75	6.74	13.0 ('11)	12.4%	11.6% ('11)
	Non-defense	2.98	5.75	10.9 ('11)	14.1%	11.3% ('11)
	Defense	0.77	0.99	2.12 ('11)	5.05%	13.7% ('11)

(D) Real values (2005 base, national currency)

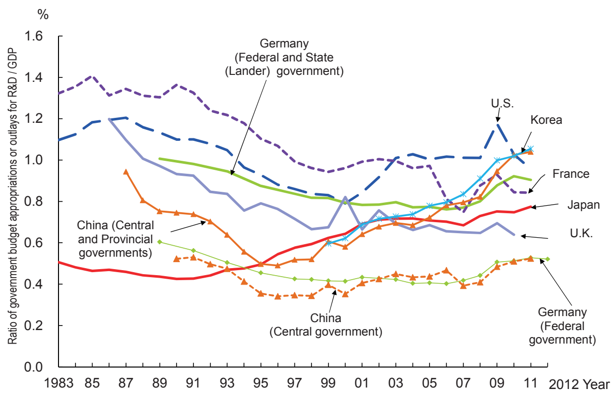
National Currencies	Government BudgetAppropriations or Outlays for R&D	2000	2005	2012	Annual Average Growth Rate '00→'05	Annual Average Growth Rate '05→'12
Japan (¥ trillions)	Total	3.06	3.58	4.03	3.18%	1.73%
	Non-defense	2.93	3.43	3.92	3.20%	1.90%
	Defense	0.13	0.14	0.12	2.67%	-2.90%
U.S. ($ billions)	Total	88.7	127	122	7.38%	-0.56%
	Non-defense	40.7	52.6	53.5	5.26%	0.18%
	Defense	48.0	74.0	68.2	9.06%	0.10%
Germany (Federal and State (Lander) Governments) (€ billions)	Total	17.1	17.2	22.2 ('11)	0.09%	4.29% ('11)
	Non-defense	15.8	16.2	21.3 ('11)	0.53%	4.61% ('11)
	Defense	1.34	0.99	0.89 ('11)	-5.80%	0.89% ('11)
Germany(Federal Govenment) (€ billions)	Total	8.94	9.04	12.9	0.21%	5.21%
	Non-defense	7.68	7.95	12.0	0.83%	6.04%
	Defense	1.26	1.09	0.91	-3.75%	-2.50%
France (€ billions)	Total	15.3	16.7	15.2 ('11)	1.82%	-1.58% ('11)
	Non-defense	12.0	13.2	14.1 ('11)	1.95%	1.58% ('11)
	Defense	3.27	3.48	1.03 ('11)	1.40%	-19.6% ('11)
U.K. (£ billions)	Total	8.96	8.66	8.31 ('10)	3.71%	-0.82% ('10)
	Non-defense	5.80	6.41	6.93 ('10)	6.37%	1.55% ('10)
	Defense	3.16	2.24	1.38 ('10)	-2.19%	-9.23% ('10)
China (Central and Provincial governments) (¥ billions)	Total	67.4	133	356 ('11)	14.7%	17.8% ('11)
	Non-defense	-	-	-	-	-
	Defense	-	-	-	-	-
China (Central government) (¥ billions)	Total	40.9	80.8	180 ('11)	14.6%	14.2% ('11)
	Non-defense	-	-	-	-	-
	Defense	-	-	-	-	-
Korea (₩ billions)	Total	4.32	6.74	11.4 ('11)	9.31%	9.17% ('11)
	Non-defense	3.43	5.75	9.55 ('11)	10.9%	8.52% ('11)
	Defense	0.89	0.99	1.86 ('11)	2.13%	11.1% ('11)

Note: <Japan> Data for all the fiscal years are of initial budget amounts.
<U.S.> The value for FY 2012 is a preliminary budget amount. The FY 2009 figure includes special funding allocated under the ARRA (American Recovery and Reinvestment Act of 2009).
<Germany> Estimation for the value of the federal government and local governments ("lander governments") in 2011, and for the federal government in 2012.
<France> Data for 1984, 1986, 1992, 1997 breaks in series with previous year for which data is available. Data for 2008 are estimates.
<U.K.> Data for FY 2006 are estimates. Data for FY 2007 and 2008 are planned values by cross cutting review.
Reference statistics E was used for the conversion to obtain purchasing power parity equivalent.
Source: <Japan> Ministry of Education, Culture, Sports, Science and Technology data
<U.S.> NSF, "Federal R&D Funding by Budget Function"
<Germany> Bundesministerium für Bildung und Forschung, "Faktenbericht Forschung 2002", "Bundesbericht Forschung 2004, 2006", "Research and Innovation in Germany 2005, 2007,"Bundesbericht Forschung und Innovation 2010, 2012"
<France and Korea> OECD, "Main Science and Technology Indicators 2012/2"
<U.K.> OST, "SET Statistics"
<China> China Science and Technology Statistics; "S&T Statistics Data Book" (website)

Next, each country's ratio of GBAORD against GDP is shown for comparison to reduce the effect of the scale of the country's economy (Chart 1-2-2). The value for Japan increased during the 1990s and was flat during the 2000s but has been increasing slightly in recent years. Since the 2000s, growth in Korea and China (central and provincial governments) has been remarkable. Ratios in the other countries have been flat or have shown a declining trend.

The ratios for the latest available year were 0.77% in Japan, 0.96% in the U.S., 0.90% or 0.52% in Germany with or without including the local governments ("Lander governments") respectively, 0.84% in France and 0.64% in the U.K. Korea had the highest ratio at 1.05%. China's ratio was close to Korea's at 0.52% for the central government and 1.04% when provincial governments are included.

Chart 1-2-2: Trends of the ratio of Government budget appropriations or outlays for R&D against GDP in selected countries



Note: <GBAORD> Same as Chart 1-2-1
<GDP> Same as Reference statistics C
Source: <GBAORD> Same as Chart 1-2-1
<GDP> Same as the reference statistics C

1.2.2 Ratio of R&D expenditure funded by the government in each country

The following are two types of methods for surveying government funded R&D expenditure:

(1) Sum up the results of the survey conducted by each performing sector to obtain its government funded R&D expenditure

(2) Obtain R&D related expenditure (the GBAORD[5]) out of the government expenditure. (See Section 1.2.1.)

Of the above mentioned two, method (1) which is conducted by the side of performing sectors can provide the total R&D expenditure, even if the flow of the expenditure is complicated, under the condition that the targets of the survey cover the entire country. However, the sources of the R&D expenditure are not always precisely identifiable. On the other hand, it is difficult for method (2) which is conducted from the side of expenditure source (the GBAORD) to obtain accurate R&D expenditure because it is unknown whether or not the entire amount was used for the purpose of R&D in actuality.

In this section, method (1) by the side of performing sectors is used to show the status of each government's R&D expenditure. With this method, the ratio of the R&D expenditure which was funded by the government for each sector against the total R&D expenditure in each country is examined. The expression "the government" here mainly represents the central government, but what is represented depends on the country. Chart 1-2-3 shows a simple definition of "the government" for each country.

A look at the ratio of R&D expenditure funded by the governments of the selected countries shows that the country with the largest ratio is France, whose ratio was 37.0% in 2010 (Chart 1-2-4). Japan had the lowest ratio among the seven countries with a government-funded ratio of 18.6% in 2011 (17.2% in 2010 in the case of Japan (estimated by the OECD)).

It deserves mentioning that the ratios of almost all of the countries were in a decreasing trend until around 2000 and have leveled out since then; however, China's ratio has continued to decrease.

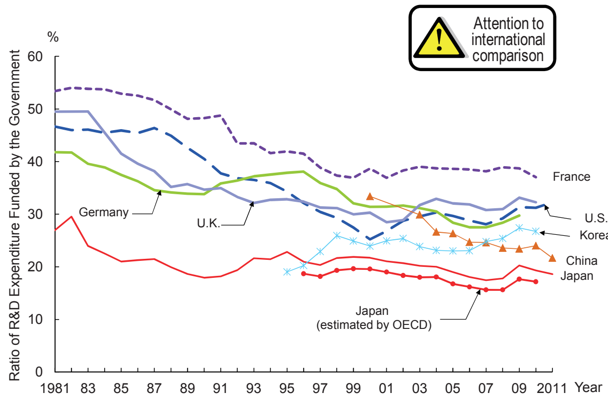
(5) Ordinarily, only the part of the S&T budget devoted to R&D (the R&D budget) should be studied, but there are no data on Japan's R&D budget. This report therefore uses S&T budget data. However, R&D accounts for most of Japan's S&T budget. R&D budget data are available for most countries other than Japan.

Chart 1-2-3: Definition of "the government" as a source of expenditure in selected countries

Country	Government
Japan	• National government and local governments • Research institutions (including JSPS, NEDO, JST, etc.) at national, public and semi-governmental corporations and independent administrative agencies (not for profit) • National and public universities (including junior colleges, university-affiliated research institutes, etc.)
Japan (OECD)	• National government and local governments • Research institutions (including JSPS, NEDO, JST, etc.) at national, public and semi-governmental corporations and independent administrative agencies (not for profit)
U.S.	Federal government (however, some R&D funds used by universities and colleges are provided by state governments)
Germany	• Government (federal, state and district governments) (Includes federal government commissions and subsidies, and in some cases repayable grants from public organizations. Does not include funds received from the federal government within the economic sector's R&D human resources development program or the industrial and economic sectors' measures on the promotion of cooperative research.)
France	• Public research institutions • Regional governments
U.K.	· Central government (U.K) · Decentralized governments (Scotland, etc.) · Research councils · Higher Education Funding Councils * Local governments are not included
China	· Government research institutes * Local governments are not included
Korea	• Government (national and public laboratories, local governments) • Government-contribution research institutions (organizations to which the government provides some or all of the funds needed to operate corporations: Korea Advanced Institute of Science and Technology, Korean Atomic Energy Research Institute, etc.)

Note: Same as Chart 1-1-4(B).
Sources: Same as Chart 1-1-4(B).

Chart 1-2-4: Trend in the ratio of R&D expenditure funded by the government in selected countries



Note: 1) When an international comparison is conducted, it should be noted that the R&D expenditure which is investigated by the side of performing sectors may be funded exclusively by the central government, or by both central and local governments, depending on the country. The definition of each country's "government" is referred to in Chart 1-2-3.
2) R&D expenditures include humanities and social sciences (for Korea, only natural sciences until 2006).

Source: <Japan> Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"
<U.S.> NSF, "National Patterns of R&D Resources: 2010–11 Data Update"
<Germany> Bundesministerium fur Bildung und Forschung, "Bundesbericht Forschung 2004,2006"、"Bundesbericht Forschungund Innovation 2010,2012"
<Japan (OECD estimate), France and Korea> OECD, "Research & Development Statistics 2012"
<U.K.> National Statistics website: www.statistics.gov.uk
<China> Ministry of Science and Technology of the People's Republic of China, "China Science and Technology Indicators"; S&T Statistics Data Book (website)

Next, differences in national policy on R&D expenditure for each country are examined by means of observing the breakdown of R&D expenditure (funded by the government) by performing sector. In other words, they are examined by understanding what proportion of government funds was used in each performing sector (Chart 1-2-5).

In the case of Japan, no significant change in each sector occurred. The university and college sector and the public organization sector accounted for the major portion of R&D expenditure through the period of the chart. Limited spending on the business enterprise sector as compared to other countries is characteristic of Japan.

In the U.S., previously a large share of R&D expenditure was allocated to the business enterprises sector. Beginning in the latter half of the1980s, this share decreased significantly while the share for the universities and colleges sector increased. However, since 2002, the share for the business enterprises sector has been increasing again while that for the universities and colleges sector has leveled out.

In Germany, the share of expenditure for the business enterprises sector has been decreasing since the mid-1980s, while that for the universities and colleges sector and public organizations and non-profit institutions sector has been increasing.

In France, previously the proportion for the public organizations sector was large, and that for the universities and colleges sector was relatively small. Starting in the 1990s, however, the proportion for the universities and colleges sector increased while that for the public organizations sector and the business enterprises sector decreased. The proportion to the business enterprises sector has been stable since entering the 2000s.

In the U.K., spending for the universities and colleges sector tended to substantially increase from 1981 to 1996, while the proportion for the business enterprises declined. However, the share for the business enterprises sector has leveled out since entering the 2000s. The proportion for the public organizations sector has gradually been declining since the latter half of the 1990s.

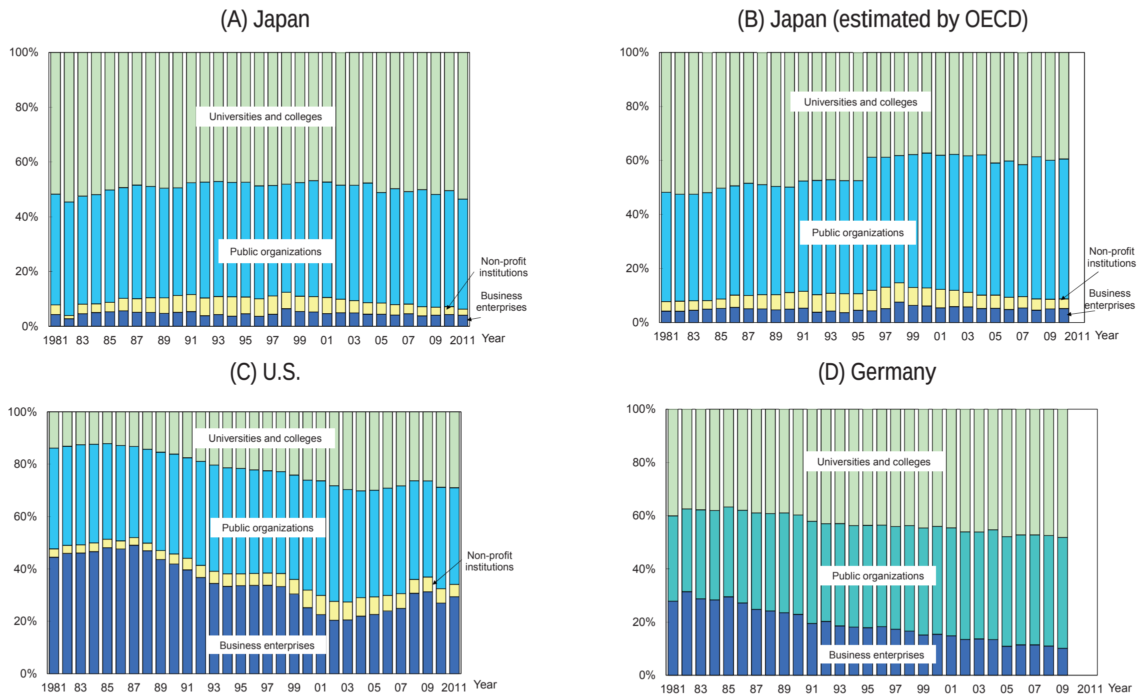
In China, R&D expenditure for the public organizations sector is large but in a downward trend. On the other hand, shares for the business enterprises and universities and colleges sectors are increasing.

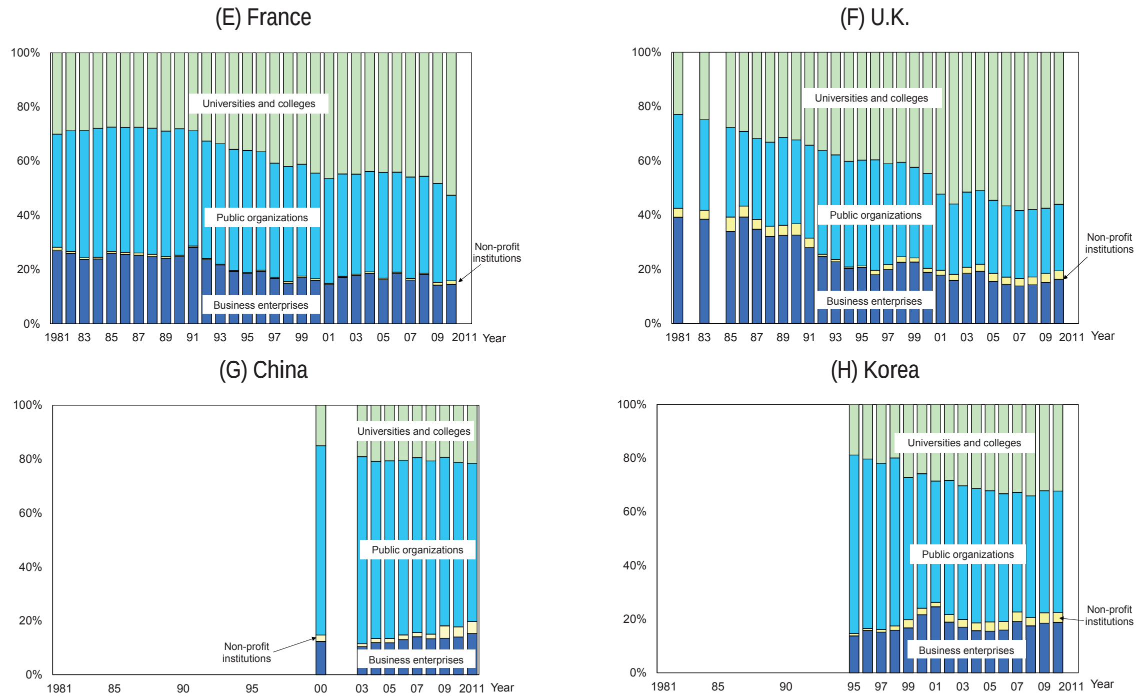
In Korea, expenditure for the public organizations sector is similarly large, while that for the universities and colleges sector is increasing. Expenditure for the business enterprises sector has remained stable since the beginning of the 2000s.

Chart 1-2-5: Trend of the proportion of R&D expenditure funded by the government by sector in selected countries

Attention to international comparison

Attention to trend





Note: 1) Attention is required for international comparison as in Chart 1-2-4
2) R&D expenses include the fields of social science and humanities (for Korea, only natural sciences until 2006).
<Japan> The government refers to the national government, local public governments, national research institutes, public research institutes, research institutes run by special corporations and independent administrative corporations, national and public universities (including junior colleges etc.).
<Japan (estimated by OECD)> 1) Attention is required for observing the change in a time series because the value which OECD adjusted and estimated (by converting the labor costs of the university and college sector in R&D expenditure with FTE) has been used since 1996.
2) The government refers to national government, local public government, national research institutes, public research institutes and research institutes run by special corporations and independent administrative corporations.
<U.S.> The government refers to the federal government.
<Germany> Former West Germany and unified Germany until 1990 and since 1991 respectively. The government refers to the federal government and local governments.
<France> The government refers to public research institutes.
<U.K.> The government refers to the central government (including decentralized governments), research councils and the higher education funding council.
<Korea> The government refers to government research institutes and government supported research institutes.

Source: <Japan> Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"
<U.S.> NSF, "National Patterns of R&D Resources: 2010–11 Data Update"
<Germany> Bundesministerium für Bildung und Forschung, "Bundesbericht Forschung 2004,2006", "Bundesbericht Forschung und Innovation 2010,2012"
<Japan (OECD estimate), France, Korea> OECD, "Research & Development Statistics 2012"
< U.K.> OECD, "Research & Development 2012"; National Statistics website: www.statistics.gov.uk since 1992
<China> Ministry of Science and Technology of the People's Republic of China, "Science and technology index of the People's Republic of China", S&T Statistics Data Book (website).

1.2.3 GBAORD (the government budget appropriations for S&T) in Japan

Science and Technology Basic Plans are based on the Science and Technology Basic Act proclaimed and implemented in November 1995. They are basic plans for the comprehensive and systematic advancement of policies designed to promote science and technology. With a view towards the coming 10 years or so, the government creates them to realize S&T policy over five years.

This section will examine changes in GBAORD under each of the First to Fourth Science and Technology Basic Plans (hereafter "Basic Plan") (Chart 1-2-6).

The First Science and Technology Basic Plan covered FY 1996–2000. It indicated the necessity of total GBAORD of about 17 trillion yen. Actual GBAORD for the five years covered by the First Science and Technology Basic Plan totaled 17.6 trillion yen. Looking at the trend over the five years, initial budgets followed a rising trend. Substantial supplemental budgets were also added. The supplemental budget added during FY 1998 as economic stimulus made a major contribution to the total five-year budget.

The Second Science and Technology Basic Plan covered FY 2001–2005. It indicated that GBAORD needed to reach approximately 24 trillion yen. Actual (national) budgets during this period totaled approximately 18.8 trillion yen. Initial budgets increased slightly, with large supplemental budgets added in 2001 and 2002.

With the 2.3 trillion yen from local government budgets added in, the total was 21.1 trillion yen.

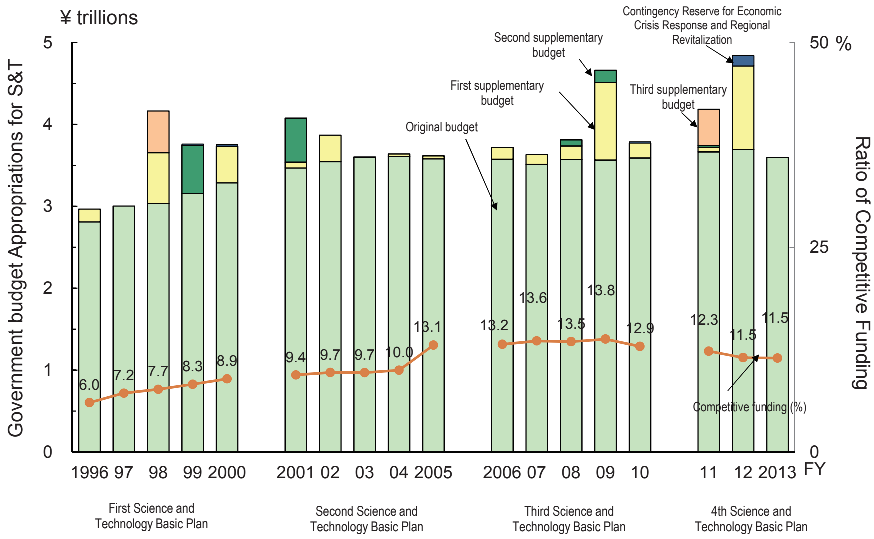
In the Third Science and Technology Basic Plan, a total budget about 25 trillion yen for the five years from FY 2006 through FY 2010 was considered necessary. (This was predicated on a ratio of GBAORD to GDP during the period of 1%, with an average nominal GDP growth rate of 3.1%.) Initial budgets during the period totaled 19.6 trillion yen. The growth trend over the five years was flat for initial budgets, but FY 2009 added about 1 trillion through supplemental budgets. The five-year total was 19.6 trillion yen. With local government budgets added, the total was 21.7 trillion yen.

The Fourth Science and Technology Basic Plan covers the five years that began in 2011. It calls for total GBAORD of about 25 trillion yen during the five years. (This is predicated on a ratio of GBAORD to GDP during the period of 1%, with an average nominal GDP growth rate of 2.8%.)

GBAORD in FY 2013 is 3.6 trillion yen, which represents a 2.6% decrease compared to the initial budget of last year. However, it must be noted that substantial supplemental budgets were added during FY 2011 and FY 2012.

Moreover, the ratio of competitive funding in the initial budget is 11.5%, which represents a decrease from the 2009 peak.

Chart 1-2-6: Trend of the government budget appropriation for S&T under the Science and Technology Basic Plans



Note: 1) The supplementary budgets were composed of only additional amounts.
2) In accordance with the formulation of the science and technology basic plans (from the first to the third) , the range of targeted costs were reviewed in FY 1996, 2001 and 2006.

Source: Data from the Ministry of Education, Culture, Sports, Science and Technology.

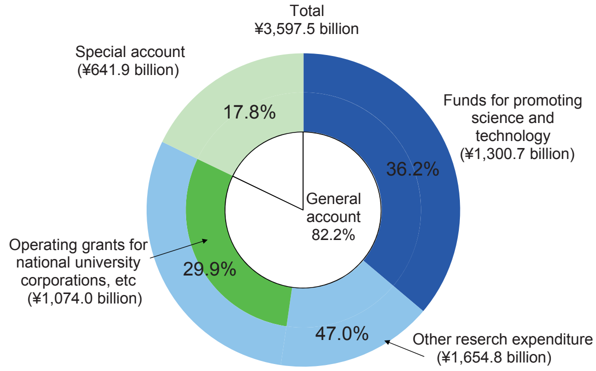
Some basic indexes regarding GBAORD are shown below.

Chart 1-2-7 compares the growth rate compared to the previous fiscal year in GBAORD with the growth rate in general expenditures. "General expenditures" as used here is total general account expenditures minus debt servicing costs, local allocation tax and so on. Because their content and scale are decided at the government's discretion according to economic conditions, they can be considered government spending. By comparing their growth rate with that of GBAORD, the priority assigned to GBAORD in the budget can be discerned.

During the 1990s, the annual growth rate of GBAORD was high and it was usually higher than that of general expenditures. From about the middle of the 2000s, the GBAORD growth rate was about equal to that of general expenditures, but it has occasionally fallen below this level more recently. However, in recent years, GBAORD's importance has been declining, as there was a 2.6% decrease in FY 2013. Moreover, the growth rate of general expenditures showed a 4.2% decrease in FY 2012.

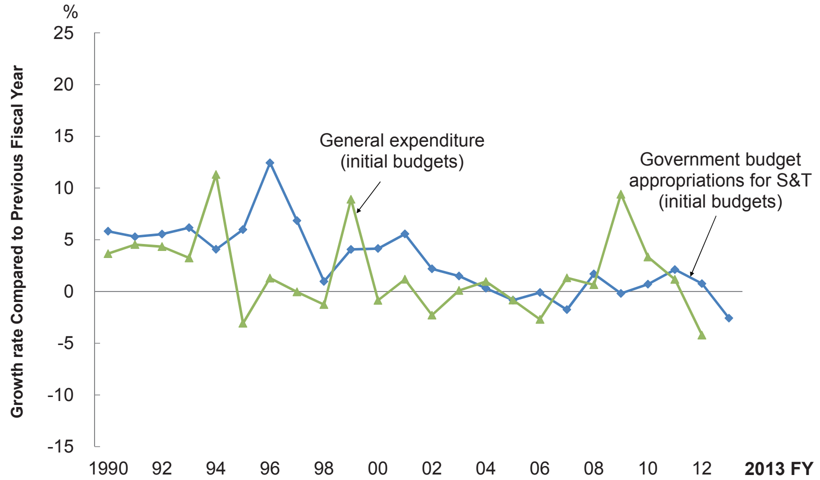
The ratio of the general account to special accounts in Japan's FY 2013 GBAORD is 82.2% to 17.8% (Chart 1-2-8). The general account comprises costs for national universities and public research institutes, "Funds for promoting science and technology" consisting of several grants and other research related costs, etc. Of the special accounts, those for supply and demand of energy (special accounts for the measures for structural improvement of petroleum and energy supply and demand) and for promotion of power development (special accounts for electric power development promotion measures) account for large shares.

Chart 1-2-8: Breakdown of the Government appropriations for S&T (FY 2013)



Note: With regard to national university corporations, until FY 2006, the budget appropriation was calculated in accordance with the sum of operating grants, subsidies for capital expenditure and self income (by hospital income, tuition fees and commission projects, etc.). This amount is the equivalent of the government budget appropriation for S&T in the national school special account system prior to the time when national universities, etc. were turned into to corporations. The calculation method was changed not to include self incomes since FY 2006.
Source: Data from the Ministry of Education, Culture, Sports, Science and Technology

Chart 1-2-7: Trend of the growth rate of the total government budget appropriations for S&T and the general expenditure, both compared to previous fiscal years in Japan

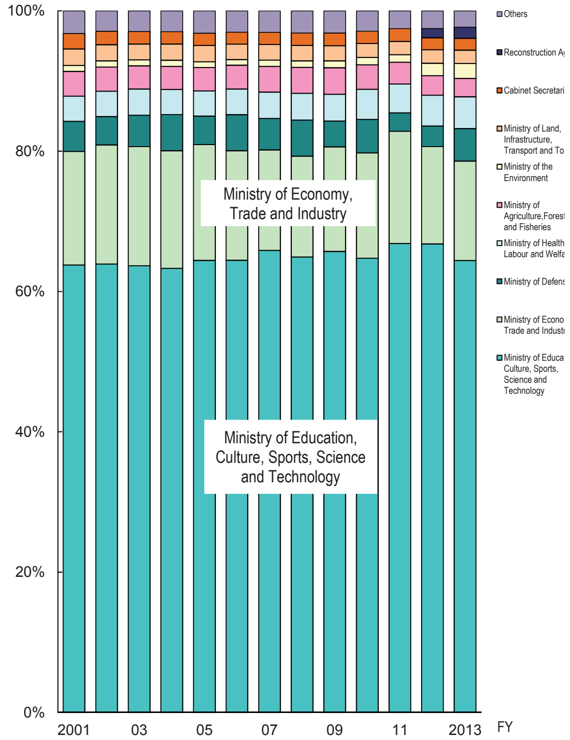


Note: 1) These are initial budgets.
2) The expenses covered were revised in FY 1996, FY 2001 and FY 2006 with the setting of the Science and Technology Basic Plans (First through Third).
3) The FY 2011 budget compilation does not use "general expenditures". Instead, it uses "expenditures subject to the basic fiscal balance," which are general account expenditures minus debt servicing costs. The equivalent of general expenditures for FY 2011 is therefore obtained by subtracting debt servicing costs and local allocation tax from general account expenditures.
Source: Data from the Ministry of Education, Culture, Sports, Science and Technology; the Ministry of Finance; the Ministry of Finance: Fiscal Statistics (Budget and Balance Sheets) (from the official website)

With regard to the breakdown of the government appropriations for S&T by ministry and agency, the Ministry of Education, Culture, Sports, Science and Technology consistently has the largest share, accounting for 64.4% in FY 2013. It is followed by the Ministry of Economy, Trade and Industry with 14.2% and other ministries and agencies with less 5% or less. The fact that the Ministry of Education, Culture, Sports, Science and Technology and Ministry of Economy, Trade and Industry account for 80% of the total makes changes in other ministries and agencies difficult to see; however, the shares for the Ministry of Health, Labour and Welfare and Ministry of the Environment have increased compared to FY 2001.

It should be noted that funding for the Reconstruction Agency was added in FY 2012. The agency's share in FY 2013 is 1.6% (see Chart 1-2-9.)

Chart 1-2-9: Trend in the breakdown of the government budget appropriation by ministry and agency



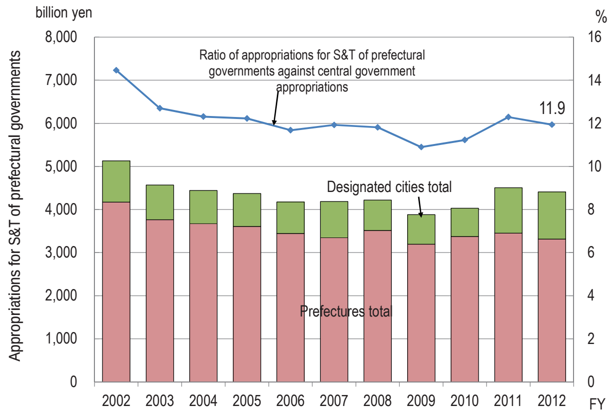
Note: 1) Data for each fiscal year is for initial budgets.
2) Figures for government appropriations for S&T were compiled by the Ministry of Education, Culture, Sports, Science and Technology based on materials submitted by each ministry and agency.
3) The expenditure, etc. for each special corporation from the government budget appropriations for S&T which is included in the special account for Industrial investment under the jurisdiction of the Ministry of Finance is earmarked to the ministries etc. which have jurisdiction over the special corporations. But with regard to the National Agriculture and Bio-oriented Research Organization under the jurisdiction of the Ministry of Finance and the Ministry of Agriculture, Forestry and Fisheries, the expenditure is earmarked to only the latter.

Source: MEXT, "Indicators of Science and Technology"; Data from the Ministry of Education, Culture, Sports, Science and Technology

For an international comparison of national budget appropriations for S&T, it is necessary to include not only that of the central government, but also that of the local governments.

The original government budget appropriation for S&T allocated by 47 prefectures and 20 designated cities was approximately 440.7 billion yen in FY 2012. This amount was the equivalent of 11.9% out of the original government budget appropriation for S&T allocated by the national government (approximately 3.7 trillion yen) in the same fiscal year (Chart 1-2-10).

Chart 1-2-10: Appropriations for S&T of the central and prefectural governments



Note: 1) The amount is the initial budget.
2) The number of designated cities is as follows: FY 2002: 12; FY 2003 and FY 2004: 13; FY 2005: 14; FY 2006: 15; FY 2007 and FY 2008: 17; FY 2009: 18; FY 2010 and FY 2011: 19; FY 2012: 20

Source: Data from the Ministry of Education, Culture, Sports, Science and Technology

1.3 R&D expenditure by sector

1.3.1 R&D expenditure in the public organization sector

Key points

- ○Japan's R&D expenditure in the public organization sector in FY 2011 was 1.34 trillion yen. The expenditure level was trending flat from the early 2000s but has been declining slightly in recent years.
- ○Looking at average annual growth rate in R&D expenditure (nominal values) on a national currency basis, Japan and France had negative growth rates during the latter half of the 2000s (2005 through the most recent available year). In contrast, the other countries showed growth, with China posting a particularly high rate of 19.1%.

(1) R&D expenditure in the public organization sector for each country

In this section, the public organization sector as a performing sector of R&D expenditure is explained.

The public organizations of each country analyzed here include the research institutes as follows: In Japan, "National" research institutes (national experimental and research institutes, etc.), "Public" research institutes (public experimental and researching institutes, etc.), and research institutes run by "Special and independent administrative corporations" are included.

In the U.S., research institutes (NIH etc.) run by the federal government, and those which belong to FFRDCs (government-funded, with R&D carried out by the industrial, university and non-profit institution sectors) are included.

In Germany, public research facilities run by the federal government; local governments and others; non-profit institutions (granted public funding of 160,000 Euros or more); and research institutes other than higher education institutions (research institutes belonging to legally independent universities) are included. It must be noted that in Germany, "the public institution sector" and "the non-profit institution sector" are not separated.

In France, research institutes run by certain types of foundation such as scientific and technical research public establishment ("Etablissement Public a Caractere Scientifique et Technologique" (EPST)) (other than CNRS) and commercial and industrial research public establishment ("Etablissement Public a Caractere Industriel et Commerce") (EPIC), etc. are included.

In the U.K., research institutes run by the central government, decentralized governments and research councils are included.

In China, research institutes run by the central government are included.

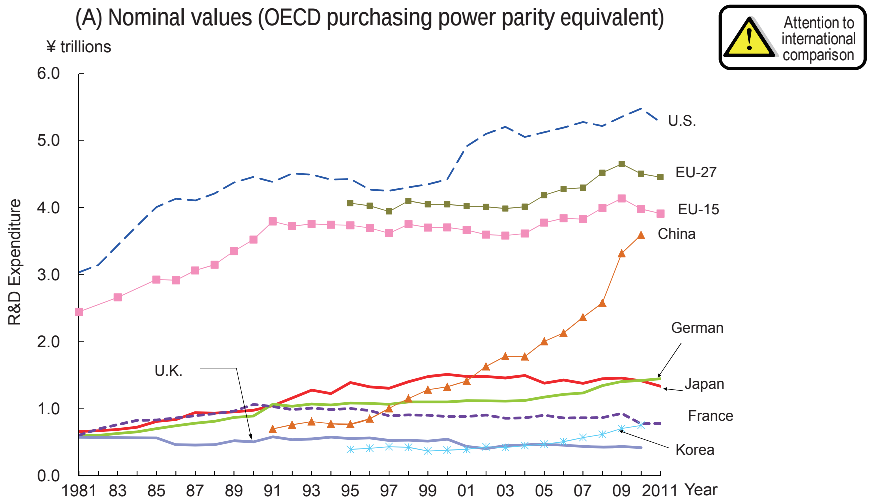
In Korea, national and public research institutes, government supported research institutes and national and public hospitals (refer to Chart 1-1-4) are included.

Chart 1-3-1(A) shows the trend of R&D expenditure (by OECD purchasing power parity equivalent) in the public organization sector for selected countries. The R&D expenditure in the public organization sector in Japan was approximately 1.34 trillion yen in FY 2011. Entering the 2000s, the trend began flat but has been showing a slight decline in recent years. Although R&D expenditure was flat in each country at the beginning of the 1990s, China started rapidly increasing its R&D expenditure during the middle of that decade, and its expenditure passed Japan's in 2002. In addition, the U.S. has been showing an increasing trend since entering the 2000s, with German and Korea following suit from the mid-2000s.

Chart 1-3-1(B) shows the annual average growth rate of R&D expenditure (nominal values) in each country on a national currency basis. During the first half of the 2000s (2000–2005), only Japan posted negative growth while all the other countries showed positive growth. The growth rate in the U.K., however, was less than 1%. During the latter half of the 2000s (2005 through the most recent available year), Japan and France showed negative growth. In contrast, the other countries showed growth, with China posting a particularly high rate of 19.1%. Looking at a comparison of real values adjusted to remove the influence of price fluctuations on a national currency basis (Chart 1-3-1(C)), Japan and the U.K. showed negative growth in the first half of the 2000s, while all the other countries increased. The countries with high increases in growth rates from the first half to the second half of the 2000s were Japan, Germany, the U.K., China and Korea. However, in the case of the U.K., this increase was only enough to reduce the rate of negative growth. On the other hand, the countries with small growth rates in the second half of the 2000s were the U.S. and France.

Chart 1-3-1: Trend of R&D expenditure in the public organization sector for selected countries

(A) Nominal values (OECD purchasing power parity equivalent)



(B) Nominal values (national currency)

National Currency	2000	2005	2011	Annual average growth rate '00→'05	Annual average growth rate '05→'11
Japan (¥ trillions)	1.51	1.38	1.34	-1.80%	-0.57%
U.S. ($ billions)	28.5	39.6	49.4	6.77%	3.77%
Germany (€ billions)	6.87	7.87	10.9	2.74%	5.59%
France (€ billions)	5.36	6.44	6.34	3.73%	-0.25%
U.K. (£ billions)	2.24	2.29	2.51 (2010)	0.43%	1.88% (2010)
China (¥ billions)	28.2	53.4	128 (2010)	13.6%	19.1% (2010)
Korea (₩ trillions)	1.84	2.87	5.56 (2010)	9.21%	14.2% (2010)

(C) Real values (2005 base, national currency)

National Currency	2000	2005	2011	Annual average growth rate '00→'05	Annual average growth rate '05→'11
Japan (¥ trillions)	1.41	1.38	1.45	-0.39%	0.77%
U.S. ($ billions)	32.1	39.6	43.6	4.24%	1.62%
Germany (€ billions)	7.25	7.87	10.3	1.65%	4.61%
France (€ billions)	5.91	6.44	5.72	1.73%	-1.94%
U.K. (£ billions)	2.51	2.29	2.23 (2010)	-1.80%	-0.55% (2010)
China (¥ billions)	33.0	53.4	100 (2010)	10.11%	13.4% (2010)
Korea (₩ trillions)	2.12	2.87	4.94 (2010)	6.18%	11.5% (2010)

Note 1) The definition of the public organization sector differs depending on the country. Therefore it is necessary to be careful when making international comparisons. Refer to Chart 1-1-4 for the definition of sectors in each selected country.

2) R&D expenses include the fields of social science and humanities (until 2006, only natural sciences in Korea)
3) For Japan (OECD estimate), France, Korea and EU, non-profit institution totals minus the business enterprises, universities and colleges and public organization sectors
4) Purchasing power parity is the same as Reference Statistics E.
<Japan and Japan (OECD estimate)> In 2001, part of non-profit institutions was moved to the business enterprise sector.
<Japan (OECD estimate)> The total R&D expenditure in which labor cost consisting a part of R&D expenditure in the university and college sector was converted to FTE. The value was corrected and estimated by the OECD.
<Germany> represents the former West Germany until 1990 and unified Germany since 1991.
Source: <Japan>Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"; OECD, "Main Science and Technology Indicators 2011/2"
<U.S.> NSF, "National Patterns of R&D Resources: 2010–11 Data Update"
<Germany>Bundesministerium für Bildung und Forschung, "Bundesbericht Forschung 2004, 2006", "Bundesbericht Forschung und Innovation 2010, 2012"; OECD, "Main Science and Technology Indicators 2012/2" since 2010
<U.K.>National Statistics website: www.statistics.gov.uk
<France, Korea, and EU> OECD, "Main Science and Technology Indicators 2012/2"

(2) R&D expenditure in Japan's public organization sector

Chart 1-3-2(A) shows the trend of R&D expenditure in Japan's public organization sector by type of organization. R&D expenditure in all the research institutes had been increasing until FY 2000 in spite of some slight fluctuations; however, after entering the 2000s the expenditure level trended flat before entering a declining trend in recent years.

Out of all sectors, the amount in that of "special corporations and independent administrative corporations" is the highest. Another matter which should be mentioned is the discontinuity between the data for "national" research institutes and that for "special corporations and independent administrative corporations" due to the fact that former national research institutes and special corporations turned into independent administrative corporations in FY 2001. It should also be added that profit-making organizations have also been included among "special corporations and independent administrative corporations" since FY 2011.

Next, the public organizations sector is classified into public institutes (run by local government) and public organizations other than public institutes to show changes in R&D expenditure using price corrected values at the 2005 base (Chart 1-3-2 (B)).

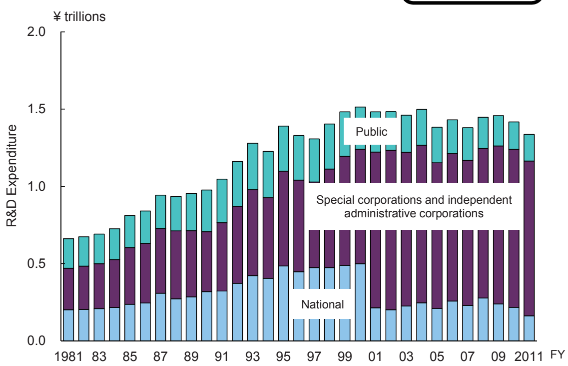
From 2000 to 2005, the annual average growth rate of R&D expenditure in public institutes run by local governments showed a decrease of -2.04%, while that in public organizations other than public institutes showed a decrease of -8.67%.

From 2005 to 2011, the annual average growth rate of R&D expenditure in public institutes run by local governments was -3.42%, showing further dwindling, while that of public organizations other than public institutes showed an increase of 4.62%.

Chart 1-3-2: Trend of R&D expenditure used by public organization sector in Japan

(A) Nominal values

Attention to trend



(B) Real values (2005 base)

(Unit: ¥ trillions)

FY	2000	2005	2011	Annual average growth rate 00→'05	Annual average growth rate 05→11
Public institutes (run by localgovernment)	0.25	0.23	0.19	-2.04%	-3.42%
Public organizationsother than publicinstitutes	1.81	1.15	1.51	-8.67%	4.62%
Total publicorganizations	2.07	1.38	1.70	-7.74%	3.49%

Note: 1) Part of the national research institutes were turned into independent administrative corporations in FY 2001, so care is needed when examining changes in time series.
2) The values for "Special corporations and independent administrative corporations" represent the values for only "Special corporations" until FY 2000.
3) Profit-making organizations have also been included among special corporations and independent administrative corporations since FY 2011.
4) Reference Statistics D were used as a GDP deflator.
Source: Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"

1.3.2 R&D expenditure in the business enterprise sector

Key points

○R&D expenditure in FY 2011 in Japan's business enterprises sector amounted to 12.3 trillion yen, which represented a 2.2% increase over the previous year. Thus, expenditure is making a recovery from the large-scale decrease of 2009.

○Looking at the ratio of R&D expenditure to GDP in the business enterprises sector of the selected countries, Japan's ratio stands at 2.59% (2011). Although Japan had been ranked at the top here beginning in 1990, Korea surpassed it in 2009. Korea had a ratio of 2.80% in 2010. The U.S.'s ratio had been trending flat for many years but has been declining recently after peaking in 2008.

○A look at three-year averages for manufacturing and non-manufacturing R&D expenditure in the business enterprises sector of the selected countries from the most recent available year for each country shows that the manufacturing shares of Japan, Korea, and Germany are approximately 90%. The shares for the U.S. and U.K. are roughly 70%, which means they have relatively large non-manufacturing shares of around 30%.

(1) R&D expenditure in the business enterprise sector for each country

R&D expenditure in the business enterprise sector accounts for the dominant proportion of the total R&D expenditure of each country. Accordingly, fluctuations in the amount in the business enterprise sector have a significant influence on a country's R&D expenditure.

As shown in Chart 1-3-3(A), Japan's R&D expenditures for 2011 (6) were 12.3 trillion yen, up by 2.2%, virtually unchanged from the previous year. Recovery from the big drop in 2009 has not been made.

The U.S.'s expenditures have been decreasing since peaking in 2008. As for other countries, Germany, France, and the U.K. have been increasing when viewed over the long term, but are showing decreasing trends in recent years. China has grown rapidly since the beginning of the 2000s. It passed Japan in 2009. Korea is also continuing to see growth.

Turning to annual average growth rates in each country's national currency (nominal values) (Chart 1-3-3(B)), the U.S., Germany and France had higher growth rates during the second half of the 2000s (2005 through the most recent available year) than during the first half (2000–2005). They were lower in all the other selected countries. Japan posted a negative growth rate during the latter half of the 2000s.

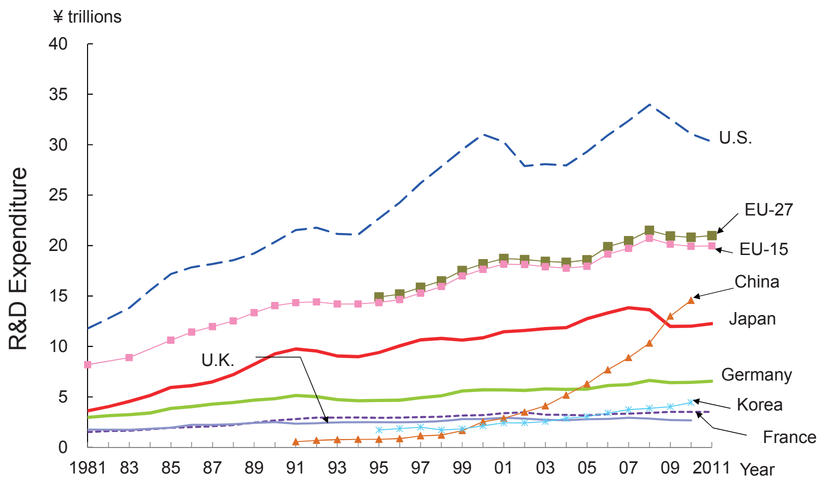
Annual average growth rates for real values (2005 base, national currency) adjusted in light of commodity price trends in each country (Chart 1-3-3(C)) show that The U.S., Germany and France had higher rates during the second half of the 2000s than during the first half.

Japan's growth rate was 4.73 % in the first half of the 2000s, but it declined to 0.71 % since the beginning of the second half of the 2000s.

It should be noted that both China and Korea have always had fairly high annual average growth rates compared to other the countries.

(6) This section uses "years" for international comparison, although in the case of Japan it is originally "fiscal years."

Chart 1-3-3: R&D expenditure in the business enterprise sector for selected countries
(A) Nominal values (OECD purchasing power parity equivalent)



(B) Nominal values (national currency)

National Currency	2000	2005	2011	Annual average growth rate	
				'00→'05	'05→'11
Japan (¥ trillions)	10.9	12.7	12.3	3.25%	-0.63%
U.S. ($ billions)	200	226	284	2.49%	3.86%
Germany (€ billions)	35.6	38.7	49.3	1.66%	4.15%
France (€ billions)	19.3	22.5	28.5	3.07%	4.01%
U.K. (£ billions)	11.5	13.7	16.1 (2010)	3.60%	3.19% (2010)
China (¥ billions)	53.7	167	519 (2010)	25.5%	25.4% (2010)
Korea (₩ trillions)	10.3	18.6	32.8 (2010)	12.6%	12.1% (2010)

(C) Real values (2005 base, national currency)

National Currency	2000	2005	2011	Annual average growth rate	
				'00→'05	'05→'11
Japan (¥ trillions)	10.1	12.7	13.3	4.73%	0.71%
U.S. ($ billions)	225	226	250	0.07%	1.71%
Germany (€ billions)	37.5	38.7	46.7	0.58%	3.19%
France (€ billions)	21.3	22.5	25.7	1.08%	2.25%
U.K. (£ billions)	12.9	13.7	14.2 (2010)	1.30%	0.73% (2010)
China (¥ billions)	62.9	167	406 (2010)	21.6%	19.4% (2010)
Korea (₩ trillions)	11.8	18.6	29.2 (2010)	9.47%	9.47% (2010)

Note: 1) Refer to Chart 1-1-4 for the definition of the business enterprise sector in each country.
2) R&D expenses include the fields of social science and humanities (until 2006, only natural sciences in Korea)
3) Purchasing power parity equivalent is the same as Reference Statistics E.
4) Real values were calculated with a GDP deflator (using Reference Statistics D).
<Germany> Data for former West Germany until 1990 and unified Germany since 1991.

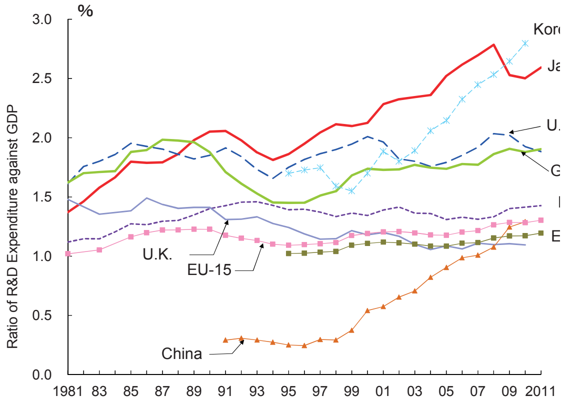
Source: <Japan> Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"; OECD, "Main Science and Technology Indicators 2011/2CD;
<U.S. > NSF, "Science & Technology Indicators 2012, from Jan. 2006: "infobrief (NSF 13-313, January 2013)
<Germany> Bundesministerium für Bildung und Forschung, "Bundesbericht Forschung 2004, 2006", "Bundesbericht Forschung und Innovation 2010, 2012"; OECD, "Main Science and Technology Indicators 2012/2" since 2010
<U.K.> National Statistics website: www.statistics.gov.uk
<France, China, Korea and EU> OECD, "Main Science and Technology Indicators 2012/2"

Chart 1-3-4 shows the "Ratio of R&D expenditure to GDP" for an international comparison considering the difference in the economy size of each country.

Looking at ratios of R&D expenditure to GDP in the business enterprises sector, Japan's ratio in 2011 is 2.59%. Although Japan had been ranked at the top beginning in 1990, Korea surpassed it in 2009. Korea had a high ratio of 2.80% in 2010.

The U.S.'s ratio had been trending flat for many years but has been declining recently after peaking in 2008. The ratios of Germany, the U.K., and France have also shown long-term flat trends; however, the U.K.'s ratio is showing a gradual decrease. On the other hand, China's ratio has continued to catch up to those of the other countries in recent years. It surpassed the U.K.'s ratio in 2009.

Chart 1-3-4: Trend in the Ratio of R&D expenditure in the business enterprise sector against GDP for selected countries



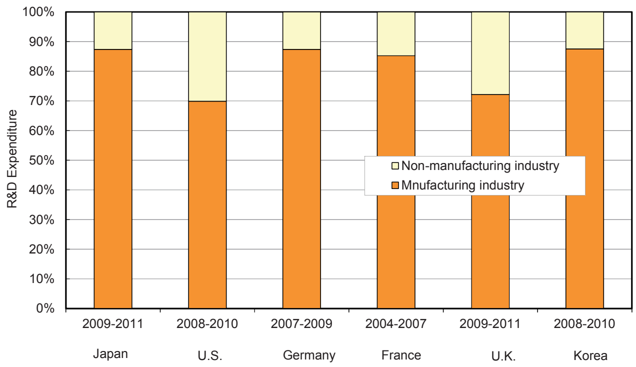
Note: 1) GDP is the same as Reference Statistics C.
2) Same as in Chart 1-3-3.
Source: Same as in Chart 1-3-3.

(2) By-industry R&D expenditures in selected countries

Looking at three-year averages for business sector R&D expenditure in manufacturing and non-manufacturing industries, manufacturing industries accounted for at least 90 percent of expenditure in Japan, Korea and Germany. Manufacturing industries accounted for roughly 70% in the U.S. and U.K., which means that those countries have relatively large non-manufacturing shares of around 30%. (Chart 1-3-5).

Chart 1-3-5: Percentages of R&D expenditure in manufacturing industries and non-manufacturing industries in the business enterprises sector of selected countries

Attention to international comparison



Note: 1) Since each country uses its own industrial classifications, care must be taken when making international comparisons.
2) See Chart 1-1-4 for definitions of the business enterprise sector in each country.
<Japan> 1) The industrial classification was made in accordance with the classification in the survey of research and development based on the Japan standard industry classification.

<U.S.> Industrial classifications use NAICS.
<Germany> German industrial classification, 2008 edition, was used.
<France> France activity classification table, "Nomenclature d'activités française (NAF) revised in 2003 was used.

Source: <Japan> Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"
<U.S. > NSF," InfoBrife (NSF 12-309)(NSF 13-324)"
<Germany> Bundesministerium für Bildung und Forschung, "Bundesbericht Forschung undInnovation2012"
<France, Korea> OECD,"R&D Statistics"
<U.K.> OST, "SET Statistics"

Chart 1-3-6 shows by-industry R&D expenditures for Japan, the U.S. and Germany. The business types used here were set for surveys of R&D statistics in the business enterprise sector, with reference to the standard industrial classifications used in each country. The standard industry types in each country generally follow the ISIC (International Standard Industrial Classification), but there is some variation by country. Rather than attempting to compare individual industries, this report instead looks at R&D expenditures according to the industrial structures of the countries.

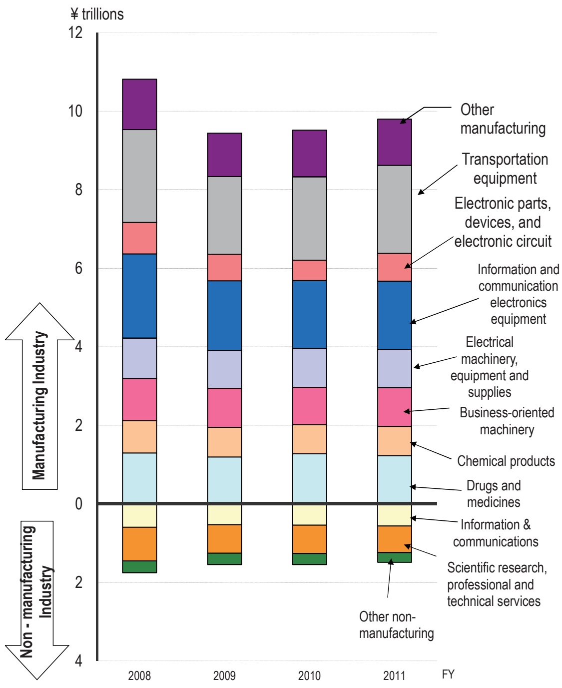
When the R&D expenditures of Japan, the U.S. and Germany are looked at in this way, in Japan the manufacturing industry accounts for a very large share and has a significant impact on overall change in R&D expenditures. It should be noted that R&D expenditure in non-manufacturing industries is in a decreasing trend. In terms of industrial classifications, the classifications with the largest shares among the manufacturing industries are "transport equipment" and "information and communication electronics equipment" followed by "drugs and medicines." Among non-manufacturing industries, "scientific research, professional and technical services" has a large but decreasing share.

In the case of the U.S., it is apparent that non-manufacturing industries account for a large share. In terms of industrial classifications, among manufacturing industries, "computers, electronic products," "chemical products," and "transportation equipment" have large values. Among non-manufacturing industries, "scientific research, professional and technical services" has a large and increasing share.

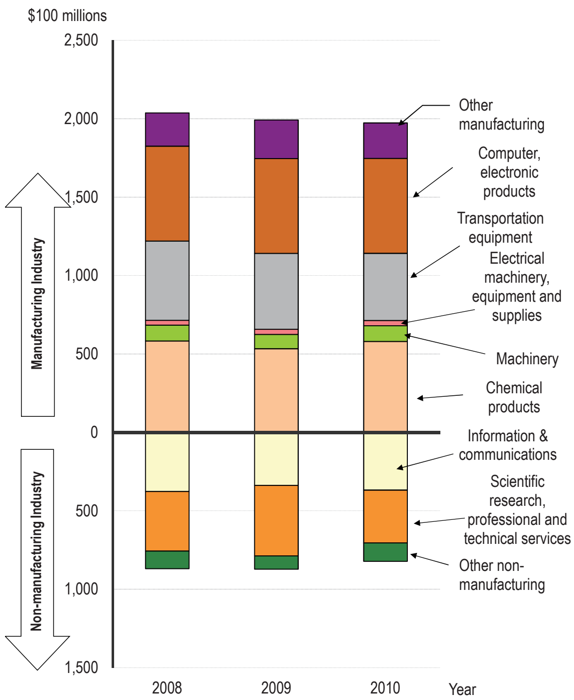
In Germany's case, it is apparent that share of non-manufacturing industries is growing. In terms of industrial classifications, "transport equipment" and "office equipment, computer, precision, electronic machinery" have large values. Among non-manufacturing industries, "specialized S&T activities" has a large and increasing share.

Chart 1-3-6: By-industry R&D expenditures in Japan, the U.S. and Germany

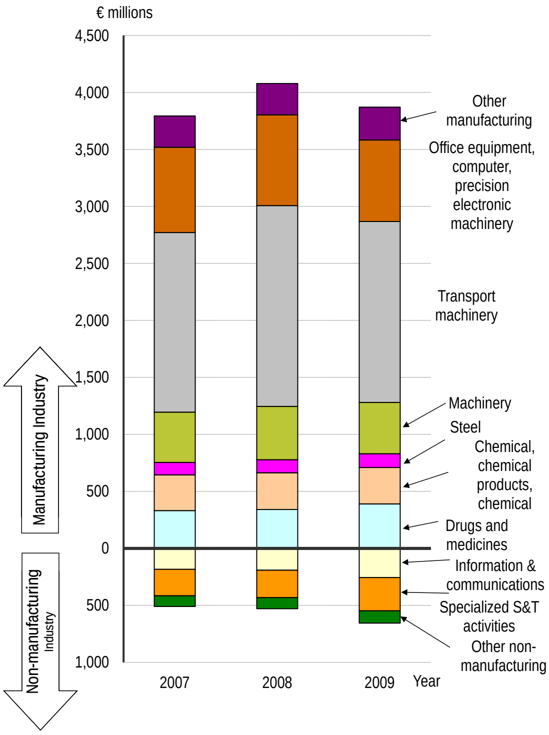
(A) Japan



(B) U.S.



(C) Germany



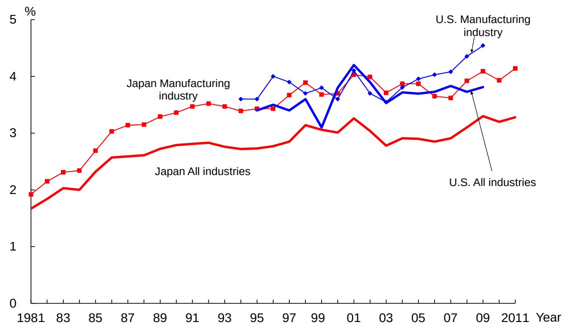
Note: Same as for Chart 1-3-5.
Source: Same as for Chart 1-3-5.

(3) R&D expenditure per turnover amount in the business enterprise sector

Chart 1-3-7 shows the trend of the ratio of the R&D expenditure against turnover in Japan and the U.S. The ratios are shown for both all industries together and for the manufacturing industry.

As far as Japan is concerned, the ratio in the manufacturing industry was higher than the ratio in all industries, showing Japan's stronger R&D intensity in the manufacturing industry compared to that in the non-manufacturing industry. Also in the U.S., intensity has been greater in manufacturing since 2000.

Chart 1-3-7: R&D per turnover in the business enterprise sector



Note: Same as for Chart 1-3-6.
<Japan> R&D expenditure per turnover in All industries is the figure from FY2001 (All industries excluding finance and insurance industries)
Source: <Japan> Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"
<U.S.> NSF, "R&D Industry"; various years, "InfoBrif (NSF 12-309)"

(4) Direct and indirect government support for business enterprises

The ratio of the amount of business enterprises' R&D expenditures borne by the government (direct support) to GDP and the ratio of the amount of corporate taxes to be paid to the government that is exempted through R&D tax incentives (indirect support) to GDP are discussed.

Countries in which direct government support to businesses is large include the U.S., France and Korea. Countries in which indirect support is large include France and Canada.

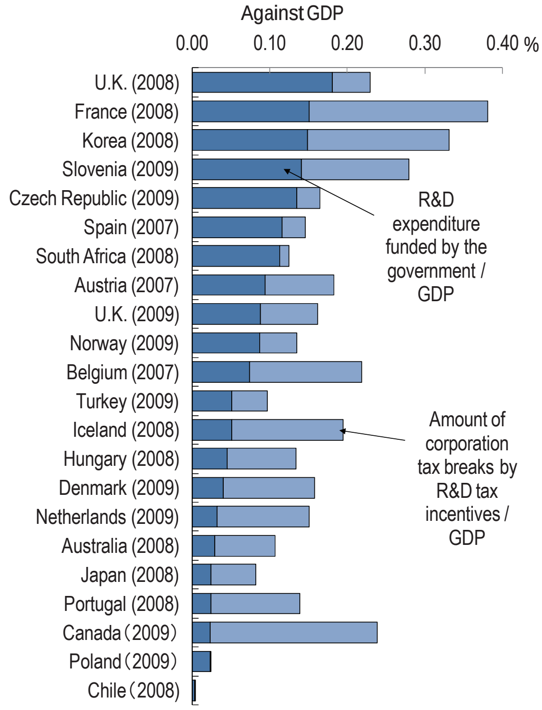
Both direct support and indirect support are large in France. This is true in Korea and Slovenia as well (Chart 1-3-8(A)).

Turning to Japan, Chart 1-3-8(B) shows changes in government direct and indirect support. As seen in the chart, direct support from the government for business enterprises has declined year by year. Indirect support increased sharply in 2004, and decreased in 2008.

The sharp increase in indirect support in 2004 likely stems mainly from a tax credit for total experimental and research expenses that was adopted in 2003. The number of business enterprises utilizing them is thought to have increased in 2004. The decrease in 2008 is probably because of a decrease in total corporate taxes, which caused a decrease in deductions.

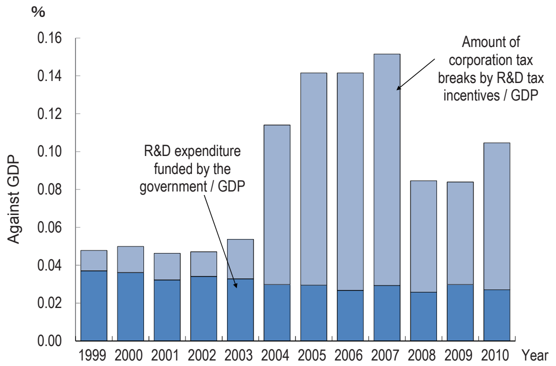
Chart 1-3-8: Government direct fund distribution and R&D tax incentives for corporate R&D

(A) Comparison of major countries



Note: Values estimated by each country (in accordance with the survey for R&D tax incentives by NESTI). Preliminary budget values are also included.
Sources: OECD, "STI Scoreboard 2011

(B) Changes in Japan



Sources: Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development," National Tax Agency, "Corporation Sample Survey"

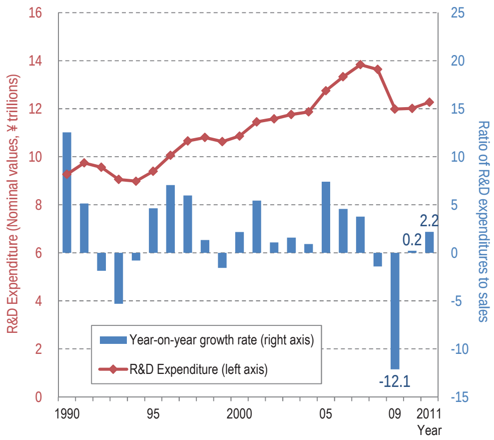
Column: R&D by Japanese business enterprises at a time of crisis

The R&D expenditures in the business enterprises sector of Japan and major countries of Europe and the U.S. dropped in 2009[7] (see Chart 1-3-3). The cause is thought to be the effects of the global economic crisis that occurred the previous year. Moreover, in Japan, the Great East Japan Earthquake of March 2011 had significant effects on the economic society. This column considers the impact that these circumstances had on R&D by business enterprises.

(1) Changes in Japan's R&D expenditure

R&D expenditure in the Japanese business enterprises sector showed continuous growth from 2000. Looking at 2005 and 2007, in particular, the average growth rate exceeded 5% (Chart 1-3-9). However, this rate began to decline in 2008, and in 2009 the year-on-year growth rate dropped significantly to -12.1%. This was the largest rate of decrease since Japan started keeping R&D statistics in 1953. It is believed that the effects of the international economic crisis that was sparked by Lehman Brothers' bankruptcy (called the “Lehman Shock” in Japan) on September 15, 2008, were behind this major decrease.

Chart 1-3-9: Changes in R&D expenditures in Japan's business enterprise sector



Note: R&D expenditures are nominal values.
Sources: Ministry of Internal Affairs and Communications, “ urces: Ministry of Internal Affairs and Communic

Subsequently, in 2010, the year-on-year growth rate for R&D expenditure rose slightly by 0.2%. However, this increase did not represent a recovery, but rather demonstrated the huge impact that the global economic crisis had on Japan's R&D.

In 2011, the rate grew by 2.2% compared to the previous year—this despite the Great East Japan Earthquake that occurred in March. The reason for this is thought to be that the effects of the Great East Japan Earthquake were not so strong as to push down overall R&D expenditure in the business enterprises sector, as expenditure was in a period of recovery from the previous two years of depressed conditions. However, the effects of the disaster may yet appear in future statistical data.

(2) Changes in various indicators of selected countries in 2009

How did the global economic crisis affect the other selected countries? Chart 1-3-10 provides indicators for drawing comparisons among the countries. According to the chart, the U.S., Germany, and the U.K. had decreasing R&D expenditure in their business enterprises sectors in 2009 that went together with negative GDP growth rates. This suggests that, like Japan, the worsening economic conditions had an impact on enterprises' R&D. Determining why Japan had such a particularly large decline compared to the other countries will require broad-ranging analysis. However, it is thought that one factor is that the exporting industries that form the backbone of Japan's manufacturing industries suffered greatly from the increasingly strong yen coupled with declining global consumption.

Chart 1-3-10: Rate of year-on-year increases in statistical indicators in selected countries in 2009

	Annual GDP grow th rate (%)		Annual grow th rate of corporate R&D expenditures (%)	
	Nominal	Real	Nominal	Real
Jaqpan	-3.18	-2.70	-12.11	-11.66
U.S.	-2.22	-3.08	-2.85	-3.70
Germany	-4.01	-5.13	-1.73	-2.87
France	-2.45	-3.15	2.58	1.85
U.K.	-2.71	-3.97	-2.00	-3.28
China	8.55	9.21	25.64	26.40
Korea	3.76	0.32	8.33	4.74

Note: Real value for GDP and R&D expenditures is calculated using the GDP deflator.
Sources: Same as for Chart 1-3-3. GDP is same as for Reference Statistics C. The deflator is the same as for Reference Statistics D.

(3) The relationship between sales and R&D expenditures

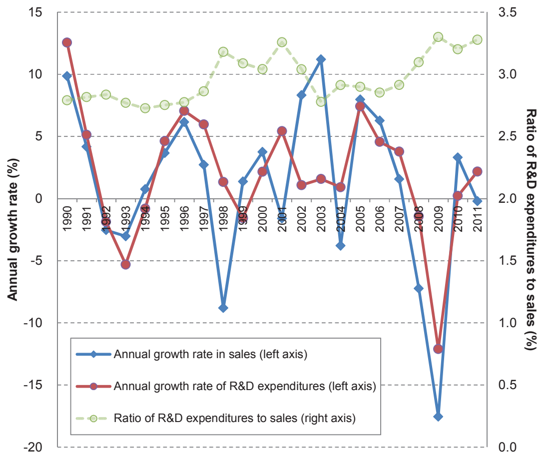
A look at the R&D expenditure and sales trends of Japanese corporations (Chart 1-3-11) shows that

(7) According to FY 2009 amounts. In this column, Japanese monetary amounts will be based on fiscal year data, but will be referred to as "years" for comparison with personnel data, foreign countries data.

R&D expenditure often decreases when sales decline. This indicates that, in general, both are linked. In the case of 2009, in particular, it is clear that the decline in R&D expenditure was linked to a considerable fall in sales. Subsequently, both sales and R&D expenditure return to growth in 2010; however, in 2011, sales once again declined while R&D expenditure saw a year-on-year increase. It should be mentioned that many Japanese corporations set a general amount for R&D expenditure at the beginning of each fiscal year. In such cases, they base their decisions on sales estimates and sales figures from the previous fiscal year. Thus, it is thought that expenditure often either moves with sales or does not reflect changes in sales until a year later.

On the other hand, during the period covered by the chart, the ratio of R&D expenditure to sales reached its high mark in 2009. This high value was continued in 2010 and 2011. The ratio of R&D expenditure to sales can be interpreted as an indicator showing the degree of focus corporations place on R&D. In this sense, then, it appears that Japanese corporations' focus on R&D has not declined since 2009.

Chart 1-3-11: Year-on-year growth rate in sales and R&D expenditures in the Japanese business enterprise sector, and ratio of R&D expenditures to sales



Note: R&D expenditures and sales are both nominal values and based on figures of businesses engaged in R&D (excluding finance and insurance industries),
Sources: Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"

(4) Breakdown of items showing changes in R&D expenditure

Looking at a breakdown by category of the cuts to R&D expenditures by Japanese corporations in 2009 (Chart 1-3-12), of the -12.1% decline, "other expenditure" and "materials" made a major contribution. Those two categories totaled -8.34%. On the other hand, the decline in "labor costs," which accounts for a large percentage of total R&D expenditures, was relatively small at -1.95%.

In 2010, when R&D expenditure increased, albeit slightly, "labor costs" and "materials" increased, while the other expenditure items decreased. In 2011, the increases in "labor costs" and "materials" were less pronounced than in the previous year. At the same time, however, "other expenditure" and "expenditures on tangible fixed assets," which had been decreasing over the previous two years, increased and even surpassed the other items in terms of their contribution to overall increase.

Chart 1-3-12: Breakdown of rate of year-on-year change in R&D expenditures in Japan's business enterprise sector in 2009

R&D expenditure items	Rate of year-on-year change (%)		
	2009	2010	2011
Labour costs	-1.95	0.89	0.04
Materials	-3.86	0.52	0.15
Expenditures on tangible fixed assets	-1.66	-0.44	0.58
Lease fee	-0.15	-0.09	-0.07
Other expenditure	-4.48	-0.66	1.47
Total	-12.11	0.22	2.18

Note: based on nominal value of R&D expenditures.
Sources: Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"

(5) Conclusion

During the worsening economic climate of 2009, Japanese corporations carried out unprecedented cuts to R&D expenditures. However, since the ratio of R&D expenditures to sales remained at a high level, overall corporations appear to have maintained their stance emphasizing R&D. Moreover, of R&D expenditures, items that can easily be temporarily contracted were cut, indicating that most of the corporations cutting R&D expenditures probably considered them temporary, at least in 2009.

The Great East Japan Earthquake of March 2011 appears not to have had the effect of dragging down overall R&D expenditure by Japanese corporations. However, because corporations' sales have shown a year-on-year decline, it is possible that the disaster's effects may appear in statistical data on R&D expenditure in the future.

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1.3.3 R&D expenditure in the university and college sector

Key points

- ○R&D expenditure in the university and college sector in Japan during FY 2011 was 3,540.5 billion yen a year-on-year increase of 3.1%. R&D expenditure by universities and colleges in Japan was 2, 020.5 billion yen in FY 2010 (OECD estimate).
- ○With regard to the average annual growth rate of R&D expenditure by real value (2005 base, national currency), Japan, the U.S., the U.K. and China showed a lower rise in the second half of the 2000s (2005 through the most recent available year) than in the first half of that decade (2000–2005).
- ○Looking at the most recent three-year average for the share of university and college R&D expenditure covered by governments, France is highest at 89.7%, while Japan is lowest at 49.5%. Compared with 2003–2005, Korea showed the largest increase, while the U.S. showed the largest decrease.
- ○As for the most recent three-year average for the share of university and college R&D expenditures borne by businesses in the selected countries, China was well ahead of the pack at 32.7%. France had the lowest share at 2.0%. Japan was the next lowest, at 2.5%. Germany showed the largest increase compared with 2003–2005, while Korea showed the largest decrease.
- ○By observing the R&D expenditure in the university and college sector in Japan by field, it was found that national universities used approximately 50% of the total R&D expenditure in the field of natural science and engineering, While private universities used approximately 70% of the total R&D expenditure in the field of social sciences and humanities.

(1) R&D expenditure in the university and college sector in each country

Higher education institutions such as universities, which have a function as R&D institutions, play an important role in R&D systems in every country. As stated in Section 1.1.2, R&D expenditure used in higher education institutions in each selected country accounts for approximately 10% to 30% of the total.

The scope of higher education institutions depends on the country, but in every country the main institutions are universities. The institutions under survey also depend on the country. The summary of targeted institutions is as follows: For Japan, universities (including graduate schools), junior colleges, technical colleges, university research institutes and other institutions were targeted[8]. For U.S., universities & colleges (institutions which perform R&D which is the equivalent of 150,000 dollars or more annually; FFRDCs are excluded) were targeted. For Germany, universities, comprehensive universities, and colleges of theology, etc. were targeted. For France, the National Center for Scientific Research (CNRS), and higher education institutions including universities and Grandes Ecoles not under the jurisdiction of the Ministry of National Education "Ministere de I'Educationale") (MEN) were targeted. In most countries, all fields were covered by the statistics. In the U.S., S&E[9] fields were covered, while in Korea, only the field of natural sciences and engineering was included until 2006 (see Chart 1-1-4).

In order to obtain R&D expenditure in the university and college sector, it was necessary to calculate the costs after separating R&D activities from educational activities; however, this separation is generally difficult.

The figures for R&D expenditure in Japan's university and college sector are those according to the "Survey of research and development" compiled by the Ministry of Internal Affairs and Communications. In these surveys, the breakdown of the R&D expenditure includes labor cost. However, the total labor cost is composed of elements including "duties

(8)In "Report on the Survey of Research and Development" compiled by the Ministry of Internal Affairs and Communications, which was used as the materials for the statistics of Japan's universities and colleges sector in this chapter, universities are surveyed by faculty (by course in the case of graduate schools), and the total number is 2,341 as of March 31, 2010. "Other institutions" include Inter University Research Institutes Corporation, the National Institution for Academic Degrees and University Evaluation, the Center for National University Finance and Management, National Institute of Multimedia Education, and the museum, center and facility at universities.

(9) Science and Engineering: computer sciences, environmental sciences, life sciences, mathematical sciences, physical sciences, psychology, social sciences and engineering; education and humanities are not included.

other than research (such as education)".

Statistics for R&D expenditure in the university and college sector in Japan do not adopt a full-time equivalent, and almost all teachers are measured as researchers. However, it not true that the duties of all teachers are exclusively limited to research. Therefore, it is natural to consider that the situation in which the labor cost of all the teachers is measured as R&D expenditure is an over-estimation with regard to R&D expenditure.

The OECD understands the actual situation [10], and multiplied 0.53 and 0.465 since 1996 to the labor costs of Japan's R&D expenditure in 1996 to 2001 and since 2002 respectively in the OECD statistics. Adjustment factor 0.465 for the data since 2002 is the Full Time Equivalent coefficient obtained from the "Survey on the Data for full-time equivalents in universities and colleges" in 2002 compiled by the Ministry of Education, Culture, Sports, Science and Technology. This survey was carried out again in 2008. The FTE equivalent coefficient in that survey was 0.362. OECD data from 2008 on use the FTE coefficient from the 2008 survey.

Hereinafter, both these values provided by the OECD (clearly referred to as "Japan (estimated by OECD)") and the values provided by the "Report on the Survey of Research and Development" compiled by the Ministry of Internal Affairs and Communications (referred to as "Japan") are given.

Chart 1-3-13(A) shows the nominal values of R&D expenditure in the university and college sector. The figure for Japan in 2011 was 3.5405 trillion yen, a year-on-year increase of 3.1%.

R&D expenditure by universities and colleges in Japan was 2.0205 trillion yen in 2010 (OECD estimate).

With regard to other countries, the rise in the U.S. and the EU was remarkable.

Among E.U. countries, in Germany, France and the U.K., where R&D expenditure is large, the amount has gradually increased over the long term. R&D expenditure has steadily increased in China since 2000.

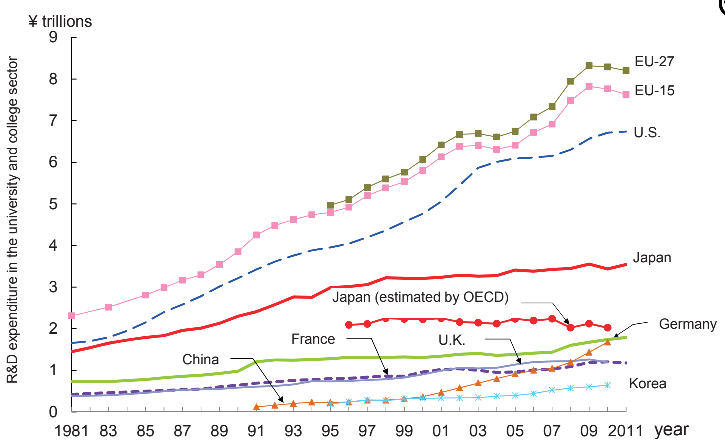
Looking next at the annual average growth rate of each country in terms of national currency (nominal value) (Chart 1-3-13 (B)), countries having higher growth rates in the second half of the 2000s (2005 to the most recent available year) than the first half of the 2000s (2000 to 2005) are Germany, France, and Korea. Japan's rate was largely unchanged in the second half of the 2000s (negative growth in the case of Japan (estimated by OECD)). It should be noted that although China had low R&D expenditure in the second half of the 2000s, it had the highest growth rate at 19.8%.

Looking at real values with consideration for prices (Chart 1-3-13(C)), the countries with higher growth rates in the second half of the 2000s than the first half are Germany, France, and Korea. The countries with lower rates are Japan, the U.S., the U.K., and China. Additionally, in the case of China, while the annual average growth rate was originally quite high, it has been declining in a manner similar to nominal values in comparison with the first half of the 2000s.

Chart 1-3-13: Trend of R&D expenditure in the university and college sector for selected countries

(A) Nominal values (OECD purchasing power equivalent)

Attention to international comparison



(10) This section uses "years" f
case of Japan it is originally "fiscal years."

(B) Nominal values (national currency of each country)

National Currency	2000	2005	2011	Annual average growth rate '00→'05	Annual average growth rate '05→'11
Japan (¥ trillions)	3.21	3.41	3.54	1.21%	0.64%
Japan (OECD) (¥ trillions)	2.22	2.23	2.02 (2010)	0.10%	-2.00% (2010)
U.S. ($ billions)	30.7	47.0	63.1	8.90%	5.03%
Germany (€ billions)	8.15	9.22	13.5	2.51%	6.49%
France (€ billions)	5.80	6.82	9.53	3.28%	5.73%
U.K. (£ billions)	3.69	5.58	7.13 (2010)	8.62%	5.02% (2010)
China (¥ billions)	7.67	24.2	59.7 (2010)	25.9%	19.8% (2010)
Korea (₩ trillions)	1.56	2.40	4.75 (2010)	8.96%	14.6% (2010)

(C) Real values (2005 base; national currency of each country)

National Currency	2000	2005	2011	Annual average growth rate '00→'05	Annual average growth rate '05→'11
Japan (¥ trillions)	2.99	3.41	3.84	2.66%	2.00%
Japan (OECD) (¥ trillions)	2.07	2.23	2.14 (2010)	1.54%	-0.82% (2010)
U.S. ($ billions)	34.6	47.0	55.7	6.32%	2.86%
Germany (€ billions)	8.59	9.22	12.7	1.43%	5.51%
France (€ billions)	6.40	6.82	8.60	1.29%	3.93%
U.K. (£ billions)	4.13	5.58	6.32 (2010)	6.20%	2.52% (2010)
China (¥ billions)	8.98	24.2	46.8 (2010)	22.0%	14.1% (2010)
Korea (₩ trillions)	1.80	2.40	4.22 (2010)	5.92%	12.0% (2010)

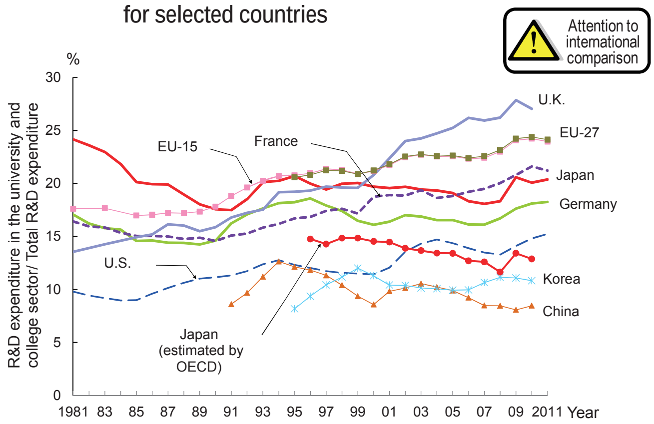
Note: 1) The definition of the university and college sector is different depending on the country. Therefore, it is necessary to be careful when making international comparisons. Refer to Chart 1-1-4 for the definitions of the university and college sector.
2) The purchasing power parity used here is the same as that in Reference statistics E.
3) R&D expenses include the fields of social science and humanities (for Korea, only natural sciences until 2006)
<Japan (estimated by OECD)> Since 1996, values corrected and estimated by the OECD (Labor cost included in the R&D expenditure for the university and college sector was converted to FTE to obtain the total R&D expenditure).
<Germany> Former West Germany until 1990 and unified Germany since 1991, respectively.
Source: Same as for Table 1-1-6

The trend of the ratio of R&D expenditure in the university and college sector against the total R&D expenditure for each country is shown in Chart 1-3-14.

The ratio of Japan's universities and colleges sector had remained flat in recent years, but in 2011 rose by 0.3 percentage points compared to the previous year to reach 20.4%.

Looking at the other countries, the U.K. is showing an increasing trend, particularly since 2000. Although this is partially due to increasing R&D expenditure in U.K., universities, it is also thought to be a result of low R&D expenditure growth in the public sector. Over the long term, the U.S. and Germany have had fluctuating ratios; however, both are showing increasing trends in recent years. On the other hand, China and Korea are remaining flat in terms of their ratios. This is thought to be because of significant growth throughout their total R&D expenditures.

Chart 1-3-14: Trend of the ratio of total R&D expenditure in the university and college sector against the total R&D expenditure for selected countries



Note: Same as for Chart 1-1-1 and Chart 1-1-6.
Source: Same as for Chart 1-1-1 and Chart 1-1-6

(2) Structure of source of funds for R&D expenditure in the university and college sector in selected countries

Chart 1-3-15 shows a breakdown of the percentages of the costs of intramural universities and colleges R&D expenditures borne by various sectors in selected countries. In other words, of universities and colleges R&D expenditures used intramurally, it shows how much of the burden of research funding is borne by different sectors. It also shows what percentages of funds borne by government and the business enterprise sector are accounted for by funding provided to universities and colleges.

Looking first at the most recent three-year average for the share of university and college R&D expenditure covered by different sectors (Charts 1-13-15 (A), (i), (ii)), the country with the highest government funding share in terms of the most recent three-year average is France; the country with the smallest is Japan. Compared with 2003–2005, the country with the largest increase in the share of government funding is Korea, while that with the largest decrease is the U.S. Looking at the share of business enterprises, the country with the largest share in terms of the most recent three-year average is China by a wide margin. On the other hand, the country with the smallest share is France. Compared with 2003 to 2005, the country with the largest increase in the share of government funding is Germany, while that with the largest decrease is the Korea.

By country, during 2009–2011 the share of costs borne by the Japanese government was 49.5%, while that borne by business enterprises was 2.5%. Compared with 2003–2005, the government share decreased by 0.7 percentage points, while the business enterprise share decreased by 0.3 percentage points.

In the U.S., the government's share of the cost for all universities and colleges was 60.3% during 2009–2011, while the business enterprise sector's share was 5.3%. This was a 1.5 percentage point decrease for government and a 0.2 percentage point increase for business compared with 2003–2005.

In Germany, government and non-profit institution bear large percentages of the costs. In 2007–2009, they accounted for 81.3% of the whole. The business enterprise sector also accounts for a large share relative to the other countries at 14.6%. Compared with 2003–2005, the share borne by government and non-profit institutions fell by 2.3 percentage points, while that of business enterprises rose by 1.3 percentage points.

The government's share in France is also large. During 2008–2010, it accounted for 89.7%, the largest share of any of the selected countries. On the other hand, the business enterprise sector's share was only 2.0%, the smallest of any of the selected countries. The government share decreased by 1.0 percentage points and the business enterprise share remained flat compared with 2003–2005.

In the U.K., government's percentage of costs is large as well, at 67.6% in 2008–2010. The business enterprise share is 4.2%. Compared with 2003–2005, the government share decreased by 0.6 percentage points and the business enterprise share decreased by 0.7 percentage points.

In China during 2009–2011, the government's share of the costs was 58.5%, while that borne by business enterprises was 34.9%, the highest among the selected countries. Compared with 2003–2005, the government share increased by 4.0 percentage points, while the business enterprise share decreased by 1.6 percentage points.

In Korea during 2008–2010, the government's share was 79.1%, while that of business enterprises was 11.5%. Compared with 2003–2005, the government share rose rapidly, by 6.3 percentage points. In contrast, the business share fell by 3.5 percentage points.

Next, the percentage of R&D expenditure by the government and business enterprise sectors that goes to universities and colleges is examined (Chart 1-3-15 (A), (iii), (iv)).

The highest share of government R&D expenditures that go to the university and college sector is 57.1%, in the U.K. Likewise, roughly half (approximately 50%) go to this sector in Japan, Germany, and France. About 30% goes to universities and colleges in the U.S. and Korea. China has the smallest percentage, at 20.8%.

Only a small percentage of the business enterprise sector's R&D expenditures go to universities and colleges in any of the selected countries. China and Germany have relatively large percentages at about 4.0%. In contrast, Japan, the U.S. and France are around 1%.

Comparing 2003–2005 to the most recent available year, with a 4.7 percentage point increase, the U.K. had the largest increase in the share of government R&D expenditure that went to universities and colleges. On the other hand, there was little if any growth from the business enterprise sector in any country.

As shown in Charts 1-3-15 (B)–(G), the share borne by foreign countries was small. However, this share is comparatively large in the U.K., standing at 10.4%. Compared with 2003 to 2005, this share has increased by 2.7 percentage points.

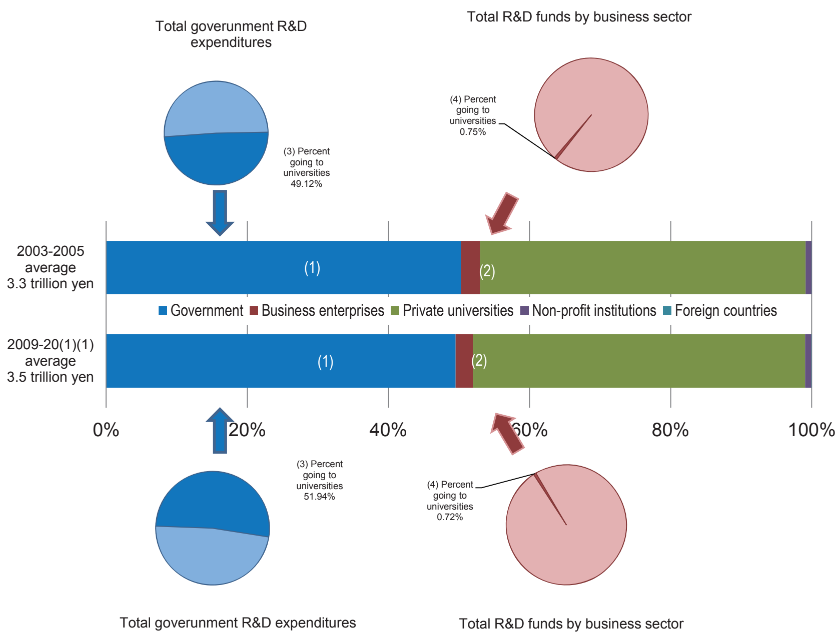
Chart 1-3-15: Changes in the cost-sharing structure for universities and colleges research funding in selected countries

(A) Table

Attention to international comparison

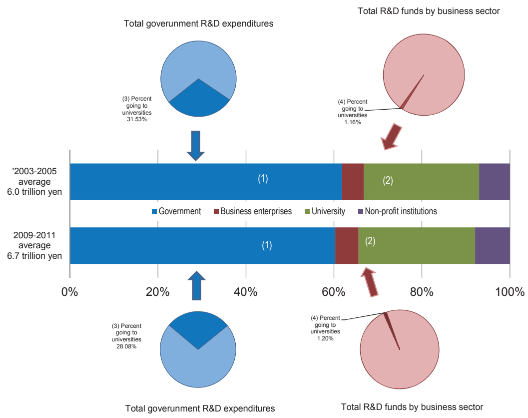
Country		Break down of university research expenditures							
Most recent year (3-year average)	Total university research expenditures (OECD purchasing power	(1) Percentage received from government	Change from 2003–2005	(2) Percentage received from business sector	Change from 2003–2005	(3) Percentage of total government R&D expenditures going to universities	Change from 2003–2005	(4) Percentage of total business sector R&D expenditures going to universities	Change from 2003–2005
Japan '09-11	¥3.5 trillion	49.50%	-0.70%	2.50%	-0.30%	51.90%	2.80%	0.70%	0.00%
Japan (OECD) '08-10	¥2.1 trillion	52.00%	1.50%	2.90%	0.10%	39.30%	0.30%	0.40%	-0.10%
U.S. '09-11	¥6.7 trillion	60.30%	-1.50%	5.30%	0.20%	28.10%	-1.80%	1.30%	0.10%
Germany '07-09	¥1.6 trillion	81.30%	-2.30%	14.60%	1.30%	47.70%	1.30%	3.70%	0.40%
France '08-10	¥1.2 trillion	89.70%	-1.00%	2.00%	0.00%	48.80%	4.60%	0.80%	0.00%
U.K. '08-10	¥1.2 trillion	67.60%	-0.60%	4.20%	-0.70%	57.10%	4.70%	2.60%	-0.20%
China '09-11	¥1.6 trillion	58.50%	4.00%	34.90%	-1.60%	20.80%	0.50%	4.00%	-1.70%
Korea '08-10	¥0.6 trillion	79.10%	6.30%	11.50%	-3.50%	32.70%	1.40%	1.80%	-0.30%

(B) Cost-sharing structure for universities and colleges R&D expenditures in Japan

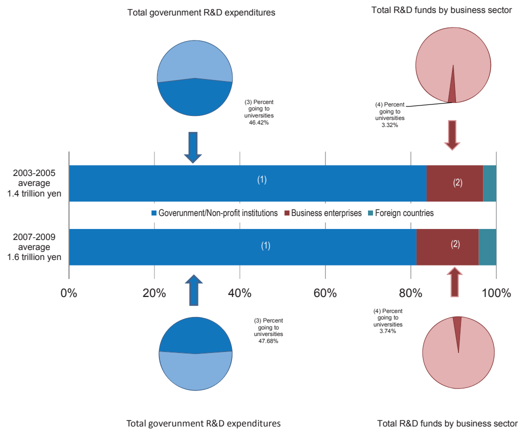


For the Japanese statistics, of R&D expenditures used at universities and colleges, the share of costs borne by universities and colleges refers to funding by private universities and colleges. Most of that is R&D expenditures self-funded by the private universities and colleges.

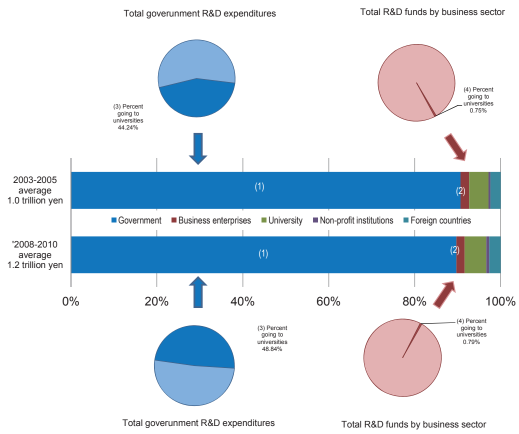
(C) Cost-sharing structure for universities and colleges R&D expenditures in the U.S.



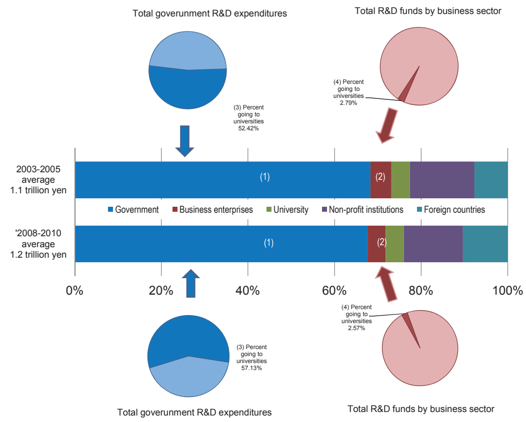
(D) Cost-sharing structure for universities and colleges R&D expenditures in Germany



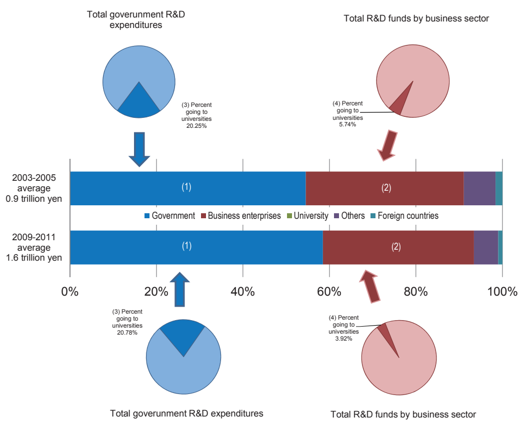
(E) Cost-sharing structure for universities and colleges R&D expenditures in France



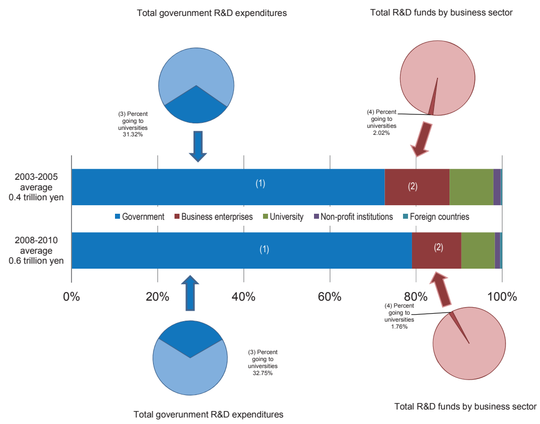
(F) Cost-sharing structure for universities and colleges R&D expenditures in the U.K.



(G) Cost-sharing structure for universities and colleges R&D expenditures in China



(H) Cost sharing structure for universities and colleges R&D expenditures in Korea



Note: 1) Three-year averages are used. For example, 2008–2010 refers to the average value for the years 2008 through 2010
2) Numbers by the arrows refer to the percentage of funds from each sector's R&D expenditures going to the university and college sector. For example, during FY 2008–2010 in Japan, of costs borne by government, 50.84% went to universities and colleges.
3) Other notes, regarding international comparison, etc., are as for Charts 1-2-3 and 1-2-4.

Sources: Same as for Chart 1-2-4.

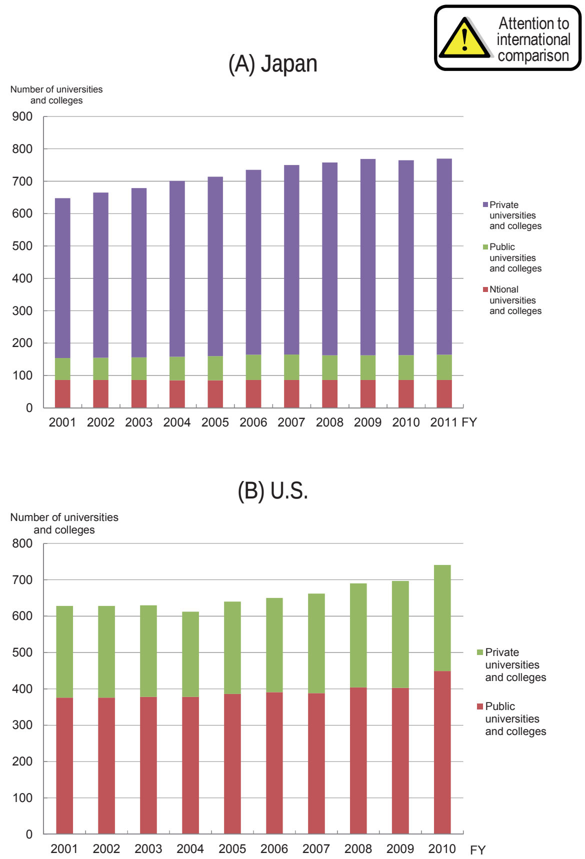
(3) Funding structure for universities and colleges R&D expenditures by form of institution in Japan and the U.S.

Chart 1-3-16 shows changes in the number of universities and colleges in Japan and the U.S. covered by R&D statistics. The U.S. (NSF) does not cover all universities and colleges. It covers only universities and colleges with annual R&D budgets of at least 150,000 dollars. While Japan’s Survey of Research and Development, in contrast, includes junior colleges, for the sake of comparison between Japan and the U.S., only four-year universities and colleges will be discussed here.

In the most recent year available, Japan had 86 national universities, 78 public universities and 606 private universities. Looking at trends, the number of private universities was increasing but has flattened out in recent years.

In the most recent year available for the U.S., there are 449 state universities and 292 private universities. Looking at trends, the number of private universities is increasing, and in the most recent year available, the number of state universities showed a year-on-year increase as well.

Chart 1-3-16: Number of universities and colleges



Note: There are differences in the scope covered by universities in Japan and the U.S., so caution is needed when making international comparisons. In Japan's case, they are four-year schools. Junior colleges, joint-use institutions, etc., are not included. In the case of the U.S., they are institutions utilizing annual research budgets of at least 150,000 dollars.
Sources: <Japan> Recalculated by NISTEP from individual data in Ministry of Internal Affairs and Communications, “Report on Survey of Research and Development”
<U.S.> NSF “Higher Education Research and Development”

Next, the funding structures of universities and colleges in Japan and the U.S. and changes therein will be examined.

Chart 1-3-17 (A) shows the funding structures for Japanese universities (four-year universities) according to type, i.e., national, public and private universities. For all universities, 40% of funding comes from government and 50% comes from private universities. Little funding comes from the business enterprises or other sectors.

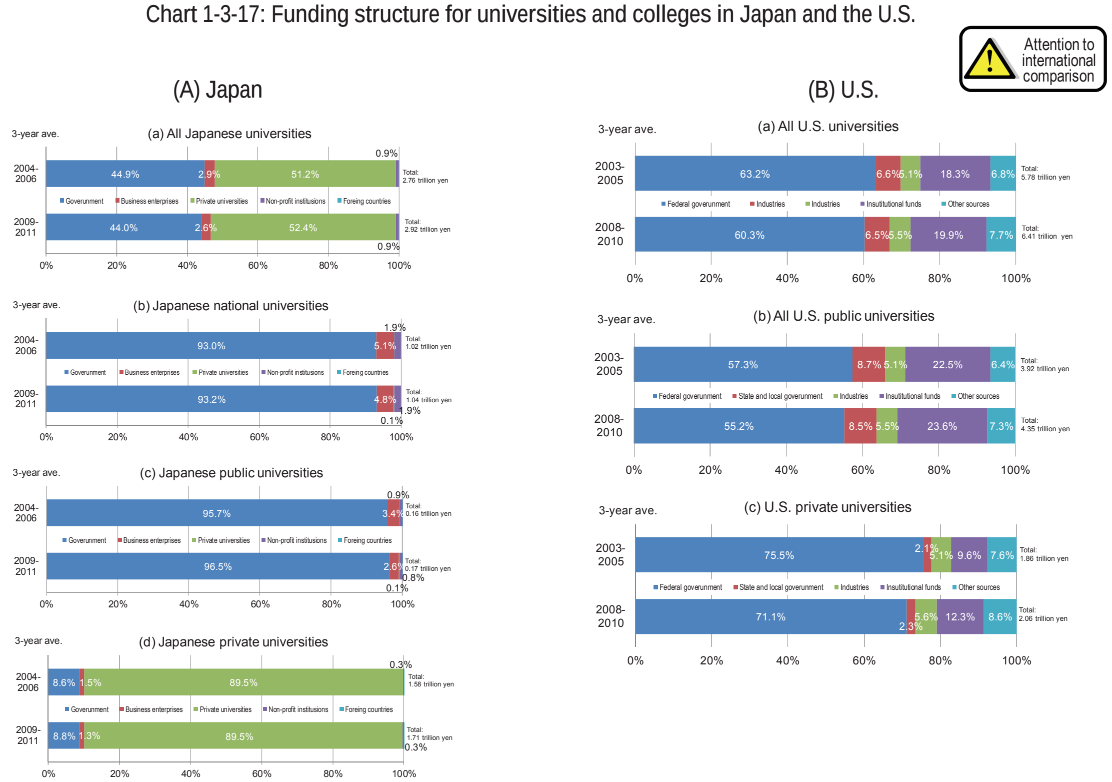
Looking at the share for national universities in 2009–2011, 93.2% of funding came from government. Compared to 2004 to 2006, this was an increase of 0.2 percentage points, which essentially means there was no change. The share of funding from business enterprises was small (4.8%) and decreasing. A similar trend is seen for public universities. As for private universities in 2009–2011, 89.5% of funding for R&D expenditures came from private universities, indicating that their R&D is mostly self-funded. Funds from government accounted for 8.8% during 2009–2011, an increase of 0.2 percentage points from 2004–2006. The share of funds from business enterprises was extremely small at 1.3%.

Chart 1-3-17 (B) shows the R&D expenditure funding structure of U.S. universities and colleges divided into public and private universities and colleges.

For all universities, just under 70% of funding comes from the federal government or state and regional governments, while approximately 20% are institutional funds (funds of unspecified purpose that come from business enterprises, foundations, and other outside funding sources; includes indirect costs of projects).

A comparison of state universities and private universities in 2008 to 2010 shows that the share of funds from the federal government and state and regional governments is larger for private universities (73.4%) than state universities (63.7%). Conversely, the share of institutional funds is larger for state universities (23.6%) than private universities (12.3%).

Chart 1-3-17: Funding structure for universities and colleges in Japan and the U.S.



Note: See Chart 1-3-15 for caution on international comparison.
<U.S.> 1) Institutional funds are funds of unspecified purpose that come from business enterprises, foundations, and other outside funding sources. This includes indirect costs of projects.
2) Other funding refers to other unclassified sources. It includes, for example, funds donated by individuals for research use. Data from "non-profit institutions" were obtained from 2010.
Sources :< Japan> Recalculated by NISTEP from individual data in Ministry of Internal Affairs and Communications, "Report on Survey of Research and Development"
<U.S.> Up to 2009: NSF, "Academic R&D Expenditures"; from 2010: NSF, "Higher Education Research and Development"

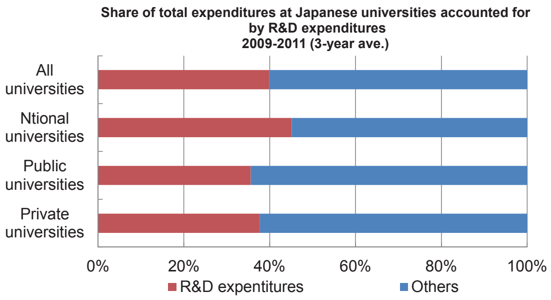
(4) Comparison of share of R&D expenditures in total operating costs at Japanese and U.S. universities and colleges

The shares of total operating costs (total expenditures) at Japanese and U.S. universities and colleges accounted for by R&D expenditures were compared. Three-year averages from 2009 through 2011 at degree-granting four-year universities and colleges in Japan and the U.S. were used.

In Japan's case, data on total expenditures and R&D expenditures from R&D statistics by the Ministry of Internal Affairs and Communications were used. Looking at Chart 1-3-18, R&D expenditures accounted for 39.9% of total expenditures at all universities. By type of university, the highest share was at national universities with 45.2%, while public universities are at 35.6% and private universities at 37.7%.

Chart 1-3-18: Share of total expenditures at Japanese universities accounted for by R&D expenditures

(A) Percentage



(B) Amount

2009-2011 (3-year ave.)	(1) Total expenditures	(2) R&D expenditures	(2)/(1)
All universities	7.3 trillion yen	2.9 trillion yen	39.9%
National universities	2.3 trillion yen	1.0 trillion yen	45.2%
Public universities	0.5 trillion yen	0.2 trillion yen	35.6%
Private universities	4.5 trillion yen	1.7 trillion yen	37.7%

Note: Four-year universities and colleges; junior colleges and university joint-use facilities, etc., are not included.
Source: Ministry of Internal Affairs and Communications, "Report on Survey of Research and Development"

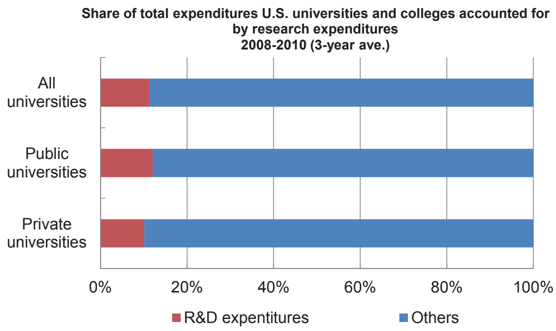
In the case of the U.S., the NSF's R&D statistics do not include total operating costs (total expenditures) at universities and colleges, so National Center for Education Statistics (NCES) IPEDS data was used. IPEDS is a database on postsecondary education (including higher education) in the U.S. It has data on total expenditures and research expenditures, so those figures were used for comparison with Japan. Research-related budget items that cannot be clearly differentiated from instructional or other purposes are counted as instruction expenditures by IPEDS. This results in the underestimation of research expenditures. This results in the underestimation of research expenditures. In addition, IPEDS also includes "academic support," including running costs of computer center and library, as a category. Some research-related expenditures may be included in that category as well. IPEDS statistics for research expenditures and other categories include salaries and wages, so personnel costs are included in the figures.

Looking at Chart 1-3-19, the share of all expenditures accounted for by research at all universities and colleges was 11.2%. At public universities and colleges, it was 12.0%, and at private universities and colleges, it was 10.1%.

Comparing Japan and the U.S., R&D expenditures account for 40% of total operating costs at Japanese universities and 10% at U.S. universities and colleges. In both Japan and the U.S., R&D expenditures account for higher shares at public universities. R&D at Japanese national universities accounts for about four times as large a share as it does at U.S. public universities and colleges.

Chart 1-3-19: Share of total expenditures at U.S. universities and colleges accounted for by research expenditures (IPEDS data)

(A) Percentage



(B) Amount

2008-2010 (3-year ave.)	(1) Total expenditures	(2) R&D expenditures	(2)/(1)
All universities	45.0 trillion yen	5.1 trillion yen	11.2%
Public universities	26.6 trillion yen	3.2 trillion yen	12.0%
Private universities	18.4 trillion yen	1.9 trillion yen	10.1%

Note: These are four-year universities and colleges (four-year institutions). In the case of some for-profit private universities and colleges, figures for public service are included in the calculation of research expenditures. However, these figures account for only about 0.03% of research expenses at all private universities and colleges.
Sources: NCES, IPEDS, "Digest of Education Statistics"

Next, U.S. universities' R&D expenditures according to the NSF will be used for comparison in place of IPEDS research expenditures.

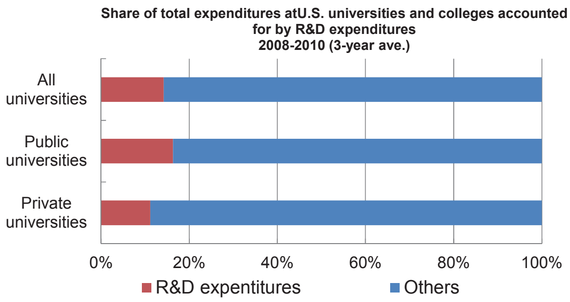
The NSF's R&D statistics cover universities and colleges with annual R&D expenditures of at least 150,000 dollars. There are 741 such universities and colleges in the U.S. (as of 2010). The NSF total is still about 1 trillion yen higher than for IPEDS' research expenditures, which cover about 2,870 universities and colleges (including about 682 public universities and colleges) (as of 2010). As noted above, this must be because IPEDS' research expenditures are under-estimated. Furthermore, because the universities and colleges that the NSF does not include each have R&D expenditures of less than 150,000, their total contribution is small. A comparison between the NSF's R&D expenditures and IPEDS' total expenditures therefore seems rational.

Looking at Chart 1-3-20 in this case, the share of total expenditures at all universities and colleges accounted for by R&D expenditures is 14.2%. By type of institution, the share is 16.3% at public universities and colleges and 11.2% at private universities and colleges.

The NSF's survey was conducted under the condition that the R&D expenditure category does not include anything that cannot be differentiated from categories such as instruction.

Chart 1-3-20: Share of total expenditures at U.S. universities and colleges accounted for by R&D expenditures (NSF data)

(A) Percentage



(B) Amount

2008-2010 (3-year ave.)	(1) Total expenditures	(2) R&D expenditures	(2)/(1)
All universities	45.0 trillion yen	6.4 trillion yen	14.2%
Public universities	26.6 trillion yen	4.3 trillion yen	16.3%
Private universities	18.4 trillion yen	2.1 trillion yen	11.2%

Note: These are four-year universities and colleges (four-year institutions).
Sources: Total expenditures: NCES, IPEDS, "Digest of Education Statistics"
R&D expenditure: Up to 2009: NSF, "Academic R&D Expenditures"; from 2010: NSF, "Higher Education Research and Development"

In the case of Japanese universities, R&D expenditures are overestimated because they include personnel costs for researchers (faculty, medical staff and other researchers) without regard to the percentage of time they spend on research. Using the OECD's R&D expenditures that corrects labor costs by adjusting them by the percentage of time devoted to research reduces the figure by about 40%. Even so, R&D expenditures account for about 30% of total expenditures.

Even with these attempted corrections, there are large differences related to total operating costs and R&D expenditures in Japanese and U.S. universities and colleges. There are still points that need to be examined in order to carry out a proper comparison of R&D expenditures in Japanese and U.S. universities and colleges (Chart 1-3-21).

Chart 1-3-21: Comparison of statistics on R&D expenditures at Japanese and U.S. universities and colleges

Name of statistical surv		How R&D expenses are measured	Researcher personnel costs	Scope of academic fields
Japan	Ministry of Internal Affairs and Communications, "Report on Survey of Research and Development"	In addition to research activity by researchers, also includes all necessary related support work, e.g., office work such as general affairs and accounting, cleaning of research facilities and security.	1) and 2) below are added. 1) Personnel costs for researchers, research assistants and technicians are their total remuneration including that for non-research work (e.g., instruction-related work). 2) Personnel costs for clerical support staff and other related workers are	All fields (natural sciences, humanities, social science and other)
U.S.	NCES, "IPEDS" (educational statistics)	Expenditures that cannot be clearly differentiated as research expenses are classified as instructional expenses.	Personnel costs ("Salaries and wages") are indicated as an item of research expenditure.	All fields (all fields at all universities are likely included for educational statistics)
	Up to 2009: NSF, "Academic R&D Expenditures": from 2010: NSF, "Higher Education Research and Development Survey (HERD)" (R&D statistics)	Expenses separately budgeted for R&D in science and engineering (including indirect expenses) as at right are counted.	Unknown. (There are no separate data on university R&D expenditures, so it is not known how personnel costs are handled.)	Up to 2009: "science & engineering"; from 2010: all fields (including science & engineering as well as non-science & engineering fields, such as humanities, education, law, and art)

Source: <Japan> Ministry of Internal Affairs and Communications, "Report on Survey of Research and Development"
<U.S.> NCES, IPEDS
NSF, "Academic R&D Expenditures", "Higher Education Research and Development Survey (HERD)"

(5) R&D expenditure in the university and college sector in Japan

As stated above, it is necessary to be careful about the fact that the labor cost, which comprises a part of the R&D expenditure in the university and college sector in Japan, includes the cost for duties other than research. However, in this section, the R&D expenditure in the university and college sector by type, national, public or private, is examined in accordance with the data associated with R&D expenditure in universities and colleges. Published in the "Report on the Survey of Research and Development" (Chart 1-3-22).

R&D expenditure for the entire university and college sector in Japan in FY 2011 was approximately 3.5 million yen, which was composed of approximately 2.3 million yen for the field of natural sciences and engineering and approximately 1.2 million yen for the field of social sciences and humanities, respectively. A year-on-year comparison shows an overall increase of 3.1%, which includes a 5.0% increase in natural sciences. On the other hand, there was a 0.2% decrease in social sciences and humanities.

Looking at overall R&D expenditure by national, public and private universities, in FY 2011 national universities accounted for 1.5 trillion yen, public universities for 0.2 trillion yen, and private universities for 1.9 trillion yen. Thus, private universities accounted for more than half of all R&D expenditure.

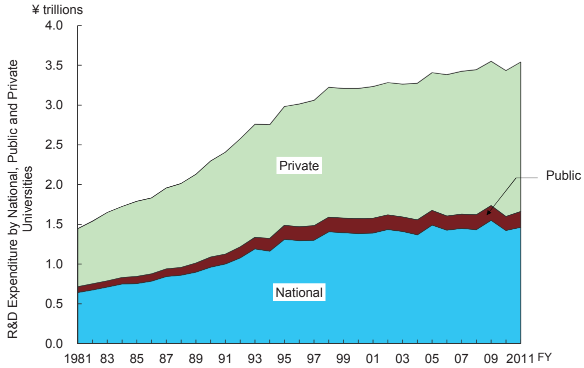
However, when just natural sciences is examined, national universities accounted for 1.2 trillion yen, public universities for 0.1 trillion yen, and private universities for 0.9 trillion yen. Accordingly, national universities accounted for more than half of all expenditure in this field.

Moreover, when just social sciences and humanities is examined, national universities accounted for 0.3 trillion yen, public universities for 0.1 trillion yen, and private universities for 0.9 trillion yen. Thus, private universities accounted for the majority of R&D expenditure in this field.

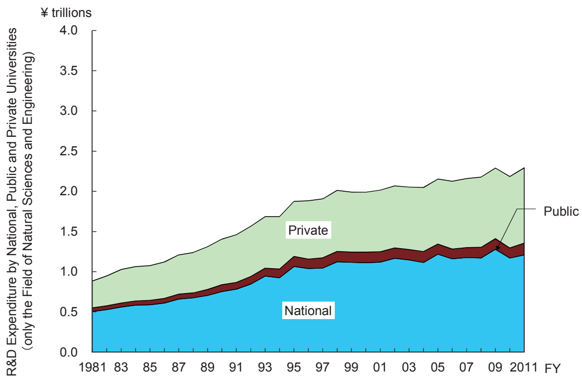
It was found that national universities accounted for large proportion of R&D expenditure in the field of natural sciences and engineering (natural sciences, engineering, agricultural sciences, medical sciences). On the other hand, private universities accounted for large proportion of R&D expenditure in the field of social sciences and humanities.

Chart 1-3-22: R&D expenditure by national, public and private universities

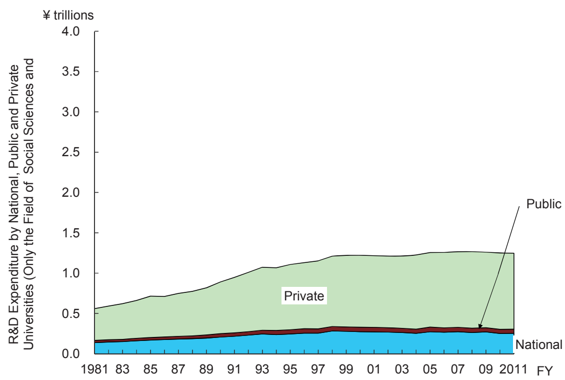
(A) All fields



(B) Field of natural sciences and engineering



(C) Field of social sciences and humanities



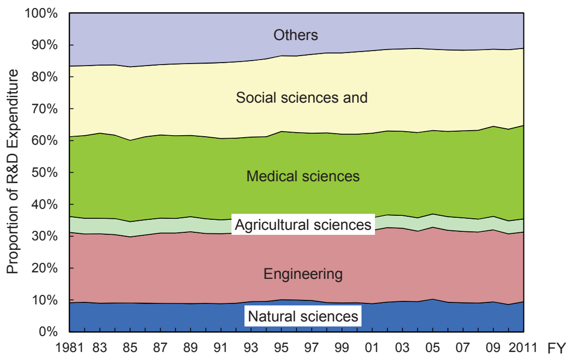
Note: "Social sciences and humanities" includes "Other."
Source: Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"

Subsequently, the trend in the proportion of R&D expenditure in each field of study in universities and colleges, etc. is examined. The field of study represents the content of research conducted in faculties and research facilities. In a case where more than one field of study is included in an organization, the field which is considered central is used to represent the field of study of research.

Chart 1-3-23 shows that R&D expenditure of each field changes only slightly. It is difficult to understand actually what kinds of R&D are performed from this chart because the fields of study shown are classified only in accordance with the kinds of faculties, as mentioned above.

However, when viewed over the long term, it is apparent that expenditure in medical sciences and social studies and humanities is increasing.

Chart 1-3-23: Trend of the proportion of R&D expenditure by field of study in universities and colleges



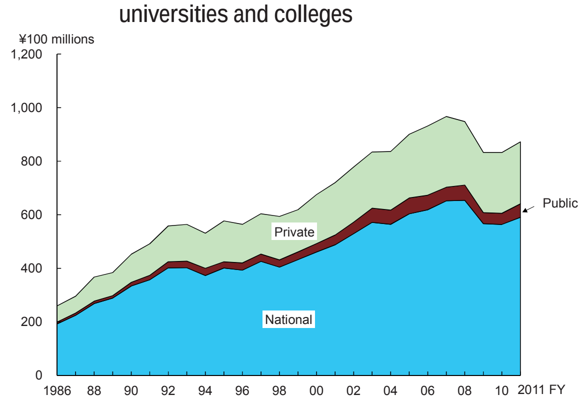
Note: Classification into the field of study represents a classification into the element of the organization, such as the faculty.
Source: Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"

In recent years, approaches trying to utilize the potential of universities are being enhanced in each country all over the world. It is true that universities are irreplaceable organizations for creating knowledge which is a source of innovation; however, transferring the knowledge generated by universities is not easy. The time is ripe to strongly enhance the cooperation between industry and academia, given the background mentioned above.

As an index to indicate the status of the cooperation between industry and academia, R&D expenditure which the university and college sector received from the business enterprise sector is examined (Chart 1-3-24). A look at trends in R&D expenditure that universities and colleges accept from the business enterprises sector shows that growth was stagnant in the 1990s. A noteworthy increase began in the early 2000s that continued until a peak in FY 2007 that was the beginning of a downward trend. However, expenditure in FY 2011 reached 87.2 billion yen, which represented a year-on-year increase of 4.8%. It must be added, however, that this amount represented no more than 2.5% of the intramural R&D expenditure (3.5 trillion yen) of universities and colleges in the same fiscal year.

Looking at national, public, and private universities as classifications, national universities had the largest amount of R&D expenditure received from the business enterprises sector. In FY 2011, national universities' expenditure was 59.0 billion yen, which accounted for approximately 70% of the total.

Chart 1-3-24: Trend of the ratio of R&D expenditure from the business enterprise sector against the total intramural R&D expenditure in universities and colleges



Note: Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"

(6) R&D expenditure by item of expense in the university and college sector for Japan

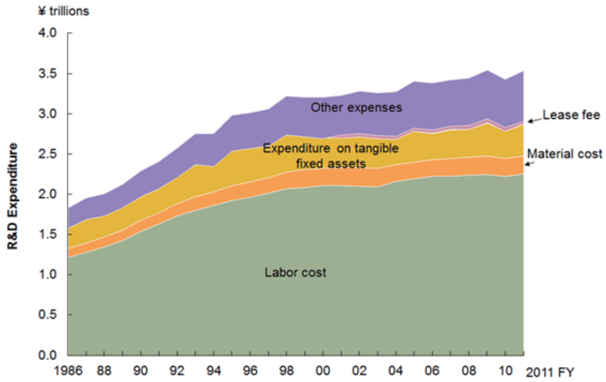
With regard to the breakdown of intramural R&D expenditure in universities and colleges by item of expense, the proportion of "labor cost" is large. The "labor cost" in FY 2011 was approximately 2,256.5 billion yen at 63.7% of the total (Chart 1-3-25). The next largest is "expenditure on tangible fixed assets." This item shows considerable fluctuation from year to year.

Comparing national and private universities, labor costs in FY 2011 at national universities were 811.9 billion yen. The growth rate has been flat since the beginning of the 2000s. This was about 55.5% of total R&D expenditures. Over the long term, the percentage has been decreasing. A look at the next largest item, expenditure on tangible fixed assets, reveals a high degree of fluctuation from year to year.

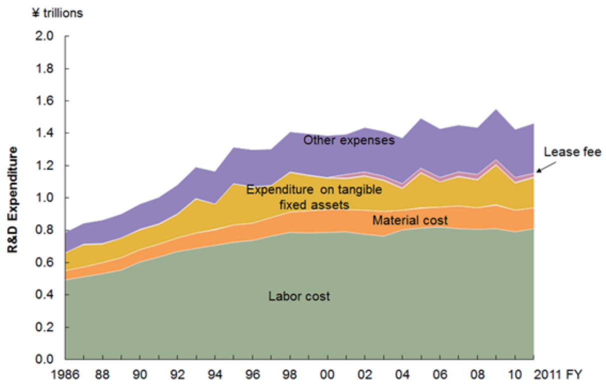
Labor costs in FY 2011 at private universities continued to increase, reaching 1.3068 trillion yen. These costs account for a 69.5% share of the total. The next largest cost is expenditure on tangible fixed assets. However, private universities do not show the same level of fluctuation here that national universities do.

Chart 1-3-25: R&D expenditure by item of expense in universities and colleges

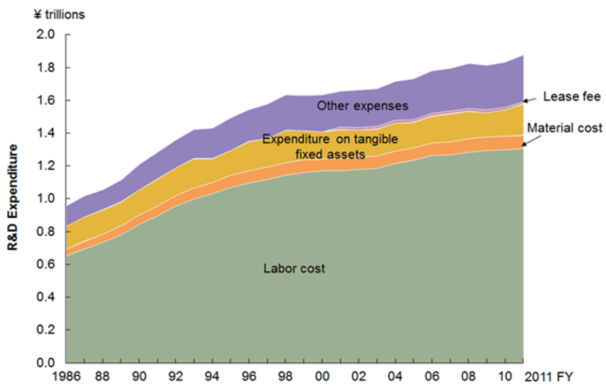
(A) Total



(B) National universities



(C) Private universities



Note: "Lease fee" was added to items for survey since FY 2001.
Source: Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"

1.4 R&D expenditure by type of R&D

Key points

○The expression R&D expenditure by type of R&D is a classification of R&D expenditure into that for basic research, applied research, and development. In Japan, however, this classification has been made only for the field of natural sciences and engineering.

○Out of R&D expenditure in FY 2011 for Japan, the proportion of that for basic research was 14.8%. Moreover, of R&D expenditure by type of R&D for the most recent available year of each country, the country with the largest basic research share is France, where basic research accounts for 25.3% of the total. On the other hand, the country with the smallest basic research share is China, where it accounts for 5.2% of the total.

○A breakdown of basic research expenditure by performing sector shows that the universities and colleges sector has the largest share in Japan, the U.S., and France. In China, the public organization sector and, in the most recent available year, the universities and colleges sector have large shares. On the other hand, in Korea, the business enterprises sector has the largest share.

1.4.1 R&D expenditure by type of R&D

The expression R&D expenditure by type of R&D represents the intramural R&D expenditure roughly classified into that for basic research, applied research and development. This classification is in accordance with the definition in the “Frascati Manual” by the OECD which each country has adopted. Therefore, the influence caused by responders’ subjective estimates should be taken into account. The summary of the definition of characters of work in the “Frascati Manual” is as follows.

Basic research is exploratory and theoretical work mainly in order to obtain new knowledge on the causes behind phenomena and observable facts without considering any specific application or use.

Applied research is also an original exploration in order to obtain new knowledge. It is, however, mainly for certain actual purposes or objectives.

(Experimental) development is systematic work in which existing knowledge obtained by research or actual experiments is applied, for the purpose of producing new materials, products and devices, introducing new procedures, systems and services, or practically revising what has already been produced or introduced.

Each country seems to measure the data in accordance with the definition above, but the expressions used are somewhat different depending on country. For example, “experimental development” is expressed as “development” in the U.S. but as “development experimental” in France, explicitly including experimental work.

Germany has not publicly announced precise data for R&D expenditure by type of R&D, and does not have any such data for the university and college sector. But measured data for R&D expenditure by type of R&D in the business enterprise sector has been published since 2001 (through the data of OECD). Also, the U.K. does not have data for R&D expenditure by type of R&D in the university and college sector. Therefore, it is impossible to measure the total R&D expenditure by type of R&D.

Japan's R&D expenditures by type of R&D(11) measures only the field of natural science and engineering, not total R&D expenditures. The same was true of Korea through 2006, but since 2007, all fields have been covered.

Chart 1-4-1 shows the proportion of development by type of R&D. In Japan, basic research accounted for 14.8% of all R&D expenditure by type of R&D in 2011(12), while applied research accounted for 22.9% and development for 62.3%. These proportions have not changed significantly when viewed

(11) The definition of R&D expenditure by type of R&D in Japan’s survey of R&D expenditure, the “Survey of Research and Development” is as follows, and only the field of science and engineering is covered.
Basic research: theoretical or experimental research in order to create hypotheses and theories or to obtain new knowledge on phenomena or observable facts, without considering a certain application or use.
Applied research: research to determine the potential of the practical use of knowledge which was discovered by basic research in order to achieve certain objectives; research to explore additional application methods with regard to methods which are already in practical use.
Development: research to introduce new materials, devices, products, systems, procedures, etc. and to revise those which already exist, by using basic research, applied research and knowledge obtained by actual experience.
(12)This section uses "years" for international comparison, although in the case of Japan it is originally "fiscal years."

over the long term.

In the U.S., the proportions of basic research, applied research, and development resemble those of Japan; however the proportion of basic research is continuing to grow.

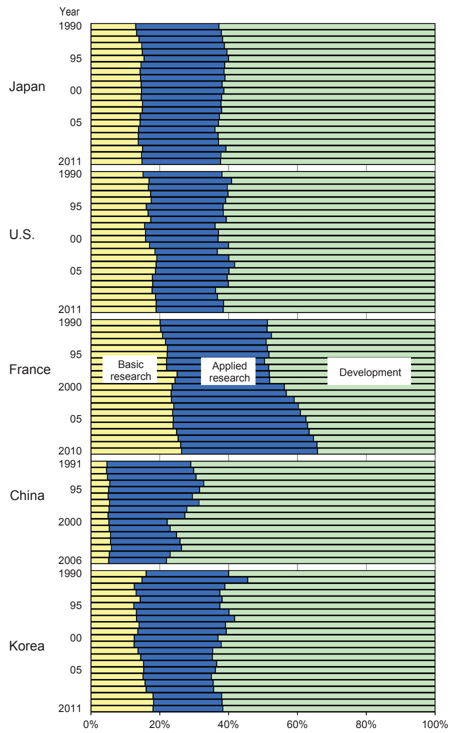
In France, basic research accounts for the largest share at 25.3% for the most recent available year. The ratio of development, on the other hand, has been declining. Additionally, the ratios of basic research and applied research are increasing, while that of development is decreasing.

In China, basic research has a small share, standing at 5.2% in the most recent available year. On the other hand, development has a large share of 78.0%. Development's share is continuing to grow.

In Korea, the percentage accounted for by basic research has been growing since 2000. The share of applied research has been shrinking, as has that of development in recent years.

Chart 1-4-1: Trend of the proportion of R&D expenditure by type of R&D in selected countries

Attention to international comparison



Note: In Japan (and Korea until 2006), R&D expenditure covers only the field of natural sciences and engineering. But R&D expenditure in other countries is the total of that for the field of natural sciences and engineering and for social sciences and humanities. Therefore it is necessary to be careful when an international comparison is being made.
<Japan> Fiscal year is used as a year scale.
<U.S.> R&D expenditures by type do not add up to total R&D expenditures for 1998 and 1999.
Source: <Japan> The Ministry of Internal affairs and communications, "Report on the Survey of Research and Development".
<U.S.> NSF, "National Patterns of R&D Resources: 2010–11 Data Update"
<France, China> OECD, "Research & Development Statistics 2012"
<Korea> National Science and Technology Information Service (website)

1.4.2 Basic research in each country

Next, we examine which sector is in charge of basic research in each country. Basic research provides low return on investment over the short term, but it builds intellectual capital in science and technology and is important in constructing foundations for the future.

Looking at the trend of the proportion of basic research expenditure by performing sector (Chart 1-4-2), the universities and colleges sector accounts for a large percentage in almost all the selected countries.

In 2011, Japan's basic research expenditure was 2.4 trillion yen, of which the universities and colleges sector accounted for 51.5%. The business enterprises sector's share was also comparatively large.

In the U.S., basic research expenditure for the most recent available year amounted 8.4 trillion yen, of which the universities and colleges sector had the largest share with 52.2%. The non-profit institutions sector in the U.S. had a 12.1% share, and this figure is continuing to grow.

Looking at basic research expenditure in France, the universities and colleges sector has a high percentage compared to other countries. This sector posted expenditure of 1.4 trillion yen, or 71.2%, in the most recent available year. Little change is seen among the ratios of each sector. The variation seen in the 1998 and 1999 figures for the public organizations sector are due to changes in the method of estimation and questionnaire. Data for this period should be considered to have little continuity with other data.

In the case of China, the public organizations sector previously had a large share; however the universities and colleges sector's share has been growing in recent years. On the other hand, the business enterprises sector's ratio is small, indicating that almost no basic research is taking place in this sector.

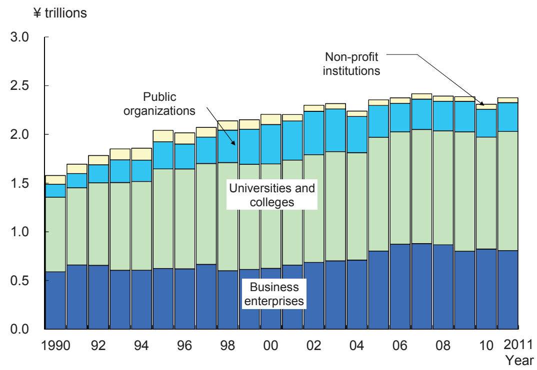
In Korea, a rapid increase in basic research expenditure that began in 2000 is apparent. This expenditure reached 1.1 trillion yen in the most recent available year. It should be noted that the business enterprises sector is the main sector conducting basic research in Korea. This sector posted a 56.9% share in the most recent available year.

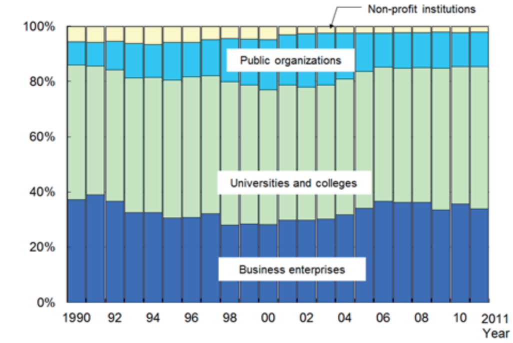
Chart 1-4-2: Basic research expenditure by sector in selected countries

Attention to international comparison

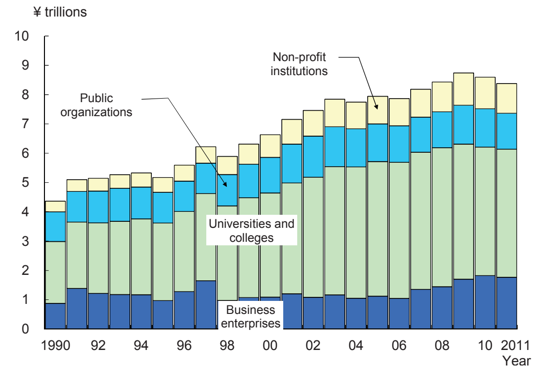
	Expenditure (Yen PPP)	Proportion of expenditure by sector

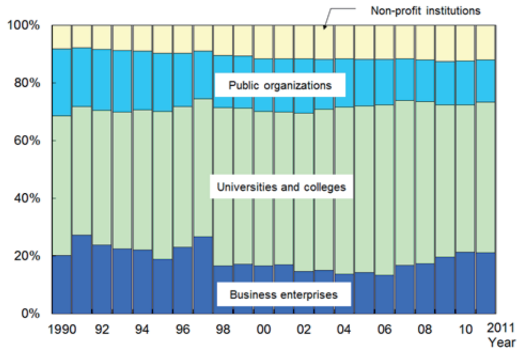
(A) Japan



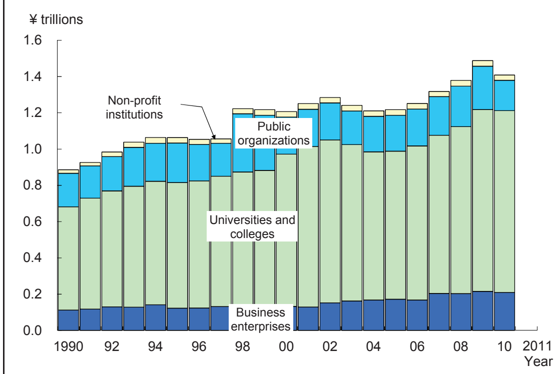


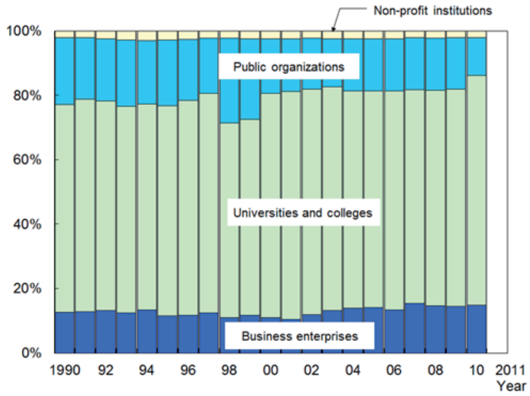
(B) U.S.





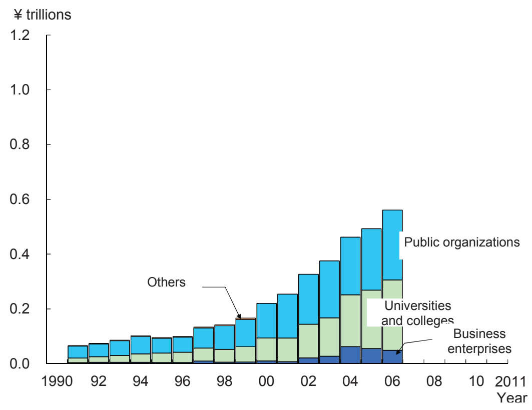
(C) France

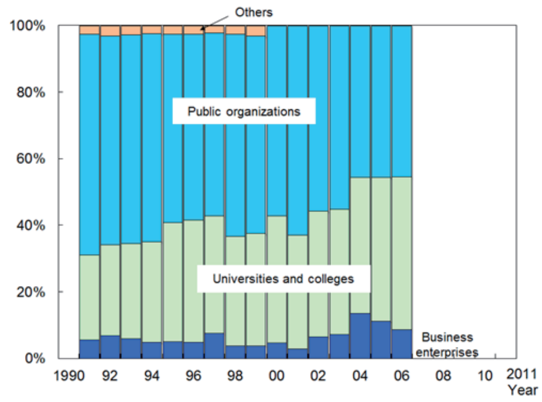




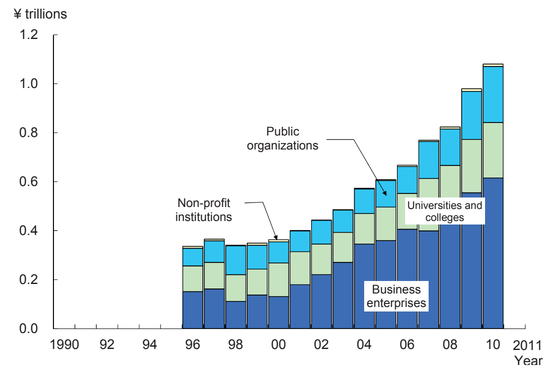
	Expenditure (Yen PPP)	Proportion of expenditure by sector

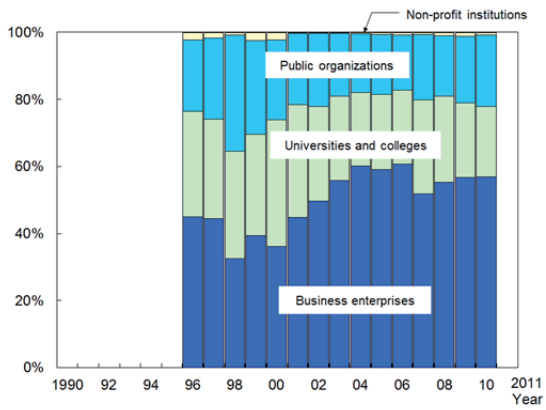
(D) China





(E) Korea





Note: 1) In Japan (and Korea until 2006), R&D expenditure covers only the field of natural sciences and engineering. But R&D expenditure in other countries is the total of the field of natural sciences and engineering and of social sciences and humanities. Therefore it is necessary to be careful when international comparisons are made.
2) Purchasing power parity equivalent is the same as for Reference statistics E.

Source: <Japan> The Ministry of Internal Affairs and Communications. "Report on the Survey of Research and Development"
<U.S.> NSF, "National Patterns of R&D Resources: 2010–11 Data Update"
<France, China and Korea> OECD, "Research & Development Statistics 2012"

Column: An international comparison of changes in R&D expenditure

Data charting changes in R&D expenditure over a fixed period provide useful indicators for ascertaining R&D trends.

At the same time, appropriately grasping changes in R&D expenditure, which serve as an indicator for the R&D input side, is necessary for understanding the trends of output indicators.

Many of the charts appearing in Chapter 1 show changes in various R&D expenditures. However, when making international comparisons, purchasing power parity is used for the purpose of currency conversion, and this conversion can be influenced by changes in parity. Thus, purchasing power parity is inappropriate for identification and detailed examination of changes in R&D expenditure. Given this, the following is an attempt to make international comparisons of changes in R&D expenditure over the past 10 years by setting the monetary amount of R&D expenditure of each country in 2000 as an index number of 100, rather than using currency conversion.

This kind of index will be able to serve as an indicator that better reflects fundamental changes in R&D expenditure if real values that exclude the effects of price fluctuations can be prepared. However, because no R&D expenditure deflator that is based on a commonly accepted method among countries exists, the author has prepared an index for nominal values only(13). Nominal values have the advantage of matching with actual perceptions.

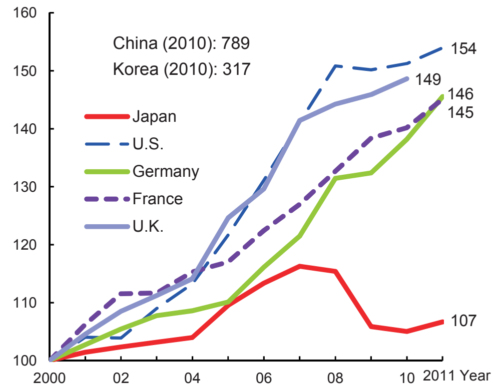
R&D expenditures in China and Korea have been growing at a remarkable pace. Consequently, juxtaposing them with the other selected countries in charts would hinder the charts' comprehensibility. For this reason, the author has decided to provide index numbers for the most recent available year only in the charts.

(1) Total R&D expenditures

A comparison of changes in the total R&D expenditures of the selected countries that sets the 2000 amount as an index number of "100" reveals that Japan has had the smallest increase among the countries since 2000 (Chart 1-5-1).

In contrast to Japan's index number of 107 for 2011, those of the U.S., Germany, France, and the U.K. were near 150 in the most recent available year. This means that the R&D expenditures of these countries increased by approximately 1.5 times during these 10 years.

Chart 1-5-1: Trends in the index numbers of R&D expenditure of selected countries



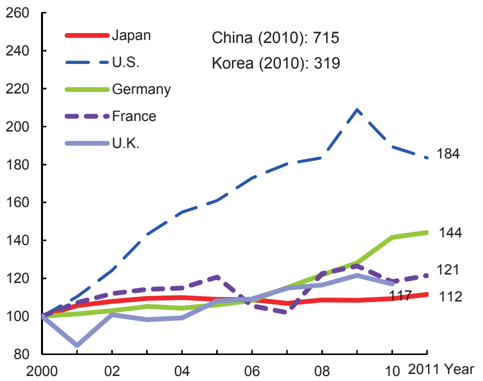
Source: Same as for Chart 1-1-1

(2) GBAORD

Next, a comparison of changes in GBAORD in each country using the index numbers shows that the U.S. has had conspicuous long-term growth. The U.S.'s number for 2011 was 184 (Chart 1-5-2). It should be noted that the U.S.'s index number for 2009 is relatively high compared to prior and subsequent years. This is largely the result of economy-boosting budgetary measures that were taken based on the American Recovery and Reinvestment Act of 2009 in response to the Lehman Brothers' bankruptcy-sparked economic crisis. In Japan's case, although some increases were seen in the first half of the 2000s, its index number remained flat in subsequent years and was low among the selected countries in the most recent available year.

(13)The GDP deflator is often used as representative data for the R&D expenditure deflator when computing the real values of R&D values. However, this method is not appropriate for viewing substantial changes in R&D expenditure, as the composition of items that form the basis for calculating price fluctuations differs greatly for R&D expenditure and GDP.

Chart 1-5-2: Trends in the index numbers of GBAORD



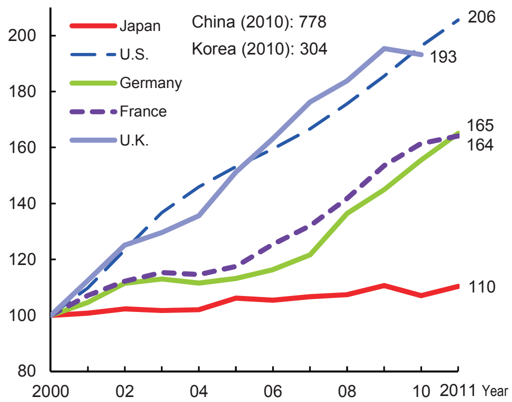
Source: Same as for Chart 1-2-1.

(3) R&D expenditure in the universities and colleges sector

Properly grasping changes in R&D expenditure in the universities and colleges sector is important when considering factors behind changes in qualitative and quantitative data on scientific research papers, which provide a major indicator of R&D output. This is because the universities and colleges sector forms the core of research paper production in almost all countries, including Japan.

A look at the trends of R&D expenditure in the university and colleges sector (Chart 1-5-3) reveals that only Japan is showing slight increases. Japan's index number for 2011 is 110, which is the lowest among the countries shown in the chart. Looking at the index numbers for the most recent available year of the other countries, the U.S. (206) and U.K. (193) posted numbers that were roughly twice their 2000 levels. Germany (165) and France (164) also had much higher numbers compared to Japan.

Chart 1-5-3: Trends in the index numbers of R&D expenditure in the universities and colleges sector



Source: Same as for Chart 1-3-13.

(4) Summary

What characteristics can be identified for Japan and the other selected countries based on a comprehensive view of the above-mentioned data?

For Japan, it is apparent that its index numbers have shown smaller growth than the other countries. In particular, growth in R&D expenditure in Japan's universities and colleges sector has been especially small in comparison with the other countries. Moreover, even though major European countries have similarly small growth in terms of their governments' S&T-related budgets, only Japan has had slow R&D expenditure growth in the universities and colleges sector. This is the pattern that characterizes Japan during this 10-year period.

As for the other selected countries, unlike Japan, they display the shared characteristic of having large increases in R&D expenditure in their universities and colleges sectors. Particularly in the cases of Germany, France, and the U.K., R&D expenditure in the universities and colleges sector is showing solid growth despite slow growth in their GBAORD. Moreover, the fact that this sector shows large increases when compared to total national R&D expenditure indicates that universities and colleges are gaining greater importance in these countries' R&D.

Like Germany, France, and the U.K., the U.S. is also seeing large growth in R&D expenditure in the universities and colleges sector in comparison to national R&D expenditure. However, in the case of the U.S., its GBAORD is showing large growth that exceeds its national R&D expenditure.

China is showing remarkable growth in all of its index numbers, and its national R&D expenditure and R&D expenditure in the universities and colleges sectors are showing growth that exceeds that of its GBAORD. Korea is also showing large and roughly equal growth in all of its index numbers.

(Hiroyuki Tomizawa)

Chapter 2: R&D personnel

Human resources, which are the basis for supporting scientific and technological activities, will be discussed here. In this chapter, R&D personnel, and more specifically, the status of researchers and research assistants in Japan and in selected countries will be explained. Concerning the present available data on the number of researchers, there are differences in definition of a researcher, and the methods of measurement applied are not unified across each country. Therefore, it could be said that this data is not suitable for strict international comparison. But even so, this data can be used to understand the condition of R&D personnel in each country if it is born in mind that there are differences in the scopes and levels of researchers in each country.

2.1 International comparison of the number of researchers in each country

Key points

○In 2012, the number of researchers in Japan was about 660,000 when the number of researchers working at universities and colleges is calculated using the FTE method. Using the head count method, the number was about 890,000.

○Comparing the number of researchers by sector, the business enterprises sector had the largest share in each country. In terms of female researchers by sector, on the other hand, the business enterprises sector accounted for only a small share in each country.

○Looking at the percentage of Japanese researchers who hold doctoral degrees, in 2012 it was 20.3% for all researchers. By sector, it was highest in the universities and colleges sector, at 55.5% in 2012. The next highest sector was the public organizations sector, at 44.3%. The percentage for the business enterprises sector was 4.2%. The growth rate has been flat, showing little change.

○Among Japanese researchers, the number of new graduates employed has declined after peaking in 2009. By sector, the business enterprises sector has shown the sharpest decline in recent years.

2.1.1 Methods for measuring the number of researchers in each country

According to the Frascati Manual issued by the OECD, "researchers" are defined as "professionals engaged in the conception or creation of new knowledge, products, processes, methods, and systems and engaged also in the management of the projects concerned [(1)]".

To measure the number of researchers, similar to the method adapted to measure R&D expenditure, a questionnaire survey is used in general, but for some sectors in some countries data obtained from other survey is used.

In addition, there are two kinds of methods used to measure the number of researchers. One method is to measure the research work by converting it into "full-time equivalents" (FTE) [(2)]. In this case, R&D activities are separated from other activities and the number of hours engaged in actual R&D activity is used as the basis for measuring the number of researchers. This method is widely accepted internationally as one which measures the number of researchers by taking their activities into account while counting them.[(3)]

The other method is to classify all activities as R&D activities, even when the research content of

(1) In Japan the definition of a "researcher" is based on the terms written on the "Report on the Survey of Research and Development" issued by the Ministry of Internal Affairs and Communications. In the statistics of this Ministry, the field of "research" is classified into "basic research", "applied research", and "development" and the "regular researchers" conducting such research are considered to be quite close to the "R&D scientists and engineers" mentioned in the Frascati Manual.

(2) For example, for researchers working at higher educational institutes such as universities and colleges, there are many cases when they are engaged in education together with their research work. The way to measure the manpower of the portion of activities engaged in actual research work rather than treating above mentioned kinds of researchers (called "part-time researchers") as the same level as "full-time researchers" is called the "full-time equivalent". Specifically, for example, if a researcher dedicates 60% of his/or her working time to R&D activities on annual basis, the value for this person as a researcher would be "0.6 people".

(3) In 1975, the OECD issued a recommendation that the full-time equivalent method should be applied to measure the manpower of researchers who are hired. The majority of OECD member countries have adopted the FTE method. The necessity of the FTE method and its principles are provided in the Frascati Manual issued by the OECD, which also provides international standards on the surveying methods for R&D statistics. The 2002 edition advises using both the HC and FTE methods.

work is combined with other activities, and to measure the number of researchers according to the actual number found by head counting (HC).

Chart 2-1-1 shows the definition and measurement method of researchers for 4 sectors which are the same as the performing sectors of R&D expenditure in each country (The data for each country was measured by FTE conversion. And indication is given in the exceptional cases where the HC value was utilized.). All the countries conduct their measurements of researchers according to the questionnaire survey as indicated in the Frascati Manual issued by the OECD and based on its definition of researchers. But in some sectors, questionnaire surveys were not performed or the FTE value measurements were not carried out, which caused the differences by country and by sector. In particular, differences can be seen according to the country regarding the measurements of researchers working in the universities and colleges sector.

In Japan, the number of researchers has been measured in R&D statistics (Survey of Research and Development) by the Ministry of internal affairs and communications. But it was not until 2002 that the FTE method was introduced to measure researchers. Numbers of researchers in Japan were shown in terms of the three measuring methods provided below (Chart 2-1-2).

Chart 2-1-2(A) shows the measurement method used until 2001, which was neither FTE nor HC, but a method of counting the number of the people as that of researchers in the column of researchers only if the corresponding cell of Column (1) was checked.

The measurement methods for 2002–2007 are shown in Chart 2-1-2(B). The number of researchers is obtained by counting the number of the people in the column for researchers by means of FTE if the corresponding cell in Column (2) is checked and by HC if the corresponding cell in Column (3) is checked, respectively.

Since 2008, the FTE coefficient obtained through new FTE surveys is used (Chart 2-1-2 (C)).

Chart 2-1-1: Definition and measurement method of researchers by sector in each country

Country	Business Enterprises Sector	Universities and Colleges Sector	Public Organizations Sector	Non-profit Institutions Sector
Japan	People who completed any undergraduate course (except for junior college cources)	(1) Teachers (HC) (2) Doctoral course students (HC) (3) Medical staff and others (HC)	People who completed any undergraduate course (except for junior college courses)	
	People who meet the above mentioned conditions or possess the equivalent or higher specialized knowledge, and conducting research on a special theme			
U.S.	Scientists and engineers mainly engaged in research	* Measured by independent surveys (HC) (1) Scientists and engineers with doctoral degree. (2) 50% of Doctoral course students who are given economic assistance	* Measured in accordance with existing personnel data (HC) Scientists and engineers who are mainly engaged in research.	Scientists and engineers possessing doctoral degrees (HC).
Germany	Staff who conceptualize or create new knowledge, products, manufacturing procedures, methods and systems. Persons in charge of the department of administration are included. Generally equivalent to scientists and engineers who graduated any university (comprehensive universities, technical universities and technical colleges)	* Measured in accordance with the statistics of education (HC) (1) Teachers × FTE coefficient of field of study × FTE coefficient of research time (2) Doctoral course students receiving economic assistance	Researchers	
France	(1) Researchers (2) Research technologists (3) Recipients of scholarship for preparing any doctoral thesis who are given reward for the work of research			
U.K.	Researchers	* Measured in accordance with existing personnel data	Researchers	Researchers
China	Scientists and enginees who are mainly engaged in research.			
Korea	Recipients of at least a doctoral degree who are engaged in R&D activities.	(1) Teachers with the position of full time lecturer or higher (2) doctoral course students (3) Recipients of at least a doctoral degree who are conducting surveys at any university research institute.	Recipients of at least a doctoral degree who are engaged in R&D activities.	
	People engaged in reseach activities who meet above mentioned conditions or possess the equivalent or higher specialized knowledge as those.			

Note: 1) The data is in accordance with statistical surveys of R&D except for data marked with ∗ which is obtained from a source other than statistical surveys of R&D.
2) Measurements are conducted on the basis of FTE in statistical surveys of R&D in each country. The cases in any sector in which FTE is not adopted are marked with (HC).
3) (2)Expression "doctoral course student" in the universities and colleges sector in Japan represents those in the later term (the 3rd to 5th year).
4) With regard to the universities and colleges sector in the U.S., the FTE of researchers is obtained by adding (1)50% of doctoral course students who are financially assisted.
5) In Germany, the public organizations sector and the non-profit institutions sector are combined. With regard to the universities and colleges sector, the FTE of researchers is obtained by multiplying the HC of teachers by FTE coefficients.
6) Expression solely used "researchers" represents that any definition and measurement method of researchers was not obtained in the sector.
7) For the U.S., the counting method used through 1999 is applied.
Source: NISTEP, "Metadata of R&D-related statistics in selected countries: Comparative study on the measurement methodology" (Research Material No. 143)
Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"

Chart 2-1-2: Methods for measuring researchers in Japan that are used in this report

(A) Until 2001

(B) 2002–2007

Sector	Researchers		(2) (FTE)	(3) (HC)
Business Enterprises	Mainly engated in research (number of people)		○	○
	Engaged in research under non-regular conditions	Number of people		○
		Number of people obtained by multiplying the ratio of research related work against the total work.	○	
Public Organizations (Natinonal and Public Organizations, Special coporations and Independent Administrative Corporations)	Mainly engated in research (number of people)		○	○
	Engaged in research under non-regular conditions	Number of people		○
		Number of people obtained by multiplying the ratio of research related work against the total work.	○	
Non-profit Institutions	Mainly engated in research (number of people)		○	○
	Engaged in research under non-regular conditions	Number of people		○
		Number of people obtained by multiplying the ratio of research related work against the total work.	○	
Universities and colleges	Teachers	Number of people		○
		Number of people obtained by multiplying the ratio of research related work against the total work.	○(0.465)	
	Doctor's course students	Number of people		○
		Number of people obtained by multiplying the ratio of research related work against the total work.	○(0.709)	
	Medical staff and others	Number of people		○
		Number of people obtained by multiplying the ratio of research related work against the total work.	○(0.465)	
	Engaged in research under external and non-regular conditions	Number of people		○

(C) After 2008

Sector	Researchers		(2) (FTE)	(3) (HC)
Business Enterprises	Mainly engated in research (number of people)		○	○
	Engaged in research under non-regular conditions	Number of people		○
		Number of people obtained by multiplying the ratio of research related work against the total work.	○	
Public Organizations (Natinonal and Public Organizations, Special coporations and Independent Administrative Corporations)	Mainly engated in research (number of people)		○	○
	Engaged in research under non-regular conditions	Number of people		○
		Number of people obtained by multiplying the ratio of research related work against the total work.	○	
Non-profit Institutions	Mainly engated in research (number of people)		○	○
	Engaged in research under non-regular conditions	Number of people		○
		Number of people obtained by multiplying the ratio of research related work against the total work.	○	
Universities and colleges	Teachers	Number of people		○
		Number of people obtained by multiplying the ratio of research related work against the total work.	○(0.362)	
	Doctor's course students	Number of people		○
		Number of people obtained by multiplying the ratio of research related work against the total work.	○(0.659)	
	Medical staff and others	Number of people		○
		Number of people obtained by multiplying the ratio of research related work against the total work.	○(0.387)	
	Engaged in research under external and non-regular conditions	Number of people		○

Note: 1) (1) "People mainly engaged in research" not converted on R&D basis until 2001. (2) "People mainly engaged in research" and "people who are engaged in research under external and non-regular conditions and converted to FTE (FTE)" since 2002. (3) "People mainly engaged in research" and "people engaged in research under external and non-regular conditions (HC)" since 2002.

2) Values for the universities and colleges sector are FTE coefficients. An FTE is obtained by multiplying the corresponding number of people by a FTE coefficient.

(1) 2002–2007: The results of the "Survey on the data for full-time equivalents in universities and colleges" conducted by MEXT in 2002 are used. For "medical staff and others", the same FTE coefficient as for "teachers" is used.

(2) 2008–: The results of the "Survey on the data for full-time equivalents in universities and colleges" conducted by MEXT in 2008 are used.

Source: Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"

2.1.2 Trends in the numbers of researchers in each country

Chart 2-1-3 shows that the number of Japan's researchers in 2012 was 660,000 (people) and its HC value was 890,000 (people) respectively. In 2008, Japan converted to using FTE to calculate the number of researchers. The continuity of FTE figures between 2007 and 2008 is therefore impaired.

The number of researchers in the U.S. was publicly announced only up to 1999 for the universities and colleges, and up to 2002 for the public organizations sector and the non-profit institutions sector. Therefore, the values estimated by the OECD have been used for the total number of researchers since 2000.

In Germany, statistical surveys for R&D are conducted in the business enterprises sector, the public organizations sector and the non-profit institutions sector. With regard to the universities and colleges sector, however, the measurement is in accordance with the statistics on education, and the FTE value of researchers is estimated using full time equivalent coefficients by academic field of study. Because the 1990 unification of East and West Germany increased the number of researchers in 1991, data continuity is impaired.

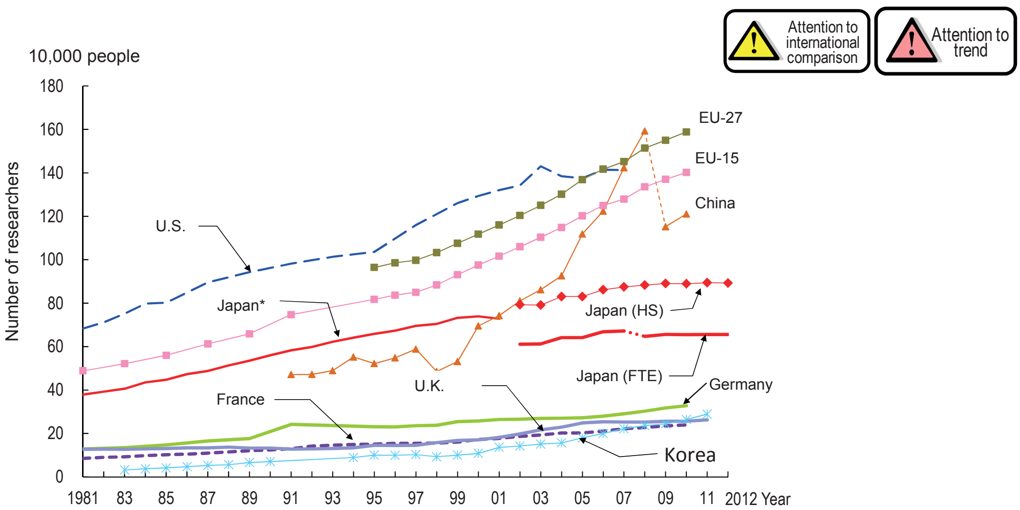
In France, the number of researchers is measured in accordance with statistical surveys for R&D which are conducted in all the sectors.

In the U.K., because no statistical survey for R&D is conducted in the universities and colleges sector, the total number of researchers since 1999 was calculated using the estimates by the OECD. Recently, however, the U.K. has begun publishing the number of researchers. Figures have been available since 2005.

China publishes R&D statistics, but details of its statistical surveys are unknown. In 2009, it began using the definitions in the OECD's Frascati Manual to collect statistics. This resulted in a big drop from the 2008 figure.

Korea conducts statistical surveys for R&D by sector. Through 2006, however, the target was limited to the "field of natural science and engineering". Since 2007, all fields have been covered. Therefore this condition should be born in mind. Korea surpassed France and the U.K. in the most recent available year.

Chart 2-1-3: Trends in the number of researchers in selected countries



Note: 1) The number of researchers in a country represents the total value of researchers in every sector, and the definition and measurement method for researchers in each sector is occasionally different depending on the country. Therefore it is necessary to be careful when international comparisons are being made. See Chart 2-1-1 for details on differences in the definition of "researcher" among the countries.
2) Values for each country are FTE, except Japan, which showed both FTE and HC values.
3) The values include the number of researchers in the field of social sciences and humanities (until 2006, only that of the field of natural science and engineering for Korea).
<Japan> (1)Values until 2001 represent the numbers of researchers measured on Apr.1 and since 2002 represent the numbers of researchers measured on Mar.31 in the corresponding year, respectively.
(2) "Japan＊"represents the values in Chart 2-1-2(A)(1).
(The number of "people mainly engaged in research" without being converted on FTE basis. External non-regular researchers are not measured.)
(3) "Japan (HC)" represents the values in Chart2-1-2(B)(2).
(The total of "people mainly engaged in research" and "people engaged in research under non-regular conditions". The number of researchers in the universities and colleges sector includes the above mentioned "external non-regular researchers").
(4) The FTE values of "Japan" through 2007 represent the values in Chart2-1-2(B).
(The measurement for the universities and colleges sector is made with the conversion in accordance with the results of the "Survey on the data for full-time equivalents in universities and colleges" in 2002. With regard to the business enterprises sector, the public organizations sector and the non-profit institu-

tions sector, "people mainly engaged in research" and "people engaged in research under non-regular condition whose values are converted on FTE basis" are measured.)

(5) FTE values for “Japan” from 2008 on are those shown in Chart 2-1-2 (C).
(The value for the “”universities and colleges” calculated using the 2008 “Survey on the data for full-time equivalents in universities and colleges,” and for ”“business enterprises” and ”public organizations and non-profit institutions” count ”“people mainly engaged in research” and “people engaged in research under non-regular condition whose values are converted on FTE basis.”)

<U.S.> OECD secretariat estimate or projection based on national sources has been used since 2000.

<Germany>Former West Germany until 1990 and unified Germany since 1991 respectively. For 2010, OECD Secretariat estimate/projection based on each country's materials.

<U.K.> OECD secretariat estimate or projection based on national sources has been used since 1999. In 2005, the measurement method was changed. Estimated values have been corrected by the Secretariat to accord with national estimates and, where necessary, with OECD standards. Figures for 2010 are provisional.

<China> Through 2008, the definition of researcher used was not in complete accordance with the OECD. The measurement method was changed in 2009. Caution is therefore necessary when observing changes over time.

<EU> OECD Secretariat estimate/projection based on each country's materials. Figures for 2009 and 2010 are provisional.

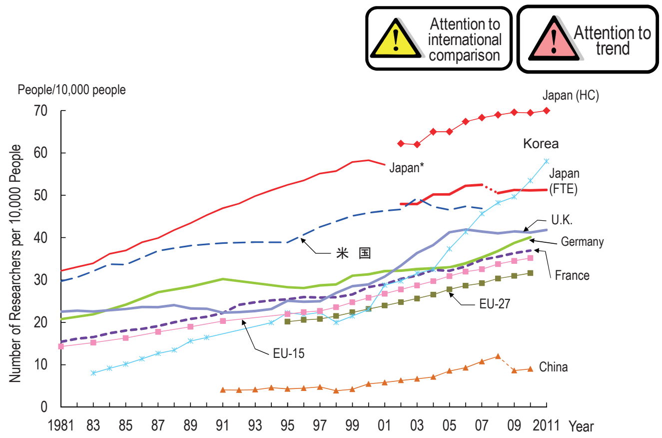
Source: <Japan>Ministry of Internal Affairs and Communications, “Report on the Survey of Research and Development ”;
MEXT, “Survey on the data for full-time equivalents in universities and colleges” (2002 and 2008)
<U.S.> NSF, “National Patterns of R&D Resources 1995, 1998, 2002 Data Update”; OECD, “Main Science and Technology Indicators 2011/2” for the data since 2000
<Germany> Bundesministerium für Bildung und Forschung, “Bundesbericht Forschung 1996, 2000, 2004”, "Forschung und Innovation in Deutschland 2007”, “Bundesbericht Forschung und Innovation 2008, 2010, 2012”; OECD, “Main Science and Technology Indicators 2012/2” for the data since 2010
<France, U.K., China, EU> OECD, “Main Science and Technology Indicators 2012/2”
<Korea>KISTEP, Statistical DB (website)

Next, an international comparison is conducted in which the influence of the size of each country is reduced by using the relative value of the number of researchers, in other words, the number of researchers per capita (Chart 2-1-4). Looking at values since 2002, values for Japan (FTE) have been higher than those of the U.S., but they have been overtaken by Korea’s in recent years. It should be noted that the FTE coefficient for researchers that is used for Japan’s FTE value was changed from 2007 to 2008, and thus FTE value continuity is impaired.

The growth rate has been highest of all in Korea. It has been especially remarkable since 2004. European countries have shown a gradual increase over the long term.

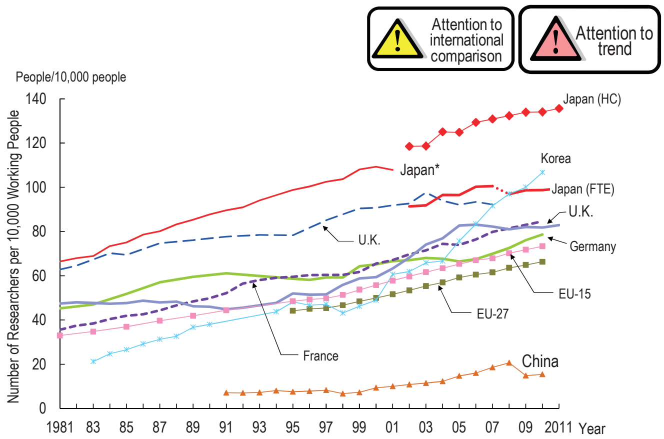
Moreover, like the number of researchers per capita, Japan’s values are high in terms of the number of researchers per labor force (Chart 2-1-5), however these values have been surpassed by Korea’s in recent years. As for rate of growth, although it appears that there is little difference in movement between the number of researchers per labor force and number of researchers per capita among most of the countries, the former for France is larger than in other European countries.

Chart 2-1-4: Trends in the number of researchers per capita in selected countries



Note: Refer to Chart 2-1-3 for notes on “attention to international comparison,” “attention to trend,” and number of researchers. The population is the same as for Reference Statistics A.
Source: Refer to Chart 2-1-3 for “attention to international comparison,” “attention to trend,” and number of researchers. The population is the same as for Reference Statistics A.

Chart 2-1-5: Trends in the number of researchers per labor force in selected countries



Note: Refer to Chart 2-1-3 for notes on “attention to international comparison,” “attention to trend,” and number of researchers. The labor force is the same as for Reference Statistics B.
Source: Refer to Chart 2-1-3 for “attention to international comparison,” “attention to trend,” and number of researchers. The labor force is the same as for Reference Statistics B.

2.1.3 Trends in the proportion of the number of researchers by sector in each selected country

(1) Breakdown of each country's researchers by sector

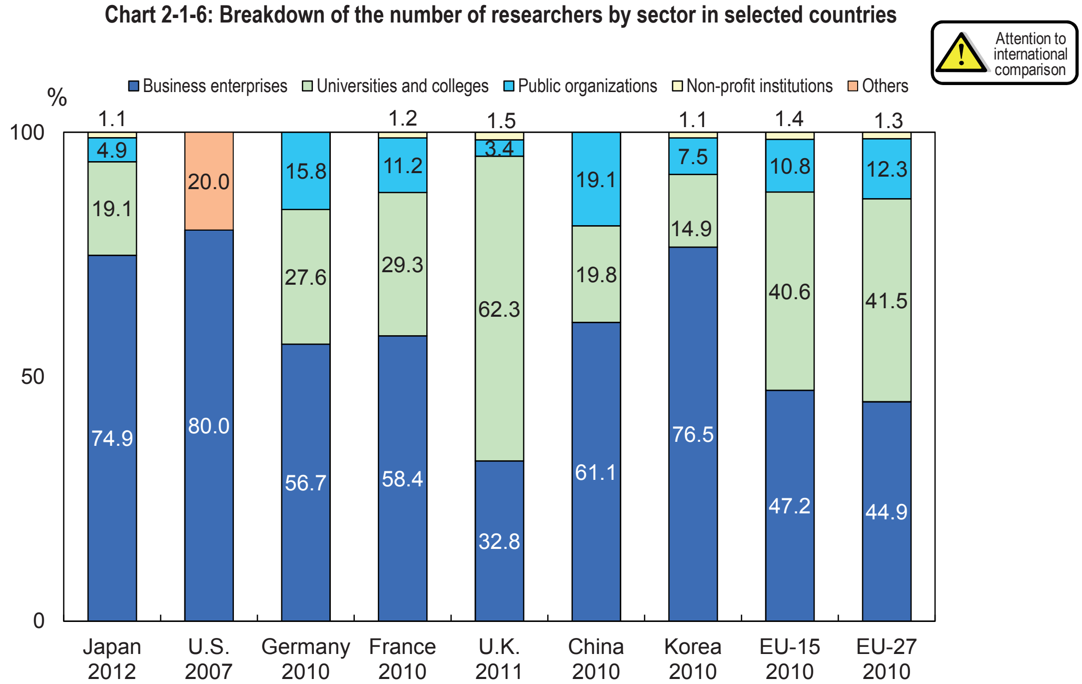
The situation and trend over time with regard to the number of researchers in each country are examined by sector, which are same as those in the classification of R&D expenditure, the "business enterprises sector", the "universities and colleges sector", the "public organizations sector" and the "non-profit institutions sector".

Although an international comparison of the number of researchers faces difficulties as mentioned in 2.1.1, in this section each country's characteristics are examined using the data which is available at the present time.

In each country except the U.K., the number of researchers in the business enterprises sector accounts for more than half of the total. This number exceeds 70% of the total in Japan, the U.S., and Korea. In the U.K., the number of researchers in the universities and colleges sector is the largest with a share in excess of 60%. The same share is around 20% in Japan and China and 30% in Germany and France. As for the public organizations sector, the largest share is in China, where it accounts for 20% of the total (Chart 2-1-6).

Next, a look at by-sector trends in the number of researchers (Chart 2-1-7), Japan has trended flat in recent years. The same is true for the U.S. In Germany, the number began to increase from the mid-2000s, with a particularly strong increase in the universities and colleges sector. In France, growth has been remarkable since entering the 2000s, particularly in the business enterprises sector. In the U.K., the number has remained largely unchanged in recent years. In 2009, China began using the definitions in the OECD's Frascati Manual to collect statistics. This resulted in a big drop from the 2008 figure. Korea's number has increased rapidly since entering the 2000s, particularly in the business enterprises sector.

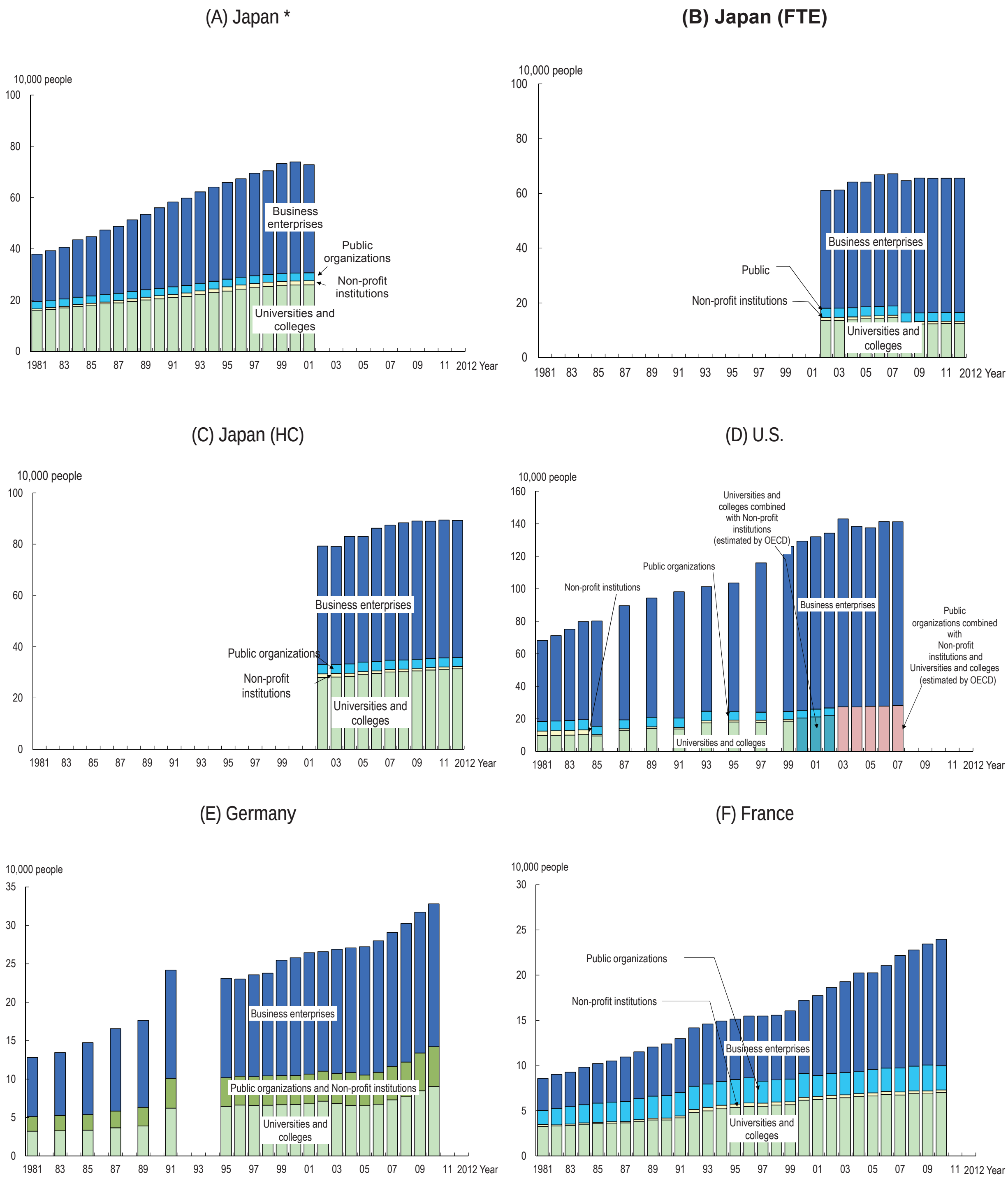
Chart 2-1-6: Breakdown of the number of researchers by sector in selected countries



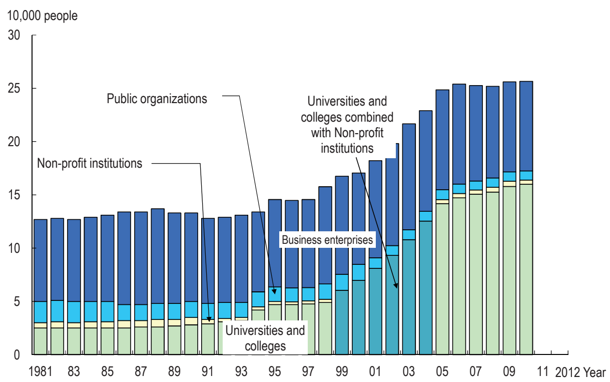
Note: 1) Values for each country are FTE.
2) Data of the field of social sciences and humanities were also included.
3) The values in the non-profit institutions sector for each country (other than Japan) were obtained by subtracting the number of researchers in the business enterprises sector, the universities and colleges sector and the public organizations sector from the total.
<U.S.> Years included are OECD Secretariat estimate/projection based on each country's materials.
<Germany> Public organizations include non-profit institutions. For the years included, estimated values have been corrected by the Secretariat to accord with national estimates and, where necessary, with OECD standards.
<U.K. and E.U.> Figures for years included are provisional.
Source: <Japan> Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"; MEXT, "Survey on the data for full-time equivalents in universities and colleges" (2002 and 2008)
<U.S., Germany, France, U.K., China, Korea and EU> OECD, "Main Science and Technology Indicators 2012/2"

Chart 2-1-7: Trends in the number of researchers by sector

Attention to international comparison

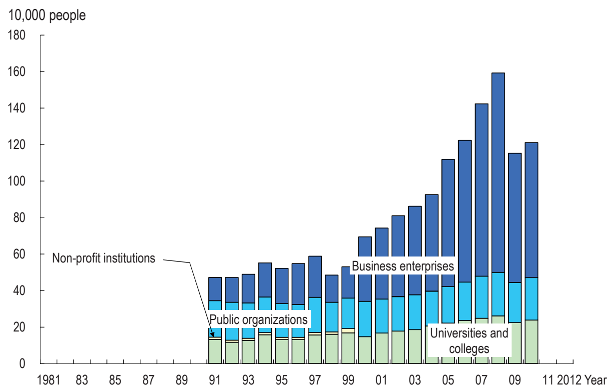


(G) U.K.

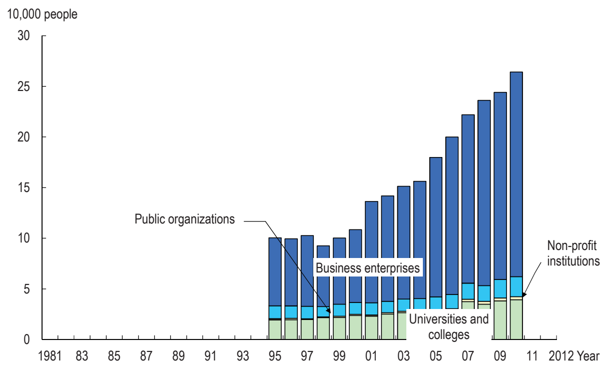


(H) China

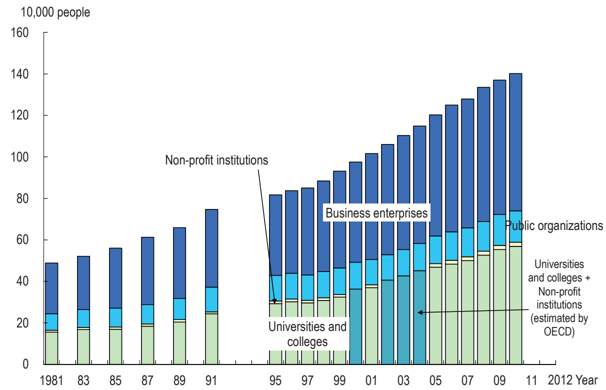
Attention to trend



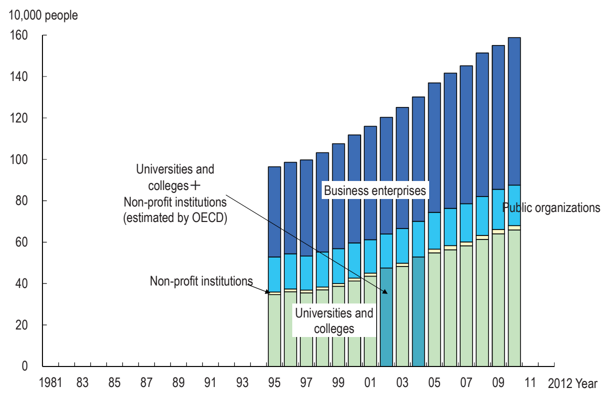
(I) Korea



(J) EU-15



(K) EU-27



Note: 1) Refer to Chart 2-1-3 for the note on making international comparisons
2) Values for each country are FTE, except Japan, which is HC.
3) The values include the number of researchers in the field of social sciences and humanities (until 2006, only that of the field of natural science and engineering for Korea).
4) Refer to Chart 2-1-3 for the number of researchers in Japan.
5) The number of researchers in the universities and colleges sector combined with the non-profit institutions sector in the U.S. since 2000 was obtained by subtracting the number of researchers in both the business enterprises sector and the public organizations sector from the total.
6) Germany represents the former West Germany until 1990 and unified Germany since 1991 respectively. For the latest available year, estimated values have been corrected by the Secretariat to accord with national estimates and, where necessary, with OECD standards.
7) For France, the U.K., China, Korea and the EU, the number of researchers in the non-profit institutions sector was obtained by subtracting the number of researchers in the business enterprises sector; the universities and colleges sector; and public organizations sector from the total.
8) Through 2008, the definition of researcher used was not in complete accordance with the OECD. The measurement method was changed in 2009. Caution is therefore necessary when observing changes over time..
9) Figures for 2010 in the U.K. and those for 2010 and 2011 in the E.U. are provisional.

Source: <Japan> Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"; MEXT, "Survey on the data for full-time equivalents in universities and colleges" (2002 and 2008).
<U.S.> NSF, "National Patterns of R&D Resources: 1995, 1998, 2002 Data Update"; OECD, "Main Science and Technology Indicators (2012/2)" since 2000.
<Germany> Bundesministerium für Bildung und Forschung, "Bundesbericht Forschung 1996, 2000, 2004"; "Forschung und Innovation in Deutschland 2007" "Bundesbericht Forschung und Innovation, 2008, 2010"; OECD, "Main Science and Technology Indicators 2012/2)" since 2010.
<France, U.K., China, Korea, and EU> OECD, "Main Science and Technology Indicators 2012/2"

(2) Researchers with doctoral degrees in Japan

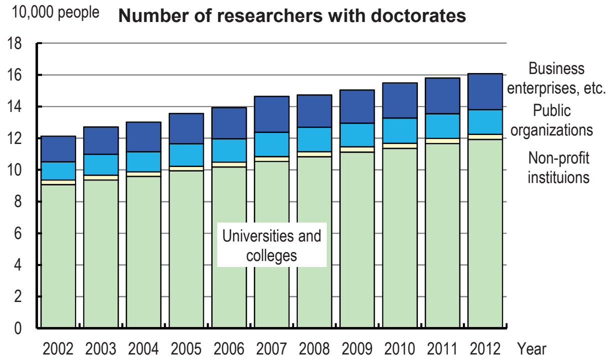
As discussed in 2.1.1 above, the definition of researcher does not require any special scientific qualifications. Depending on the country, however, the definition of researcher may include clear conditions such as "specialist knowledge at least equivalent to that of a holder of a doctoral or higher degree." Examination of the number of researchers with doctoral degrees may be one indicator for looking at the number of researchers with advanced knowledge.

Looking at the state of Japanese researchers with doctoral degrees (Chart 2-1-8(A)), they numbered 160,000 in 2012. The universities and colleges sector accounted for the largest number of these researchers. The trend in that sector is upward. The smallest number of such researchers was found in the non-profit institutions sector, but that sector has fewer researchers than the other sectors do. While the shares of business enterprises and public organizations are also small, they are showing gradual increases when viewed over the long term.

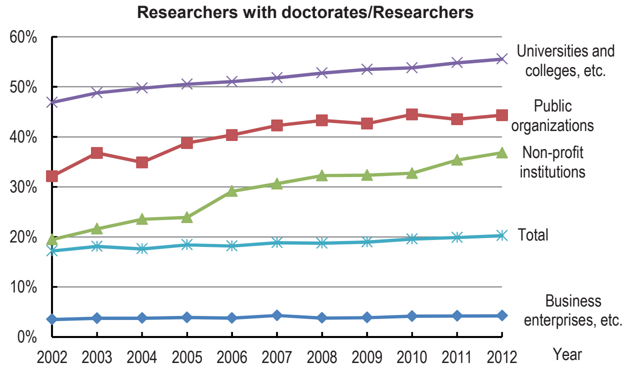
As for the percentage of researchers (not including current enrollees in doctoral courses) in each sector with doctoral degrees (Chart 2-1-8(B)), in 2012 the overall figure was 20.3%. By sector, the percentage was highest in the universities and colleges sector, at 55.5% in 2012. It was followed by the public organizations sector at 43.3%. The trend is rising in both sectors. The percentage of doctorate holders of non-profit institutions is also showing considerable growth. The business enterprises sector has the lowest percentage of researchers with doctorates, at just 4.2% in 2012. The trend is flat, with little change since 2002.

Chart 2-1-8: State of researchers with doctorates in each sector (HC)

(A) Changes in the number of doctorate holders



(B) Percentage of researchers who hold doctorates



Note: The universities and colleges sector includes "teachers" and "medical staff and others." It does not include "doctoral course students in graduate schools." It also excludes people engaged in research under external and non-regular conditions.
Sources: Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development.""

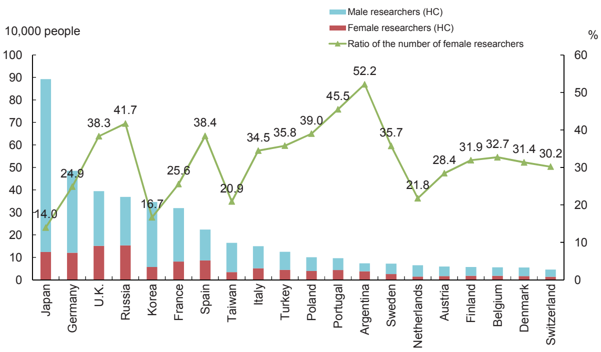
2.1.4 Female researchers in each country

In this section, the ratio of female researchers in each country is examined. The active role of female researchers is expected from the viewpoint of the diversity of researchers. Furthermore, promotion of the activities of female researchers has been one of basic policies of the Science and Technology Basic Plans since the first plan.

The ratio of the number of female researchers against the total was measured using HC values. No precise figures on the number of female researchers exist for the U.S. Figures for the U.K. are estimates by that country.

The ratio of the number of female researchers against the total in Japan was 14.0% in 2012. This ratio was the smallest among the surveyed countries, but the number place Japan third behind Russia and the U.K. (Chart 2-1-9).

Chart 2-1-9: Ratio of the number of female researchers against the total (comparison in HC values)



Note: 1) Data are from the following years: Japan: 2012; Germany, Sweden, the Netherlands, Austria, Belgium, and Denmark: 2009; Switzerland: 2008; all other countries and regions: 2010.
2) Values are on a head count basis.
3) Data for the U.S. and China are not included in materials below.
4) Data for the U.K. are national projections or estimated values.
5) Value for Russia is underestimated or based on underestimated data.
Source: <Japan> Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"
<Others> OECD, "Main Science and Technology Indicators 2012/2"

What exactly is the difference in the proportion of the number of female researchers by sector in each country? The female ratio against the total by sector was examined for selected countries where the data was available (Chart 2-1-10).

In each country, the ratio of female researchers was smallest in the business enterprises sector. The ratio was relatively large in the universities and colleges sector in each country.

In Japan, the number of female researchers in the universities and colleges sector accounted for the largest proportion of the total at 24.7% in 2012. The number of female researchers in the business enterprises sector was lowest, accounting for 7.6% of the total.

In Germany, data for the public organizations sector and for the non-profit institutions sector were combined. A look at 2009 values shows that the two sectors of universities and colleges and public organizations/non-profit institutions have large percentages of 34.7% and 32.4%, respectively.

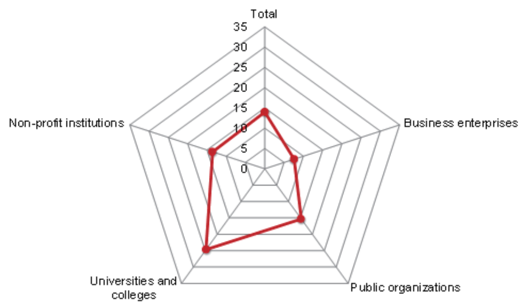
In France, the largest percentage belongs to the public organizations sector, which accounts for 34.8%, followed by the universities and colleges sector with 32.8%.

In the U.K., the largest percentage belongs to the universities and colleges sector, which accounts for 44.2%, followed by the non-profit institutions sector with 37.5%.

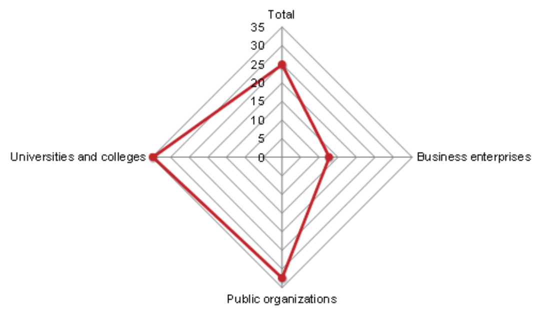
And in Korea, the non-profit institutions sector has the largest percentage with 33.9%, followed by the universities and colleges sector with 26.6%.

Chart 2-1-10: The ratio of the number of female researchers by sector for selected countries

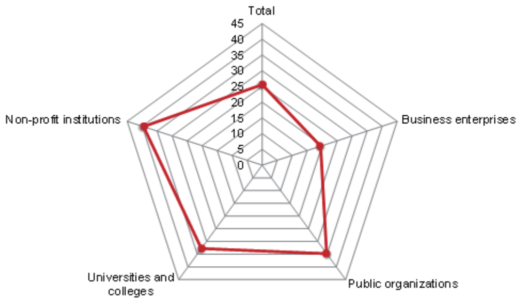
(A) Japan (2012)



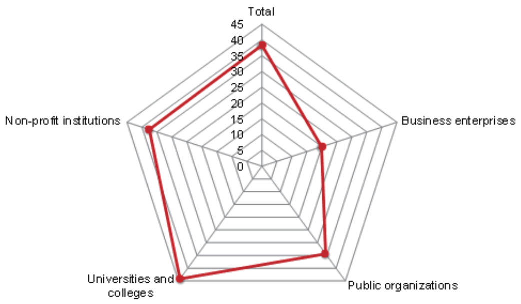
(B) Germany (2009)



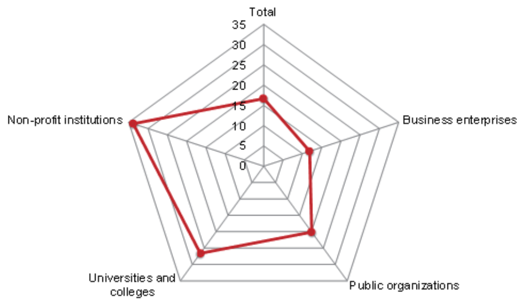
(C) France (2010)



(D) U.K. (2010)



(E) Korea (2010)

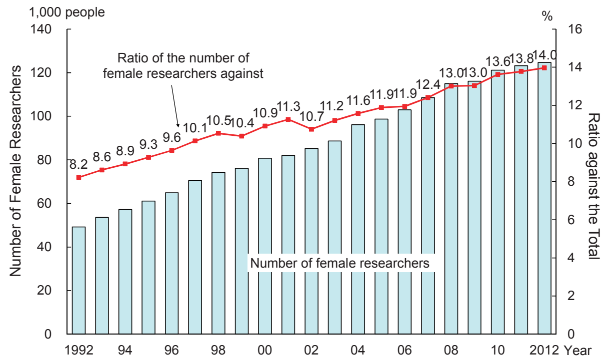


Note: Figures for France's public organizations sector do not include defense-related research.
Figures for the U.K.'s business enterprises sector are national projections or estimated values.
Sources: <Japan> Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"
<Other countries> OECD, "Main Science and Technology Indicators 2011/2"

Next, the number of female researchers in Japan and their ratio to the total number of researchers was examined (Chart 2-1-11). The number of female researchers as of 2012 was 124,686. This shows a fairly consistent growth trend. The same is true for percentage.

It is true that the number is not high compared to other countries; however, it can be predicted that the role of female researchers in Japan will advance with the development of knowledge-based society.

Chart 2-1-11: The number of female researchers and their ratio against the total number of researchers



Note: The ratios of the number of female researchers published in the "Report on the Survey of Research and Development" by the Ministry of Internal Affairs and Communications were used. The numbers of researchers until 2001 in this chart were obtained by measuring only regular researchers in the business enterprises sector and the non-profit institutions sector, and those including external non-regular researchers in the universities and colleges sector. The numbers of researchers by gender since 2002 were surveyed on head count basis.
Source: Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"

2.1.5 Mobility of researchers

Enhancing the mobility of researchers is considered to advance the use of the abilities of researchers, who are in charge of knowledge production, and simultaneously to develop a research environment with vitality in each workplace.

(1) Birthplaces of Doctoral degree holders in the U.S.

The number of foreign researchers can be considered an indicator of researcher mobility and internationalism. However, the number of foreign researchers is not calculated in the case of Japan. Likewise, in the U.S., although data are available on foreigners when looking at “scientists and engineers” as an occupational classification, no figures are available on “researchers” in the narrow sense. This section will therefore look at foreigners obtaining doctoral degrees in the U.S., a situation for which data exist.

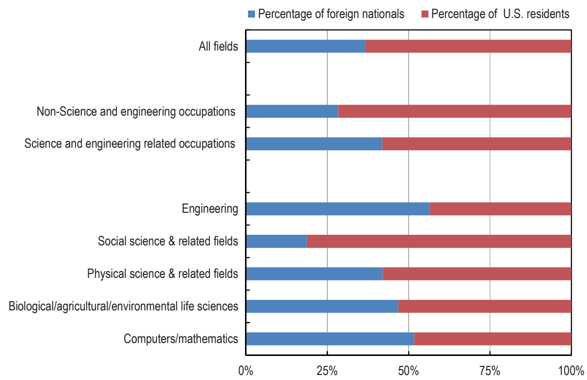
Of the 1.30 million people obtaining doctoral degrees in the U.S. in 2010, 470,000, 36.6%, were foreign nationals (Chart 2-1-12). The percentage was highest in science and engineering-related fields. Breaking those fields down further, engineering had the highest percentage at 56.5% among foreign nationals. The computers/mathematics field also has a high percentage with 51.7%.

Turning next to the countries and regions doctoral degree holders in the U.S. come from and the fields they are employed in (Chart 2-1-13), 28.2% of those employed come from outside the U.S. People from Asia are the most common, accounting for 18.7% of employment of holders of doctoral degrees.

Looking at individual occupational fields, that with the largest percentage of people from Asia is engineering with a 40.1% share. The computer and information scientist field also has a high percentage of people from Asia with 35.8%.

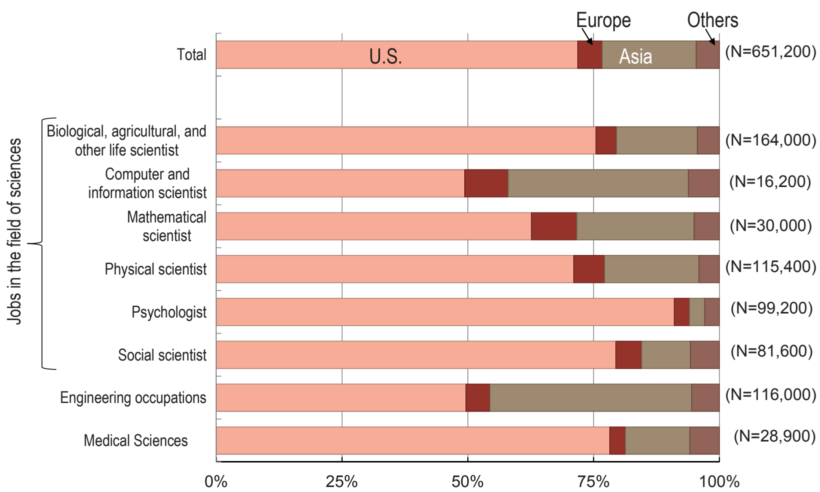
In the U.S., a large percentage of the people obtaining doctoral degrees in engineering and in computer science and mathematics are foreign nationals, and a large percentage is employed in the U.S.

Chart 2-1-12: Ratios of foreign-born doctoral degree recipients by specialized field of study (2010)



Sources: NSF, "SESTAT Public 2010" website.

Chart 2-1-13: Status of employment for doctoral degree holders by country or region of origin in each occupational field (2008)



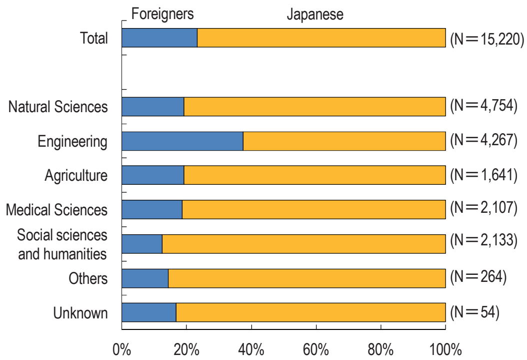
Note: “Kagaku kogaku” (科学工学) is a Japanese translation of “science and engineering.”
Source: NSF, “Characteristics of Doctoral Scientists and Engineers in the United States: 2008”

(2) Percentage of postdoctoral fellows who are foreign nationals

Next, the percentage of postdoctoral fellows who are foreign nationals is examined. Chart 2-1-14 shows the percentages of postdoctoral fellows in Japan's universities and colleges sector and public organizations sector who are foreign nationals. The fields discussed here refer to the primary research fields of the laboratories with which the postdoctoral fellows are affiliated.

The overall percentage of foreign nationals is 23.2%. By sector, engineering has the largest percentage at 37.5%, followed by the physical sciences and agriculture sectors at 19.1% each.

Chart 2-1-14: Employment status (percentage of foreign nationals) of postdoctoral fellows at Japanese universities and public organizations (as of November 2009)



Note: 1) "Postdoctoral fellow" as used here refers to a person with a doctoral degree hired for a fixed term who 1) is engaged in research work in a research institution at a university, etc., but who does not have the status of Professor, associate professor, assistant professor, lecturer, etc., or 2) is engaged in research work in a research institution in an independent administrative agency, etc., but who is not a team leader, senior research fellow, etc., of his or her research group. (This includes so-called ABDs who have obtained the required number of credits and conditionally withdrawn from school.)

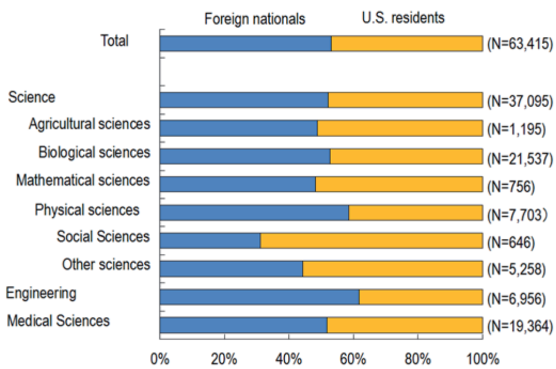
2) Research fields are the primary fields of the postdoctoral fellows' affiliated laboratories.

Source: NISTEP, "Survey on Postdoctoral Fellows Regarding Employment and Moving-out Situations: Complete Survey for Universities and Public Research Institutes in Japan (FY 2009 Data)" (Research Material No. 202)

Chart 2-1-15 shows the percentage of postdoctoral fellows in the U.S. who are foreign nationals (temporary visa holders). The fields here refer to the fields of the institutions with which the postdoctoral fellows are affiliated.

Overall, more than half of U.S. postdoctoral fellows, 53.1%, are foreign nationals. By sector, the highest percentage is in engineering at 61.8%, and the second highest is in physics at 58.5%.

Chart 2-1-15: Employment status (percentage of foreign nationals by field) of postdoctoral fellows at U.S. universities (2010)



Note: 1) "Foreign nationals" here refer to temporary visa holders. "U.S. residents" refers to U.S. citizens and permanent residents.

2) "Postdoctoral fellow" as used here refers to a person meeting both of the following qualifications.

(i) A person who has within the last five years received a PhD or equivalent (e.g., SCD [Doctor of Science] or Deng [Doctor of Engineering]), or a primary professional degree (MD [Doctor of Medicine], DDS [Doctor of Dental Science], DO [Doctor of Osteopathic Medicine/Osteopathy], or DVM [Doctor of Veterinary Medicine]), or a foreign degree equivalent to a U.S. doctoral degree.

(ii) A person who is generally employed for a period from five to seven years, mainly for training in a discipline and in research, and who works under a senior scholar in an assigned unit in an institution.

3) "Research field" refers to the fields of the postdoctoral fellows' affiliated organizations

Source: NSF-NIH Survey of Graduate Students and Postdoctorates in Science and Engineering, Fall 2010.

(3) Mobility of Japanese researchers between sectors

The status of new graduate employment(4) and entering(5) and exiting(6) a place of employment among Japanese researchers was examined (Chart 2-1-16(A)). The number of researchers hired in Japan in 2012 was 60,370. Of these, 25,935 were new graduate hires and 34,435 were mid-career recruits. The number of researchers who left their place of employment was 50,058. The number of new graduates employed reached its lowest level since calculations began after peaking in 2009.

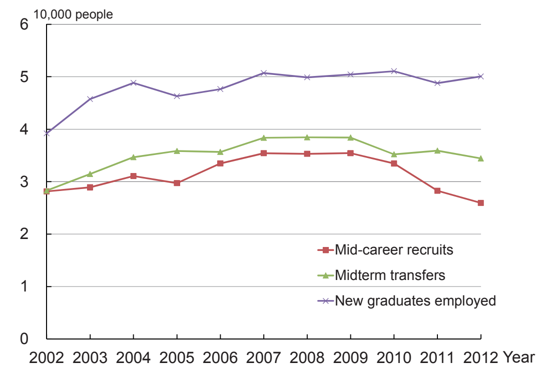
By sector, in the business enterprises sector new graduates employed have consistently outnumbered mid-career recruits. In recent years, however, the gap has been closing. The number of new graduates employed is continuing to fall since peaking in 2009. This number, which stood at 27,000 in 2009, fell to 18,000 in 2012.

In the non-profit institutions/public organizations sector, the numbers of mid-career recruits and midterm transfers is larger than that for new graduates employed. Over the long term, the number of midterm transfers has been falling since the mid-2000s, while that for mid-career recruits has been in a long-term decline.

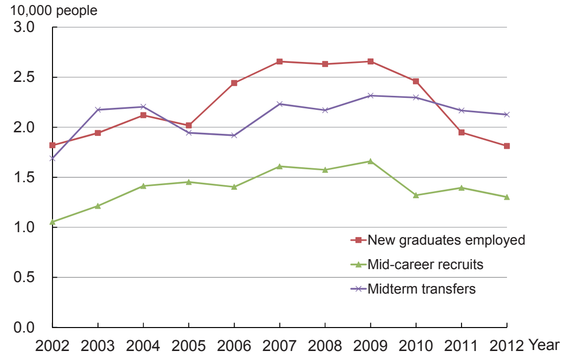
In the universities and colleges sector, the numbers of mid-career recruits and midterm transfers are larger than that for new graduates employed. The numbers of mid-career recruits and midterm transfers in the universities and colleges sector had been increasing until around 2008, but have been flat since then. However, the number for midterm transfers did show an increase in the most recent available year.

Chart 2-1-16: Numbers of new graduates employed and midterm recruits/transfers among researchers

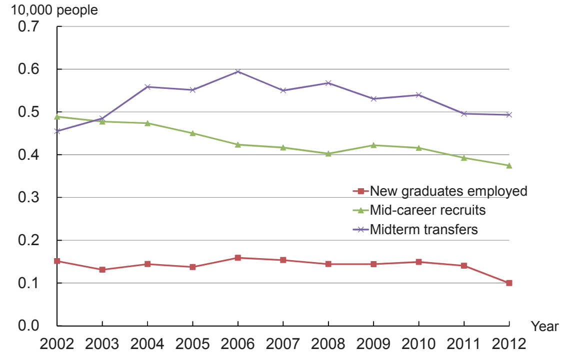
(A) Total



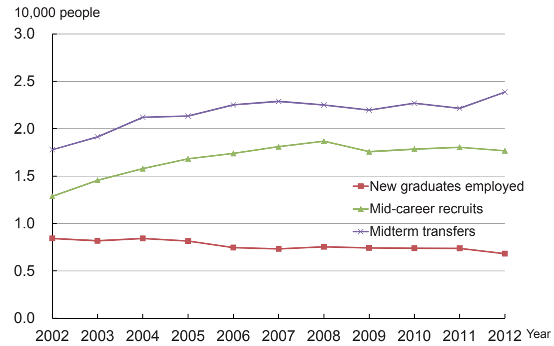
(B) Business enterprises



(C) Non-profit institutions/public organizations



(D) Universities and colleges



Sources: Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"

(4) New graduate employment refers to so-called new university graduates. Casual and part time workers are included only if they have completed school and have experience as temporary workers at universities or research institutes. Researchers hired for fixed terms are considered new graduate employees if the term is at least nine months.
(5) People coming from outside the organization (not including new graduate hires)
(6) People exiting employment in a workplace include retirees.

The sectors of origin of researchers who were mid-career recruits were examined by comparing data from 2002 with that from the most recent available year (Chart 2-1-17).

In 2012, a very large percentage, 94.3%, of researchers transferring in the business enterprises sector came from other business enterprises. Compared with 2002, this was a 3.5 percentage point increase. It should be noted that 41.5% transferred from parent enterprises, which marked an increase of 11.9 percentage points compared to 2002.

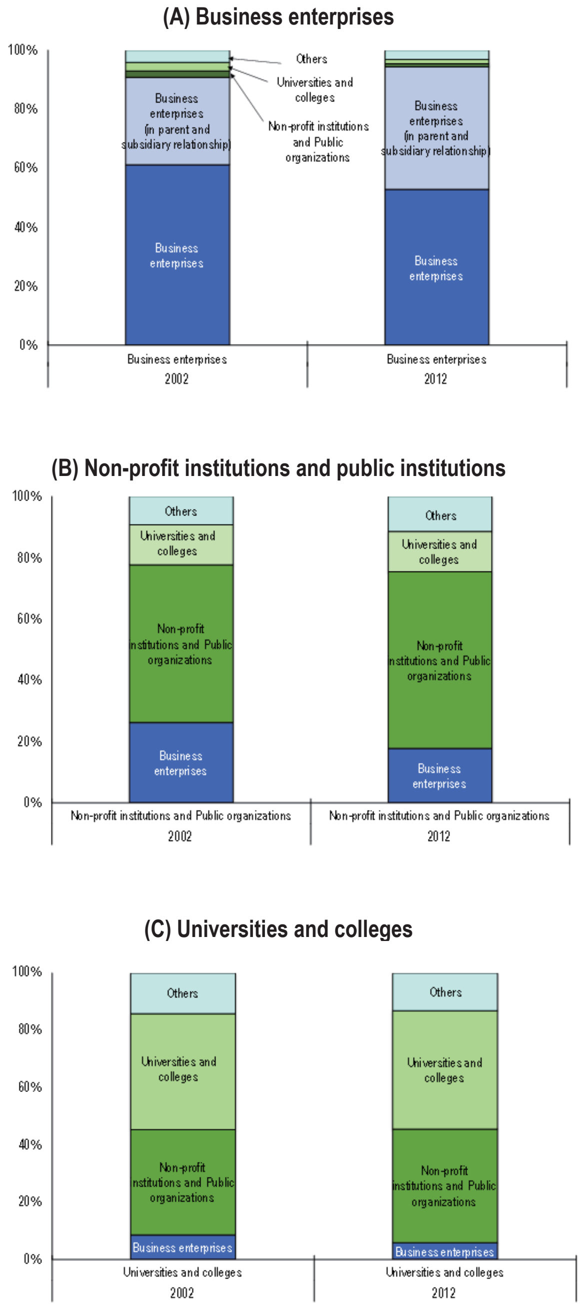
Movement between parent companies and subsidiaries is increasing. On the other hand, the number of mid-career researchers transferring from other sectors is decreasing.

In the non-profit institutions and public organizations sector, researchers transferring within the sector accounted for the largest percentage at 57.7%. Compared to 2002, this was an increase of 6.1 percentage points. On the other hand, the percentage of researchers transferring from business enterprises was 17.8%, which represents a decrease of 8.4 percentage points from 2002.

In the universities and colleges sector, 41.3% of researchers transferred from the same sector. However, many also transferred from other sectors, as 39.6% coming from the non-profit institutions/public organizations sector, a figure that is roughly equivalent to the percentage coming from the same sector. In the case of the universities and colleges sector, the percentage of researchers transferring from the non-profit institutions/public organizations sector is large and growing.

For the business enterprises sector and non-profit institutions/public organizations sector, the numbers of researchers transferring from other sectors is decreasing, while that for researchers transferring from the same sector is increasing. It would thus be difficult to assert that mobility among sectors is increasing.

Chart 2-1-17: Breakdown of mid-career researchers by sectors of origin



Sources: Ministry of Internal Affairs and Communications, “Report on the Survey of Research and Development”

2.2 Researchers by sector

Key points

○The number of researchers in Japan's public organizations in 2012 was 32,000. No significant changes over time are apparent. Looking at the numbers of researchers in public organizations in each country, the country with the most conspicuous growth is China, which posted a figure of 232,000 in the most recent available year. On the other hand, the U.K., which had 8,000 researchers in the most recent available year, is showing a decreasing or flat trend.

○Looking at numbers of researchers in the business enterprises sector, there were 491,000 researchers in Japan in 2012. In terms of trends, Japan and the U.S. had been showing continuous increases; however, both have leveled out in recent years. China has shown a sharp upward trend beginning in the 2000s. Korea has also shown an upward trend during the same period, and it surpassed the European countries in the most recent available year. Germany and France have shown upward trends when viewed over the long term, while the U.K. has remained flat.

○With regard to the proportion of the number of researchers by industry, the ratio of those in the manufacturing industry to the non-manufacturing industry in Japan was approximately 90% to 10%, and in the U.S. was approximately 60% to 40%. The trends of both countries are different in this way.

○Looking at percentages of researchers by specialized field of study in Japan's universities and colleges sector (i.e., by field of personal specialized knowledge), the most researchers having knowledge in "natural sciences," "engineering," and "agriculture" are in national universities, which account for 60 to 70% of the total. In engineering, the share of these universities is growing year by year. Many researchers having knowledge in social sciences and humanities and "others" are in private universities. In the case of medical sciences, the shares of national universities and private universities were roughly the same.

2.2.1 Researchers in the public organizations sector

(1) Researchers in public organizations in each country

Below is a summary of what "public organizations" in this section represent.

In Japan, "national" institutes (such as national testing and research institutes), "public" institutes (such as public testing and research institutes), and "special and public administrative corporations" (non-profit) are included.

In the U.S., research institutes run by the federal government are included.

In Germany, research institutes run by the federal government and local governments and other public research institutes, non-profit institutions (receiving 160,000 Euros or more as public funds) and the research institutes except for higher education institutions are included.

In France, types of research institutes such as scientific and technical research public establishment "Etablissement public a caractere scientifique et technologique" (EPST) (except for CNRS) and commercial and industrial research public establishment "Etablissement Public a Caractere Industriel et Commercial" (EPIC) are included.

In the U.K., research institutes run by the central government and decentralized governments and research councils are included.

In China, research institutes run by the central government are included. And in Korea, national and public research institutes, government supported research institutes and national and public hospitals are included.

It should be noted that the number of researchers in the public organizations sector may fluctuate widely due to the privatization of public organizations and changes in what is subject to measurement with R&D statistics. The number of researchers in public organizations is examined in light of differences in each country.

The number of researchers in Japan's public organizations in 2012 was 32,000. This number has not changed significantly over time.

The U.S. stopped publishing the number or researchers in 2002.

The Germany, France and the U.K., however, have shown remarkable fluctuation. The main reasons are considered to be the transfer of some public organizations into the business enterprises sector, the change in surveying methods for measuring the number of researchers, etc.

In the most recent available year, the number of researchers in Germany was 52,000. Germany's number has continued to grow since the mid-2000s.

The number of researchers in France has continued to grow when viewed over the long term.

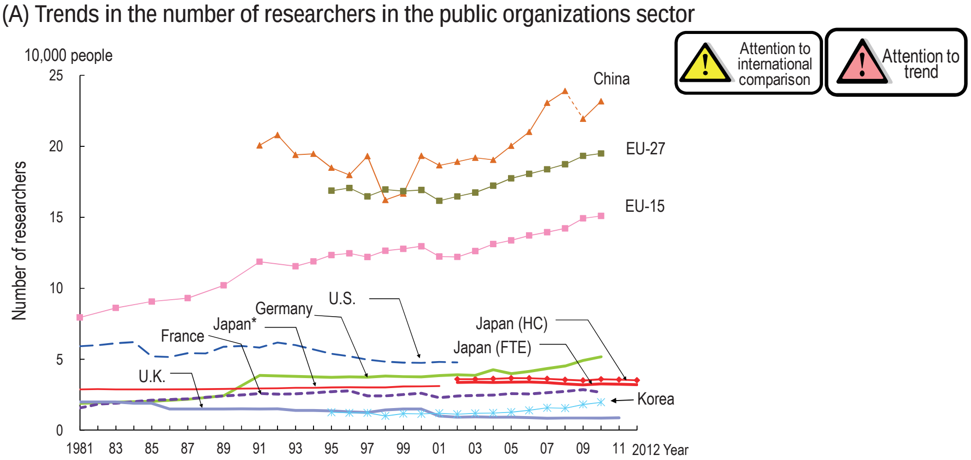
China began making calculations in accordance with definitions in the OECD's Frascati Manual in 2009. Consequently, its 2009 value was considerably lower than its 2008 value. However, China's value has continued to increase since then and reached 232,000 in the most recent available year.

Looking at per-capita numbers of researchers in the public organizations sector, Japan stood at 2.6. The country with the largest figure was Germany at 6.3. However, Germany's figure also includes its regional portion (state governments, etc.).

In the U.K., both the number of researchers and their ratio per 10,000 population are small (Chart 2-2-1 (A, B)).

Chart 2-2-1: Researchers in the public organizations sector in selected countries

(A) Trends in the number of researchers in the public organizations sector



(B) Number of researchers in the public organizations sector per 10,000-person population

(Unit: people)

Country (year)	
Japan (2011)	2.54
U.S. (2002)	1.66
Germany (2010)	6.33
France (2010)	4.12
U.K. (2011)	1.40
China (2010)	1.73
Korea (2010)	4.00

Note: 1) The definition and measurement method of researchers in the public organizations sector is different depending on country. Therefore it is necessary to be careful when international comparisons are being made. Refer to Chart 2-1-1 for the definition of researchers in each country.
2) Values for each country are FTE, except Japan (HC), which is HC.
3) Values include the number of researchers in social sciences and humanities (only in natural sciences and engineering in Korea through 2006).
<Japan> 1) National and public research institutes, special corporations and independent administrative corporations.
2) Refer to Chart 2-1-3 for researchers.
<U.S. > 1) The federal government only.
2) Out of "federal scientists and engineers", only researchers who are mainly in charge of "research" and "development" as their work have been measured since 1998.
3) A part of the Department of Defense has been excluded since 2003.
<Germany> 1) The federal government, non-profit institutions (organizations which receives 160,000 Euros or more as public funds), legally independent university research institutes and research institutes run by local governments (Equivalent of local governments).
2) Former West Germany and unified Germany until 1990 and since 1991 respectively.
3) Figures for 2010 are national projections or estimated values.
<France> 1) Scientific and technical research establishment "Etablissement public a caractere scientifique et technologique" (other than CNRS), commercial and industrial research public establishment "Etablissement public a caractere industriel et commercial", administrative research public establishment "Etablissement public a caractere administratif" (other than higher education institutions) and departments and agencies belonging to ministries.
2) Data continuity with the previous year is impaired for 1992, 1997 and 2000. Defense-related research is not included from 1997 on.
<U.K.> 1) The central government (U.K), decentralized governments (Scotland etc.) and research councils.
2) Continuity between values for 1981, 1986 (the U.K. Atomic Energy Authority was shifted to the business enterprise sector in 1985), 1991 to 1993, and 2001 (DERA (7) was shifted to the business enterprises sector in line with its dissolution in 2000) and data up to their previous fiscal years is impaired. Figures for 2010 are provisional.

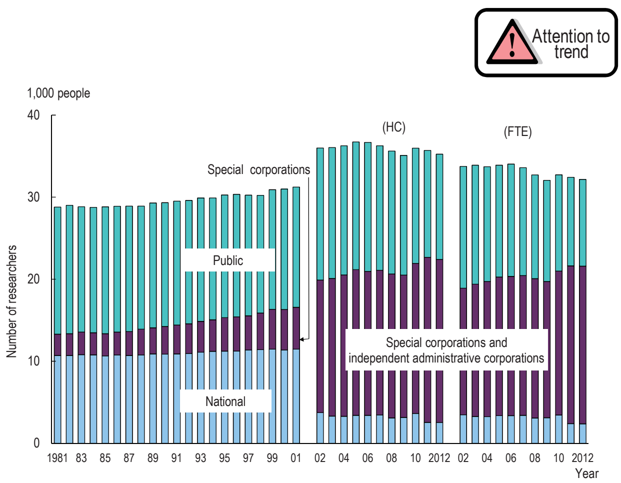
(7) the Defence Evaluation and Research Agency (DERA)

<China> 1) Research institutes run by the government.
2) Through 2008, the definition of researcher used was not in complete accordance with the OECD. The measurement method was changed in 2009. Caution is therefore necessary when observing changes over time.
<Korea> National and public research institutes, government supported research institutes and national and public hospitals.
<E.U.> 1) OECD Secretariat estimate/projection based on each country's materials. Figures for 2009 and 2010 are provisional.
2) Data continuity with the previous year is impaired for the E.U.-15 for 1991 and 1993 and for the EU-27 for 1997.
Source: <Japan> Ministry of Internal Affairs and Communications, “Report on the Survey of Research and Development”
<U.S.> NSF, “National Patterns of R&D Resources 1995, 1998, 2002 Data Update”; from 2000, OECD, “Main Science and Technology Indicators 2012/2”
<Germany> Bundesministerium für Bildung und Forschung, “Bundesbericht Forschung 1996, 2000, 2004”; “Forschung und Innovation in Deutschland 2007” “Bundesbericht Forschung und Innovation, 2008, 2010, 2012”; OECD, “Main Science and Technology Indicators 2012/2)” since 2010.
<France, U.K., China, Korea, and EU> OECD, “Main Science and Technology Indicators 2012/2”

(2) Researchers in the public organizations sector in Japan

It should be noted that in Japan's public organizations sector, part of the "national" research institutes turned into independent administrative corporations in 2001 (furthermore, part of the "special" corporations also turned into independent administrative corporations in 2003). As a result, data since 2002 has had no continuity with the previous data. Given this background, the number of Japan's researchers in the public organizations sector was 32,164 people in total in 2012. When examined by type of organization, the number of researchers in "special and independent administrative corporations" accounts for more than half of the total or 19,216 people, while that in "public" research institutes accounts for approximately 30% of the total or 10,583 people, and that in "national" research institutes accounts for slightly less than 10% of the total or 2,365 people. Since 2002, there has been a downward trend. The number of researchers in public institutions has particularly decreased (Chart 2-2-2).

Chart 2-2-2: Trend in the number of researchers in the public organizations sector in Japan



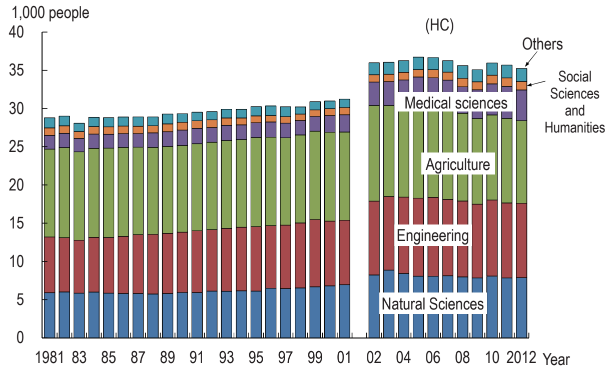
Note: 1) A part of national research institutes turned into independent administrative corporations in 2001. Therefore it is necessary to be careful when trends in time series are being examined.
2) Values for "special corporations and independent administrative corporations" until 2000 represent values for only "special corporations".
3) Because of changes to the content and timing of surveys, the number of regular researchers as of April 1 were used until 2000 and the number as of March 31 have been used since 2001.
Source: Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"

Next the number of researchers by specialty is examined. Specialty here represents a classification by specialized knowledge of individual researchers.

The number of researchers having specialized knowledge in "agriculture" has made up a large proportion consistently, although it is gradually decreasing. Among the types of organization to which they belong, "public research institutes" is at the top in terms of the number of researchers. The number of researchers in the field of "engineering" makes up the second largest proportion. For researchers in the field of "engineering" and "natural sciences", research institutes run by "special and independent administrative corporations" are the main workplaces. Many researchers in the field of "medical sciences" are affiliated with research institutes at special and public administrative corporations as well as at public research institutes (Chart 2-2-3).

Chart 2-2-3: Breakdown of researchers in the public organizations sector by specialty in Japan

(A) Trend in the number of researchers



(B) Affiliations of researchers by specialty (2012)

(Unit: People)

Field of research	Public organizations			
	Total	National	Public	Special Corporations and Independent Administrative Corporations
Natural Sciences	7,869	539	1,773	5,557
Engineering	9,723	798	2,139	6,786
Agriculture	10,833	205	6,195	4,433
Medical Sciences	4,007	538	1,325	2,144
Social Sciences ar	1,102	310	185	607
Others	1,700	143	1,197	360
Grand Total	35,234	2,533	12,814	19,887

Note: Same as for Chart 2-2-2. HC values have been used since 2002.
Source: Same as for Chart 2-2-2.

2.2.2 Researchers in the business enterprises sector

(1) Researchers in the business enterprises sector in each country

The number of researchers in the business enterprises sector is measured by statistical survey on R&D in every selected country. Therefore, the data for this sector is considered potentially more suitable for international comparison compared to that for other sectors. The same data, however, can show fluctuation over time. The fluctuation is influenced by the fact that, in each country, the methods and scopes of surveys change when they are adjusted to structural change in industries due to the sophistication of economic activities, and due to the revision of the standard classifications of industries.

The number of researchers in the business enterprises sector (FTE value) in Japan had been on a continually rising trend, but in recent years it has been flat. In 2012, there were 491,000 such researchers.

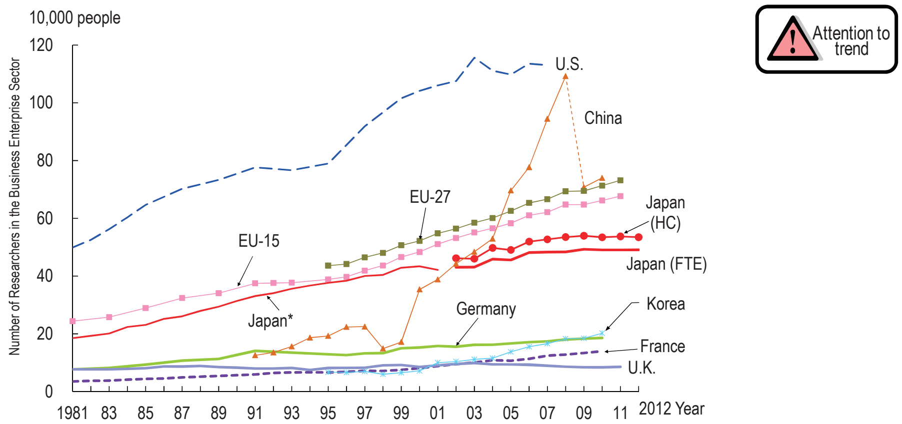
The U.S. experienced drastic growth from 1995 through 2003, but this growth subsequently flattened out.

In France and the U.K., some public organizations were privatized and transferred to the business enterprises sector, causing a corresponding increase in researchers. Although the effect is not large enough to cause a significant change in the chart, Germany and France show long-term rising trends. The trend in the U.K. is flat.

China showed rapid growth upon entering the 2000s. However, from 2009, China began making calculations in accordance with definitions in the OECD's Frascati Manual, and thus its values since then have been lower. Nonetheless, its value is growing again and reached 740,000 in 2010.

Korea has shown a long-term upward trend, and it surpassed the European countries in the most recent available year (Chart 2-2-4).

Chart 2-2-4: Trends in the number of researchers in the business enterprise sector in selected countries



Note: FTE values were used.

<Japan> 1) Values until 2001 represent the numbers of researchers measured on Apr.1and since 2002 represent the numbers of researchers measured on Mar.31 in corresponding year respectively.
2) Refer to Chart 2-1-3 for what the researchers represent.
3) The industrial classification adopted in the Survey of Research and Development was used based on Japan standard industry classification.
4) As industrial classification was revised, the classification adopted in the Survey of Research and Development was changed in its 1996, 2002 and 2008 versions.

<U.S.> 1) SIC were used until 1998 and NAICS has been used since 1999 as the industrial classification.
2) FFRDCs have been excluded since 2001.

<Germany> 1) West Germany until 1990 and unified Germany since 1991, respectively.
2) German Industrial classification, "Classification of Economic Activities", was revised in 1993 and 2003.
3) Figures for 2008 are national projections or estimated values. Figures for 2010 are provisional.

<France> 1) Classification under the scope of surveys was changed in 1991 and 1992 (France Télécom and GIAT Industries was moved from the government sector to the business enterprises sector).
2) The survey method on research personnel in the administration sector was changed in 1997.
3) French industrial classification, "Nomenclature d'activités française ", was revised in 2001 and 2005.
4) Data continuity with the previous year is impaired for 2000 and 2005.

<U.K..> 1) Classification under the scope of surveys was changed during 1985 and 1986, and in 2000 ("United Kingdom Atomic Energy Authority" was transferred from the government sector to the business enterprises sector during 1985 and 1986).
2) The Defence Evaluation and Research Agency (DERA) stopped operating in 2000. Three-quarters of it was turned into limited private companies and were transferred to the business enterprises sector.
3) Classification of research institutes was re-classified during 1991 and 1992.
4) British industrial classification, "UK Standard Industrial Classification of Economic Activities", was revised in 1980, 1992, 1997, 2003 and 2007.
5) Figures for 2010 are provisional

<China> 1) Through 2008, the definition of researcher used was not in complete accordance with the OECD.
2) Until 1999, figures were underestimated, or based on underestimated data.

Source: <Japan> Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"
<U.S.> NSF, "National Patterns of R&D Resources 1995, 1998, 2002 Data Update"; from 2000,OECD, "Main Science and Technology Indicators 2012/2"
<Germany> Bundesministerium für Bildung und Forschung, "Bundesbericht Forschung 1996, 2000, 2004"; "Forschung und Innovation in Deutschland 2007" "Bundesbericht Forschung und Innovation, 2008, 2010, 2012"; OECD, "Main Science and Technology Indicators 2012/2)" since 2010.
<France, U.K., China, Korea, and EU> OECD, "Main Science and Technology Indicators 2012/2"

(2) Researchers by industry in each country

Chart 2-2-5 shows the number of researchers by industry in various countries. Industrial classification in this section represents what each country established for the statistical survey of R&D in the business enterprises sector referring to standard industrial classifications. Standard industrial classifications in each country are mostly established consistent with ISIC (International Standard Industry Classifications). However, some discrepancies inevitably exist depending on the country.

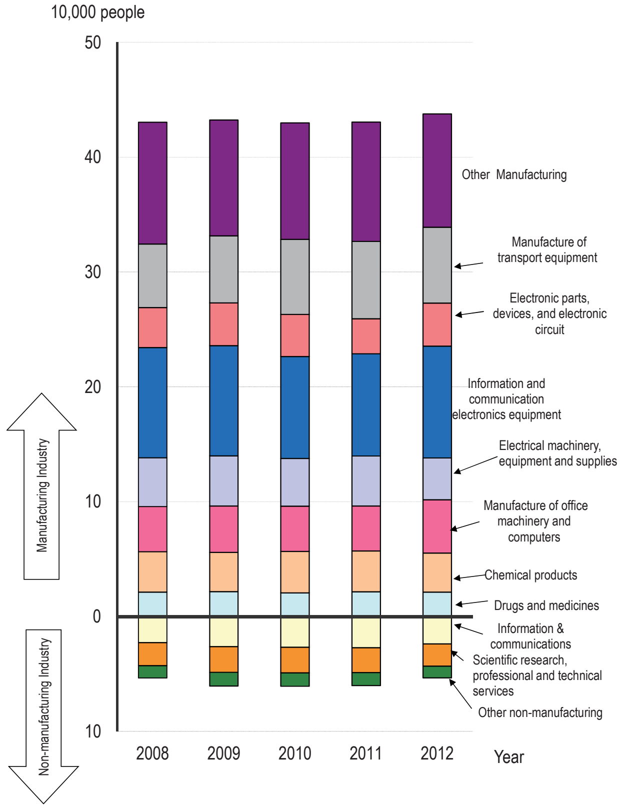
Given the background mentioned above, by examining the number of researchers by industry in Japan, the U.S., and Germany, it was found that the number of researchers in the manufacturing industry accounted for a considerably large ratio in Japan. This means that the increase in the number of total researchers was probably greatly influenced by the manufacturing industry. In terms of individual industrial classifications, the classification with the largest number is information and communication electronics equipment, followed by transport equipment. Although no significant changes over time are apparent, the most recent available data show an increase in manufacturing industry and a decrease in non-manufacturing industry.

In the U.S., the number of researchers in non-manufacturing industry is large. "Specialized, scientific and technical services" account for a large share of this. As for manufacturing industry, the number is large in computers and electronic products.

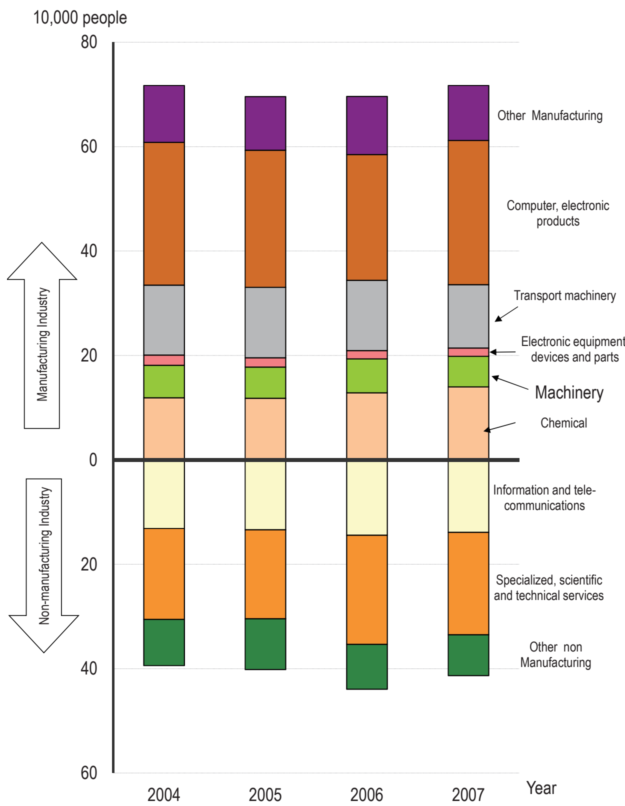
In Germany, the number of researchers in manufacturing industry is level while that for non-manufacturing industry is increasing. In manufacturing industry, transport equipment has a large number, followed by office machinery and computers, electrical machinery, precision and optical instruments. In non-manufacturing industry, specialized S&T activities have a large and growing number. The same is true for information and communications.

Chart 2-2-5: Number of researchers by industry in each country

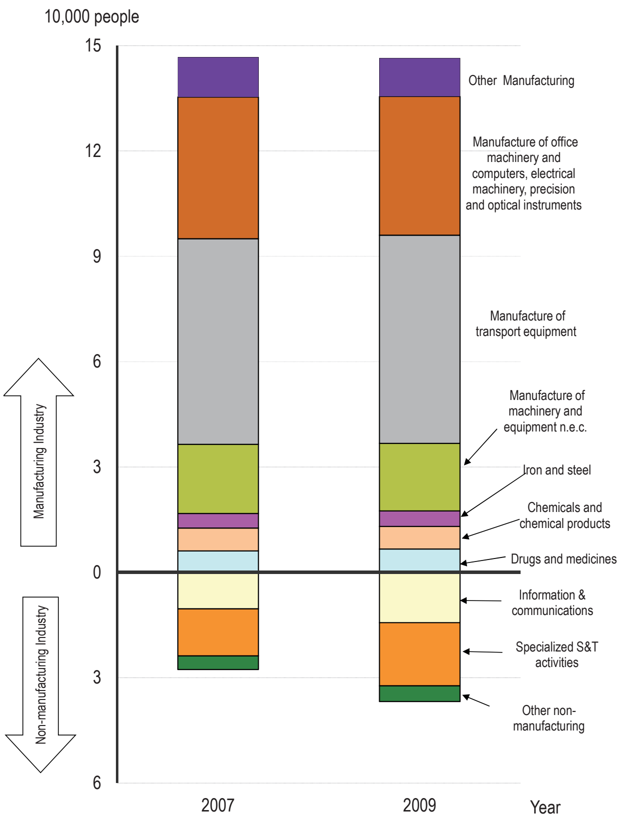
(A) Japan



(B) U.S.



(C) Germany

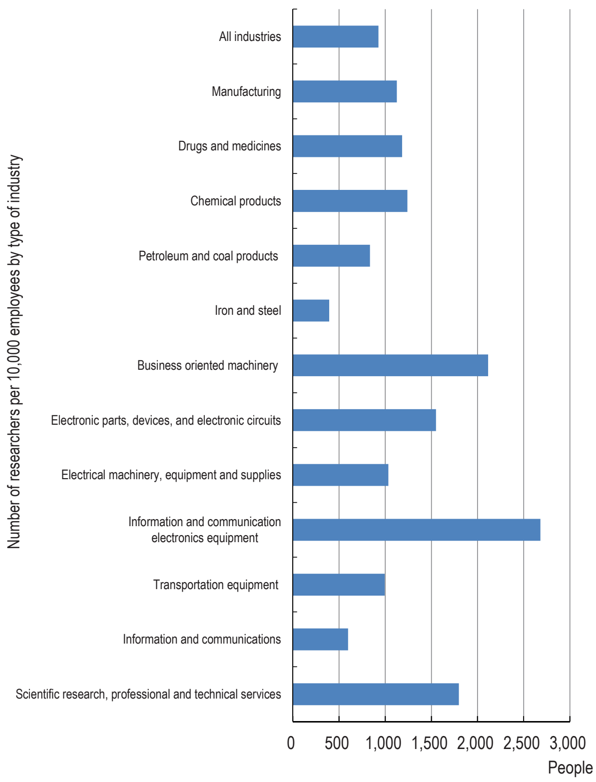


Note: Same as for Chart 2-2-4.
Source: <Japan> Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"
<U.S.> NSF, "Industrial R&D for each year" Industrial R&D Information System
<Germany> BMBF, "Research and Innovation in Germany 2007", "Bundesbericht Forschung und Innovation 2008, 2010"

(3) Density of the number of researchers against the total number of employees by industry for Japan

The number of researchers per 10,000 employees (whether or not researchers) was examined in some types of industries picked up in order to understand which types of industries and enterprises employ researchers in Japan (Chart 2-2-6). In 2012, the industry with the largest number was "information and communication electronics equipment" with 2,681. Next was "business-oriented machinery" with 2,114. "Scientific research, professional and technical services," which is a non-manufacturing industrial sector, also had a large number with 1,799. It should be noted that the manufacturing industry of "information and communication electronics equipment" includes the manufacturing industries of telecommunication machinery and equipment, audio and video equipment, electronic computer, etc. The industry of "scientific research, professional and technical services" includes categories such as natural science research institutes and other academic institutions.

Chart 2-2-6: Number of researchers per 10,000 employees by type of industry in Japan (2012)



Source: Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"

2.2.3 Researchers in the universities and colleges sector

(1) Researchers in the universities and colleges sector in each country

International comparison of the number of researchers is difficult in the universities and colleges sector. The details were described in 2.1.1., and the main points which should be noted are restated below.

(1) Differences in the method of survey: Some countries use existing data such as statistics on education (statistics measuring teaching staff and students) and on the status of occupations and academic degrees without conducting statistical surveys on R&D. (2) Differences in measurement methods: In cases where statistical surveys on R&D are conducted, it is possible to measure the number of researchers on an FTE basis based on questionnaires. However, in cases where the FTE values are measured in accordance with statistics on education etc., the values need to be obtained by multiplying full time equivalent coefficients. Japan is special because it conducts statistical surveys on R&D but does not obtain FTE values in these surveys. (3) Differences in the coverage of surveys: Doctoral degree holders included in researchers in the universities and colleges sector are treated differently in surveys depending on country. For instance, whether or not they receive financial assistance and whether or not full time equivalent coefficients are multiplied depends on each country. As for S&T indicators, Japan's Ministry of Education, Culture, Sports, Science and Technology carried out surveys in 2002 and 2008 in order to measure the FTE number of researchers in Japan's universities and colleges sector by finding an FTE coefficient. The value obtained using that FTE coefficient is used as the FTE number of researchers (see Chart 2-1-2). Data continuity between 2007 and 2008 is therefore impaired.

Given the above, trends over time by country are examined. In Japan, the number of researchers in the universities and colleges sector was approximately 125,000 people in 2012, a slight increase from 2008.

The number of researchers in universities and colleges of the U.S. has not been announced since 2000.

In Germany, slight increases have continued, with no major change other than the influence of the 1991 reunification of East and West Germany; however, an upward trend has been apparent in recent years.

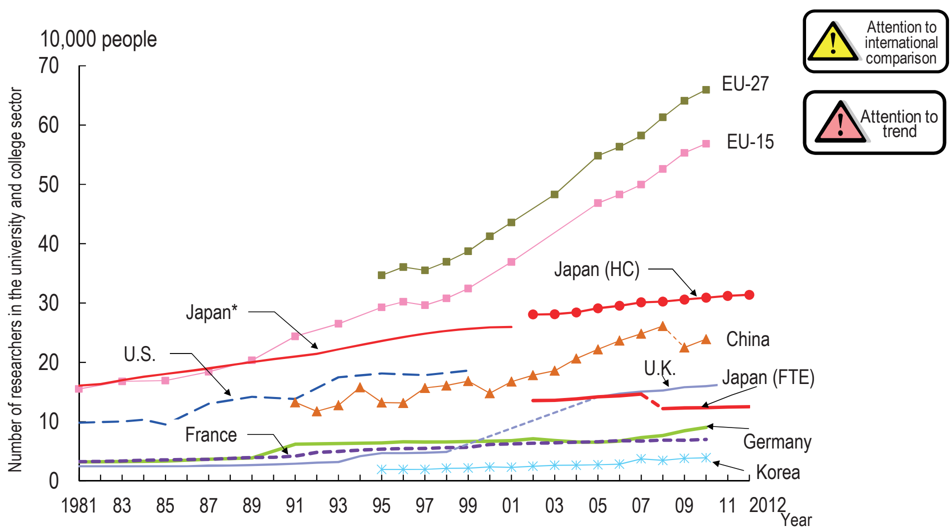
In France, the number of researchers has been consistently on the rise.

In the U.K., the number of researchers surged during 1993 and 1994. However, this is considered the result of a change in the coverage of surveys due to reform of higher education institutions (the integration of universities and former polytechnics). There are no data for the U.K. for 1999 through 2004, and values from 2005 on are estimated.

The number of researchers in China has been growing rapidly since 2000. It should be noted that China began making calculations in accordance with definitions in the OECD's Frascati Manual in 2009, and thus its values since then have been considerably lower.

In Korea, the number of researchers is rising, although there is still a gap with the other countries (Chart 2-2-7).

Chart 2-2-7: Trends in the number of researchers in the universities and colleges sector for selected countries



Note: 1) The definition and measurement method of researchers in the universities and colleges sector is different depending on the country. Therefore it is necessary to be careful when international comparisons are being made. Refer to Chart 2-1-1 for the differences in researchers in each country.
2) Values for each country are FTE, except Japan (HC), which is HC.
3) Values are the total of that in the field of the natural sciences and engineering and the field of social sciences and humanities (only natural sciences and engineering were included in Korea through 2006).
<Japan> 1) Faculties in universities (including graduate school courses), junior colleges, university research institutes. etc.
2) Refer to Chart 2-1-3 for researchers.
<U.S.> University & Colleges
<Germany> 1) Universities ,Comprehensive universities, Colleges of education, Colleges of theology, Colleges of art, Universities of applied sciences, Colleges of public administration
2) Former West Germany until 1990 and united Germany since 1991. respectively.
3) For 2010, estimated values have been corrected by the Secretariat to accord with national estimates and, where necessary, with OECD standards.
<France> 1) French National Centre for Scientific Research (CNRS), Grandes Ecoles (other than those under the jurisdiction of the Ministry of National Education (MEN)), higher education institutions.
2) Data continuity with the previous year is impaired for 1997 and 2000.
<U.K.> 1) Data continuity with the previous year is impaired for 1994 and 2005.
2) For 2005‐2008, estimated values have been corrected by the Secretariat to accord with national estimates and, where necessary, with OECD standards.
<China> Through 2008, the definition of researcher used was not in complete accordance with the OECD. The measurement method was changed in 2009. Caution is therefore necessary when observing changes over time.
<Korea> All university and college majors (extension campuses and local campuses are included), university research institutes, university hospitals (only for the case that a medical university and its accounting department are integrated).

Source: <Japan> Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"; MEXT, “Survey on the data for full-time equivalents in universities and colleges” (2002 and 2008)
<U.S.> NSF, “National Patterns of R&D Resources 1995, 1998, 2002 Data Update”
<Germany> Bundesministerium für Bildung und Forschung, “Bundesbericht Forschung 1996, 2000, 2004”; “Forschung und Innovation in Deutschland 2007” “Bundesbericht Forschung und Innovation, 2008, 2010 ,2012”; OECD, “Main Science and Technology Indicators 2012/2)” since 2010.
<France, U.K., China, Korea, and EU> OECD, “Main Science and Technology Indicators 2012/2”

Column: R&D personnel in U.S. universities

In November 2012, the National Science Foundation (NSF) announced data on R&D personnel in universities and colleges for the first time in many years.

Data on R&D personnel in U.S. universities appearing in NSF reports were limited to numbers of researchers up to 1999 (see Chart 2-2-7).

The definition of “researcher” and method for measuring their numbers are 1) scientists and engineers having a doctoral degree and 2) persons obtained by adding a 50% of Doctral course students who are given financial assistance. Because this figure represents a condition that is stricter than that used in the definition of “researcher” in the Frascati Manual, the U.S. tends to have fewer researchers when compared to other countries, including Japan.

In the data on “all R&D personnel” that were recently announced by the NSF, R&D personnel are measured in the following manner (Chart 2-2-8):

1) R&D personnel: Principal investigators and other personnel who are receiving a salary or other remuneration pertaining to R&D (HC: head count). Also includes students who receive compensation from a financial source for R&D, regardless of whether or not it is monetary.

2) Principal investigator: A person who is designated by his or her institution to supervise an R&D plan or program and who has responsibility for a project’s scientific and technical orientation.

3) Postdoc: A researcher working for a fixed term of 5 to 7 years who received his or her doctoral decree within the past 5 years.

These data come from the Higher Education Research and Development Survey (HERD Survey. This survey is the successor of the “Survey of Research and Development Expenditures at Universities and Colleges.” It has collected more detailed information since 2011.

Data on R&D personnel in the U.S.’s HERD Survey cover 741 universities and colleges. Of these, 84.1% provided responses on R&D personnel. The other relevant items of the survey also received answers exceeding 80%. Thus, the data cover approximately 80% of the R&D personnel (head count) in U.S. universities and colleges. The data do not include totals for all universities and colleges in the U.S., and thus Chart 2-2-8 provides figures that were calculated by the author. The chart shows that R&D personnel in U.S. universities and colleges number 770,000 people, of which approximately 130,000 are principal investigators and 50,000 are postdocs.

Chart 2-2-8: Breakdown of all R&D personnel in the U.S. (2010)

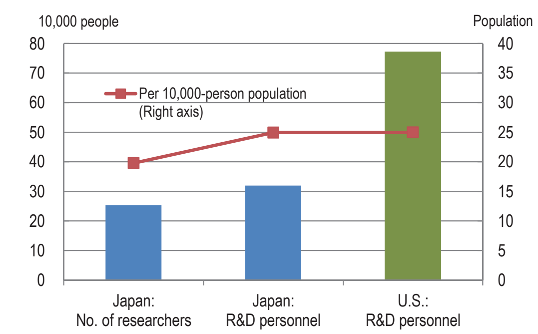
No. of targeted institutions	All R&D personnel			
741	Total	Principal investigators	Other personnel	Postdocs
All universities/colleges (people)	772,329	132,457	639,220	53,233
Response rate	84.1%	85.2%	84.1%	81.8%

Source: NSF, “ Higher Education Research and Development”

The following presents a comparison with Japan in order to show the scale of R&D personnel in U.S. universities and colleges. Data on Japan’s R&D personnel come from “R&D Personnel” in the “Survey of Research and Development.” Presented are the totals of “researchers,” “research assistants,” “technical staff,” and “administrators & others.” All receive salaries pertaining to R&D, and these salaries are calculated as personnel expenses within intramural R&D expenditure. Thus, it is believed that these totals are comparable with item 1) “research personnel” in R&D personnel data for the U.S. The number of researchers for Japan (HC) is also presented for reference purposes.

As can be seen in Chart 2-2-9, the U.S. has a larger number of R&D personnel; however, when viewed in terms of number per 10,000-person population, Japan and the U.S. are roughly equal.

Chart 2-2-9: U.S.-Japan comparison of R&D personnel in universities and colleges (2010)



Note: Universities and colleges of Japan do not include departments (including graduate schools, etc), junior colleges, technical colleges, etc.)
Sources: Japan: MIC, “Report on the Survey of Research and Development”
U.S.: NSF, “ Higher Education Research and Development”

(Yumiko Kanda)

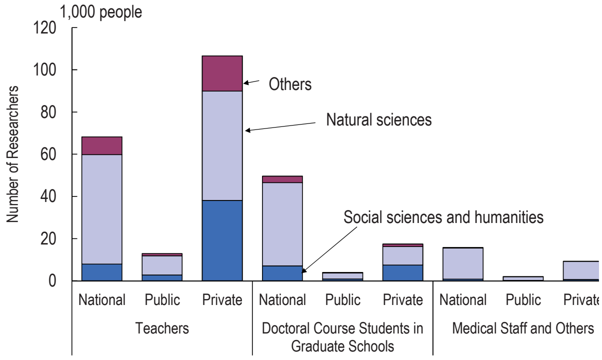
(2) Researchers in the universities and colleges sector in Japan

Chart 2-2-10 shows the number of researchers in the universities and colleges sector in Japan by type of researcher, by type of organization, and by academic field of study in Japan. The number of researchers in the universities and colleges sector in this section represents the number of "regular researchers" as stated in the "Report on the Survey of Research and Development", which does not cover external non-regular researchers.

This number was 285,800 people on March 31, 2011, and 65.7% of those or 187,730 people are teachers. The number of researchers in the universities and colleges sector includes "doctoral course students in graduate schools (70,991 people)" and "medical staff and others (27,079 people)". In these statistics, almost all the teachers in universities are measured as researchers(8).

Overall, teachers are most common at private universities, while doctoral course students in graduate schools are most common at national universities. Breaking down researchers at national universities by field, natural sciences is the most common field. This is also true of doctoral course students in graduate schools. At private universities, on the other hand, although natural sciences is the most common field, the humanities and social sciences field is also large, with little difference between the two.

Chart 2-2-10: Breakdown of the number of researchers in the universities and colleges sector in Japan (2012)



Note: Values are for universities and graduate schools
Source: Ministry of Internal Affairs and Communications "Report on the Survey of Research and Development"

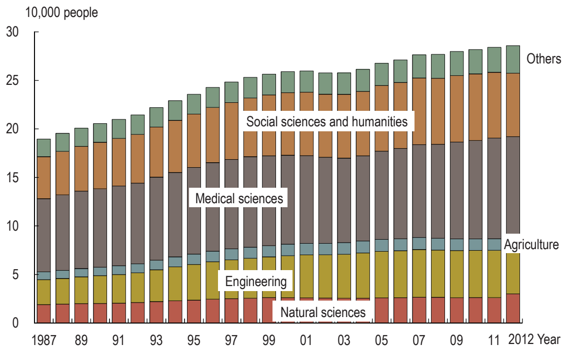
Next, the trend in the number of researchers by specialized field of study was shown (Chart 2-2-11(A)).

Here, "specialized field of study" means "by field of personal specialized knowledge" (however, priority is placed on a description of current duties when classification is difficult).

The total number of researchers is increasing, and researchers in the field of "medical sciences" and the field of "social sciences and humanities" account for the main elements of the entire structure.

Chart 2-2-11: Researchers in universities and colleges of Japan

(A) Trend in the number of researchers by specialized field of study



(8) According to the statistics on universities and colleges (MEXT, "Report on School Basic Survey" 2012 version), as of May 1, 2012, the number of regular teachers in faculties of universities combined with graduate schools was 177,570 , in junior colleges was 8,916, and in technical colleges was 4,337, respectively, totaling 190,823.

Furthermore, the proportion of researchers by type of university in each specialized field is examined.

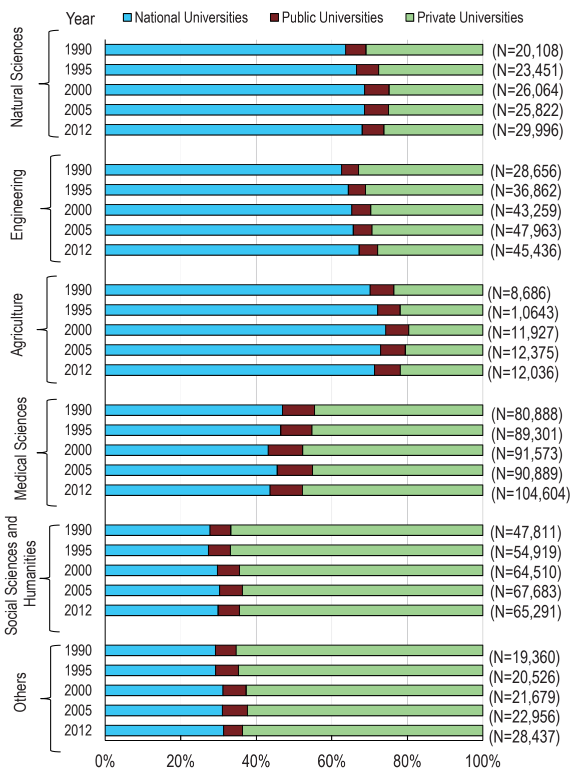
Chart 2-2-11(B) shows the proportion of the number of researchers by type of university, in other words, national, public and private universities, after classifying them by the field of their personal specialized knowledge.

The number of researchers in "national universities" accounts for large proportion, 60 to 70% of the number of researchers with knowledge in the field of "natural sciences", "engineering" and "agriculture". With regard to the field of "engineering", the proportion is increasing. The number of researchers in "private universities" accounts for a large proportion of the number of researchers with knowledge in the field of "social sciences and humanities" and "others". Researchers in "medical sciences" have been about equally common at "national universities" and "private universities", although in 2000 and 2012 there were more at private universities.

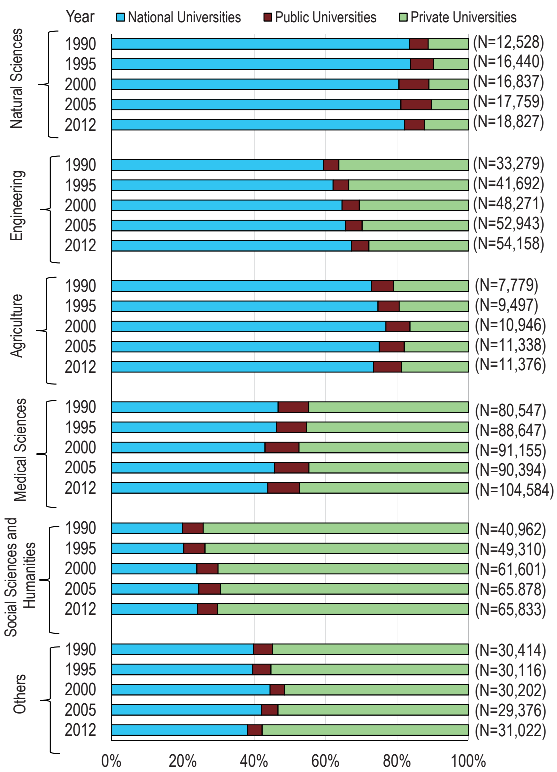
Next, the proportion of researchers by type of university in each field of affiliation (academic field) is examined (Chart 2-2-11 (C)). This proportion is almost the same as in the case for each specialized field of study (Chart 2-2-11 (B)). But the number of researchers in "national universities" accounts for a substantial 80% or more of those whose affiliation is in the field of "natural sciences", while the proportion in "private universities" accounts for only approximately 10% of the same.

The fact of the matter is that the number of researchers in "private universities" accounts for 20% to 30% of the number of researchers whose personal specialized field is "natural sciences". But only approximately 10% of researchers in "private universities" have affiliations related to "natural sciences". This means that researchers who have specialized knowledge in "natural sciences" in "private universities" do not necessarily have affiliations related to "natural sciences".

(B) Proportion of researchers by type of university (national, public and private) in each personal specialized field of study



(C) Proportion of the number of researchers by type of university (national, public and private) in each academic field of affiliation



Source: Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"

(3) Greater diversity in alma maters of university teachers

In Japan, traditionally many teachers currently working for a university graduated from the same university. Therefore the diversification of teachers' alma maters is a policy objective.

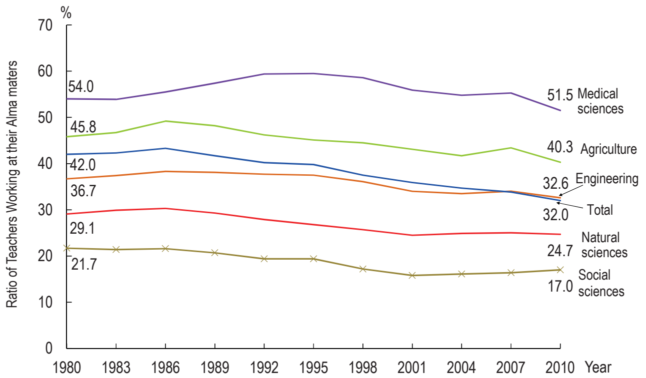
The average ratio of university teachers working at their alma mater in FY 2010 was 32.6% against the total, but is decreasing in the long term. By field of study, the medical sciences field has the largest proportion of teachers working at their alma maters, approximately 50%. The smallest proportion of teachers working at their alma maters is in the social sciences at around 20%.

Over the long term, there has been a declining trend in every field, indicating a decrease in teachers working at their alma maters (Chart 2-2-12 (A)).

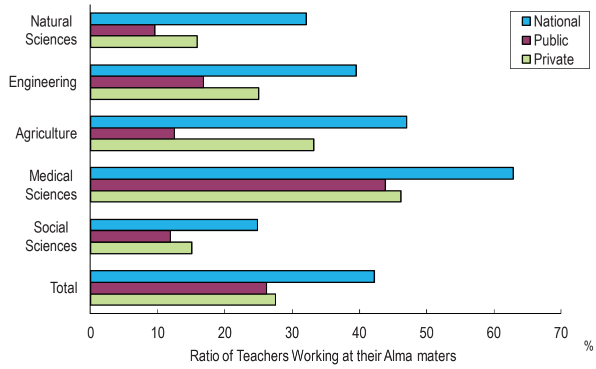
Examined by type of university, the ratio of university teachers working at their alma maters against the total was large in national universities and small in public universities in every specialized field of study. And when examined by field of study, the number of university teachers working at their alma maters accounts for especially large proportion in "medical sciences" in all types of, or national, public and private universities. In the natural sciences, on the other hand, the ratio for such teachers was much higher at national universities. It was only half as high at private universities and a quarter as high at public universities (Chart 2-2-12 (B)).

Chart 2-2-12: Ratio of university teachers working at their alma maters

(A) Trend of ratio by specialized field of affiliated university



(B) Ratios by type of university (FY 2010)



Note: The field of "Medical Sciences" includes Medicine.
Resource: MEXT, "Statistical Survey on School Teachers"

2.3 Research assistants

Key Points

○With regard to the number of research assistants per researcher by sector, the number of research assistants in the universities and colleges sector is smaller than in other sectors in Japan, Germany, France, the U.K. and China. The number of research assistants in the universities and colleges sector is large in Korea. Over time, growth has been flat or has declined in almost all the countries, but it has been increasing in Korea since 2000.

○Looking at a breakdown of Japan's universities and colleges sector, administrators and others began to increase in the early 2000s, while research assistants began increasing from the mid-2000s.

○The number of research assistants per researcher in Japan's universities and colleges sector has remained relatively unchanged.

○Among national, public and private universities in Japan, the number of research assistants per researcher is highest at national universities. Looking at trends by field of study, the number has particularly increased since 2000 in the fields of natural sciences and agriculture.

2.3.1 Status of research assistants in each country

Research assistants tend to be recognized as being peripheral despite the fact that they are important participants in R&D. However, both researchers and research assistants play important roles in modern R&D as it becomes more complicated and larger in scale.

Each country has its own statistics on the number of research-related human resources including research assistants, but each of the statistics is different, as in the case of the number of researchers. But, "Technical and equivalent staff[9]" and "Other supporting staff[10]" according to the definition of "Frascati Manual" compiled by the OECD correspond to so called research assistants.

Chart 2-3-1 shows the names of elements which comprise "research assistants". For Japan, France and Korea, the terms found in the questionnaire for the statistical survey of R&D was used. For Germany, the terms in R&D documents were used. For the U.K. and China, the terms in documents compiled by the OECD were used. There was no data for research assistants in the U.S.

Chart 2-3-2 shows the number of research assistants per researcher (hereinafter referred to as "number of research assistants") by sector.

Looking at Japan's most recent available year, the number of research assistants in public organizations is high at 1, while in the universities and colleges sector the number is low at 0.2. Over time, the number of research assistants in non-profit institutions has been increasing. Other sectors have stayed flat, while the business enterprises sector is showing a downward trend.

In the most recent available year for Germany, the number of research assistants was 0.8 in the business enterprises, public organizations and non-profit institutions sectors. This was higher than the 0.3 for the universities and colleges sector. Over time, the number has been decreasing in each sector.

In the most recent available year for France, the number of research assistants in the public organizations sectors was 0.9, while that for the non-profit institutions sector was 1.0. It was 0.7 in the business enterprises sector and 0.5 in the universities and colleges sector. Over time, the number has been flat in the universities and colleges sector and has declined sharply in the other sectors.

For the U.K., there are no data for non-profit institutions and universities from 1994 through 2004. The U.K. began announcing estimated figures for universities in 2005. The continuity of data from before 1994 and from 2005 on is therefore impaired. During the most recent available year, the number of

(9) Technical staff and their equivalent are people who are required to have technical knowledge and experience in one or more fields of study from among engineering, physics and life sciences, social sciences and humanities. They participate in R&D by accomplishing scientific and technical duties related to the application of concepts and practical methods usually under the guidance of researchers. The equivalent staffs accomplish duties related to R&D under the guidance for research in the field of social sciences and humanities.

(10) Other supporting staffs include skilled and unskilled craftsmen, secre-taries and clerical staff who participate in R&D projects or are related to those projects.

research assistants was high in the public organizations sector and low in the universities and colleges sector.

China began counting researchers in accordance with OECD standards in 2009, so their number has decreased. Consequently, the number of research assistants increased dramatically in 2009.

In the most recent available year for Korea, the number of research assistants was large in the universities and colleges sector at 0.9 and small in the business enterprises sector at 0.1. This is the opposite of the situation in the other countries. Moreover, the number of research assistants in the universities and colleges sector has been increasing over time, which also differs from what is happening in the other countries.

Chart 2-3-1: Research assistants by sector in each country

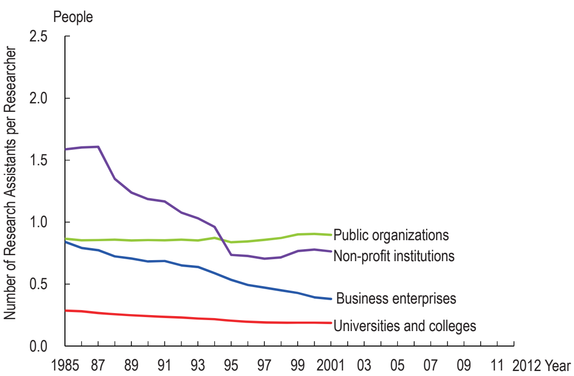
Country	Business Enterprises	Universities and Colleges	Public Organizations	Non-profit Institutions
Japan	(1) Assistant research workers (2) Technicians (3) Clerical and other supporting personnel	(1) Assistant research workers (HC) (2) Technicians (HC) (3) Clerical and other supporting personnel (HC)	(1) Assistant research workers (2) Technicians (3) Clerical and other supporting personnel	(1) Assistant research workers (2) Technicians (3) Clerical and other supporting personnel
U.S.	NA			
Germany	(1) technisches personal : Technicians (2) Sonstige: Others (specialized labor, assistant labor, clerical staff, etc. directly related to R&D fields)			
France	(1) Techniciens: Technicians (2) Ouvriers: labor (3) Administratifs: Clerical staff	Classification by EPST/EPA/other organizations (1) Ingénieur d'étude, assistant ingénieur, technicien: Design engineers, assistant engineers, technicians (2) Autre personnel: Other personnel Classification by EPIC (1) Personnel de soutien technique: Technical assistant personnel (2) Personnel de soutien administratif et de service: Clerical and service personnel		
U.K.	(1) Technicians: Technicians (2) Other support staff: other supporting staff			
China	(1) Technicians: Technicians (2) Other support staff: Other supporting staff			
Korea	Assistant research workers (1) Research assistant personnel and technical personnel (2) Research administration personnel and other assistant personnel	Assistant research workers (1) Master's degree students participating in research (2) Other assistant personnel (Research management and clerical	Assistant research workers (1) Research assistant personnel and technical personnel (2) Research administration personel and other assistant personnel	Assistant research workers (1) Research assistant personnel and technical personnel (2) Research administration personnel and other assistant personnel

Note: 1) For the U.S., Germany and France, terms in their national languages are shown (this version is in Japanese). For the U.K. and China, terms used in OECD materials are shown.
2) Values for each country are FTE, except where marked with (HC), which refers to actual values.
3) Nothing on the U.S.
Source: NISTEP, "Metadata of R&D-related statistics in selected countries: Comparative study on the measurement methodology" (Research Material No. 143); Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"; OECD, "R&D Statistics (last updated 2009.2)

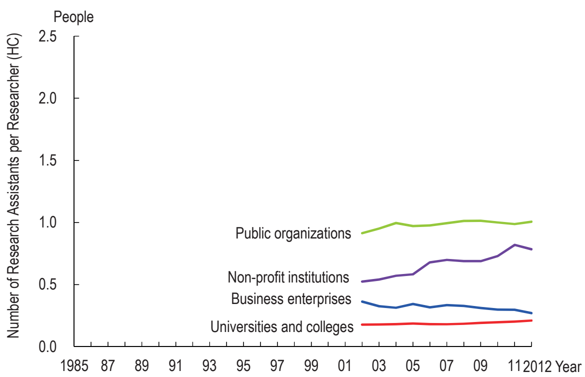
Chart 2-3-2: Trends in the number of research assistants per researcher by sector for selected countries

Attention to international comparison

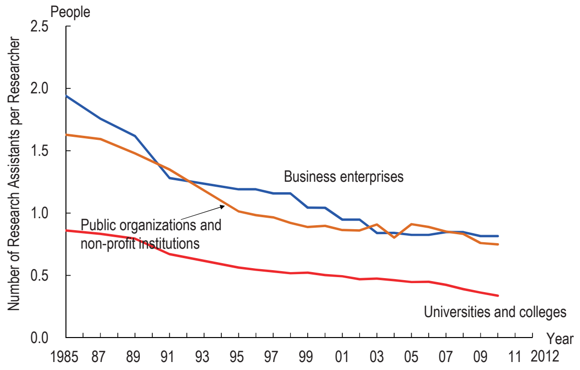
(A) Japan *



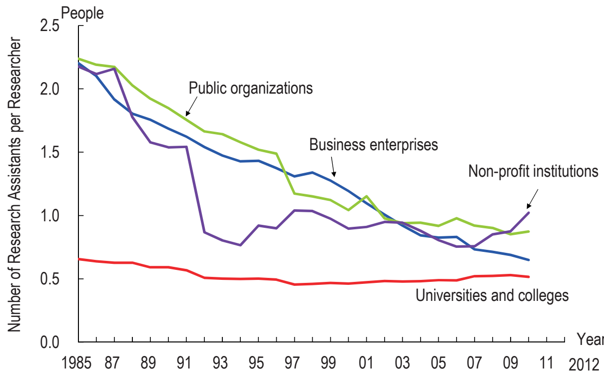
(B) Japan (HC)



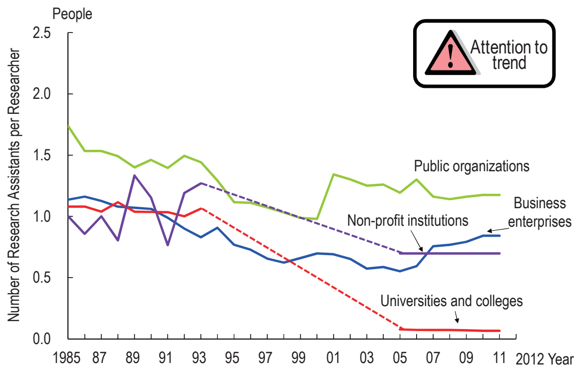
(C) Germany



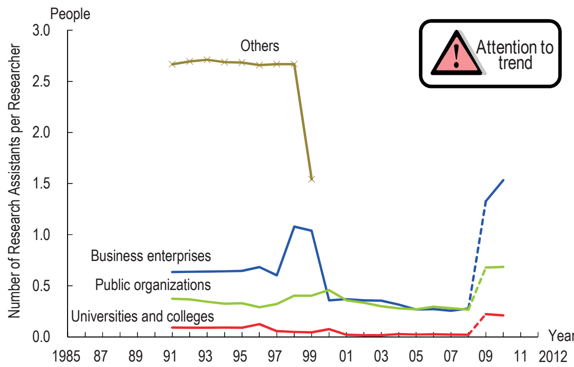
(D) France



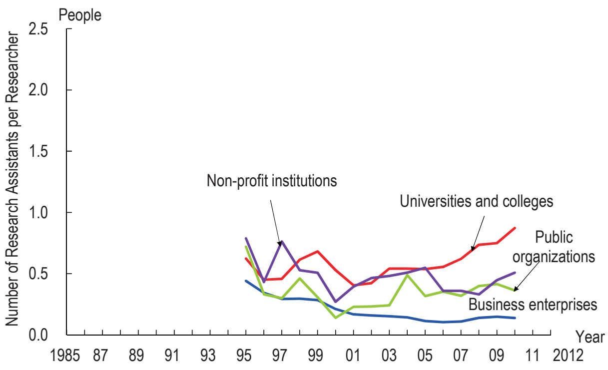
(E) U.K.



(F) China



(G) Korea



Note: 1) The definition and measurement methods of research assistants are different depending on the country or sector. Therefore it is necessary to be careful when international comparisons are being made. Refer to Chart 2-3-1 for the differences in research assistants.

2) The note for researchers is the same as for Chart 2-1-1.

3) FTE values were used in each country. But a part of Japan's data was HC values.

4) "Japan ∗ " used the values in accordance with Chart 2-1-2(A) (Values represent the number of researchers mainly engaged in research, and were not measured on FTE basis. External non-regular researchers were not covered.)

5) "Japan (HC)" used values in accordance with Chart 2-1-2 (A)(3) (the total number of researchers "mainly engaged in research" and "engaged in research under non-regular conditions". The number of researchers in universities and colleges sector includes the number of above mentioned "external non-regular researchers")

6) For France, the U.K. and Korea, the values for "non-profit institutions" were found by subtracting business enterprises, universities and public organizations from the total number of research assistants.

7) With no data for assistants at U.K. universities and non-profit institutions for 1994–2004, estimated values for 2005 on have been corrected by the Secretariat to accord with national estimates and, where necessary, with OECD standards. Because the values may have been underestimated, or may be based on underestimated data, caution is necessary when making comparisons over time.

8) Through 2008, China's definition of researcher used was not in complete accordance with the OECD. The measurement method was changed in 2009. Caution is therefore necessary when observing changes over time.

Source: <Japan> Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development",
<Germany> Bundesministerium für Bildung und Forschung, "Bundesbericht Forschung 1996, 2000, 2004"; "Forschung und Innovation in Deutschland 2007" "Bundesbericht Forschung und Innovation, 2008, 2010, 2012"; OECD, "Main Science and Technology Indicators 2012/2)" since 2010.
<Other countries> OECD "Main Science and Technology Indicators 2012/2"

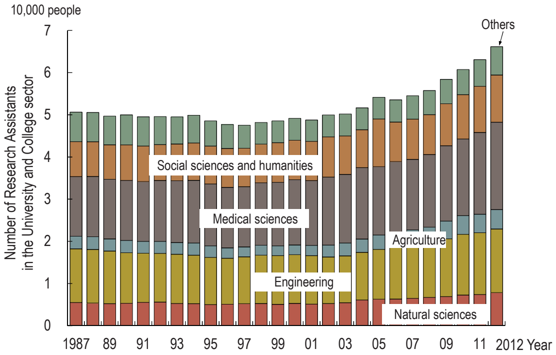
2.3.2 Status of research assistants in the universities and colleges sector in Japan

(1) Breakdown of the number of research assistants

As mentioned in Section 2.3.1., Japan's research assistants consist of "technicians", "assistant research workers" and "clerical and other supporting staff". In this section, details on research assistants in the universities and colleges sector in Japan are examined.

Chart 2-3-3 shows the number of research assistants by the academic field of their affiliation. Their numbers have tended to be on the rise mainly in the field of agriculture and medical sciences since around 2000, and the total for all fields was 66,000 people in 2012.

Chart 2-3-3: Numbers of research assistants by academic field of study in the universities and colleges sector



Source: Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"

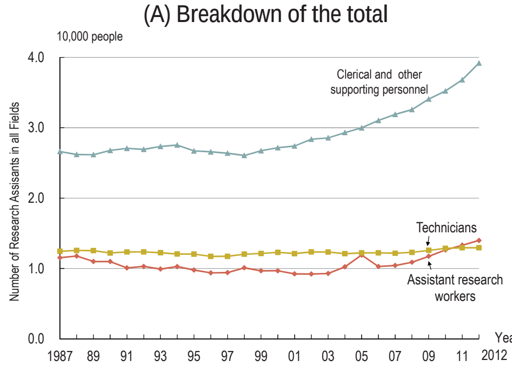
Next, looking at the breakdown of the number of research assistants, the number of "clerical and other supporting personnel", which account for the largest proportion of the total, has been increasing since 2000. It was and 39,000 people in 2012 (Chart 2-3-4(A)).

Above mentioned increase seems to have been caused by the revision of a cabinet order on the Act for Securing the Proper Operation of Worker Dispatching Undertakings and Improved Working Conditions for Dispatched Workers in FY 1997, which added "research tasks related to sciences" to the list of temporary tasks permitted and as a result enabled temporary researchers to be employed. Another likely cause is a decision in FY 2001 to enable research institutes to employ research assistants who are necessary for the accomplishment of scientific research covered by grants in aid.

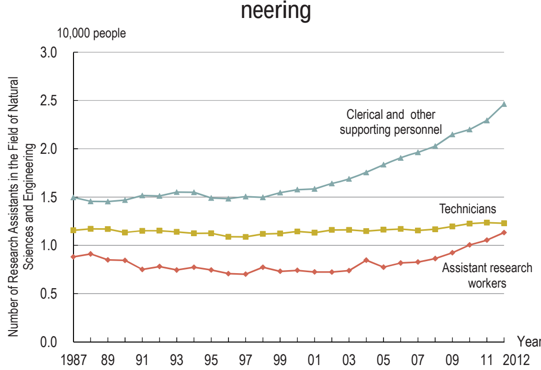
The breakdown of the number of research assistants by the academic field of their affiliation shows that the number of "clerical and other supporting personnel" is highest both in the field of "natural sciences" and the field of "social sciences and humanities" as it was in the breakdown of the total. But the number of "technicians" and "assistant research workers" is substantially larger in the field of "natural sciences" compared to that in the field of "social sciences and humanities" (Chart 2-3-4(B), (C)).

Chart 2-3-4: Breakdown of research assistants by academic field of study in the universities and colleges sector

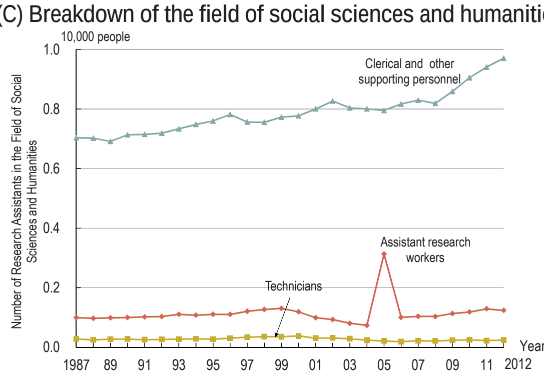
(A) Breakdown of the total



(B) Breakdown of the field of natural sciences and engineering



(C) Breakdown of the field of social sciences and humanities



Note: 1) Expression "assistant research workers" represent s the people who assist "researchers" and work under the researchers' guidance.
2) Expression "technicians" represents the people who are not categorized as "researchers" nor "assistant research workers" and conduct research related auxiliary technical services under the guidance and supervision of "researchers" and "assistant research workers".
3) Expression "clerical and other supporting personnel" represents the people who are not categorized as "assistant research workers" nor "technicians", and work in general affairs, accounting and miscellaneous affairs.

Source: Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"

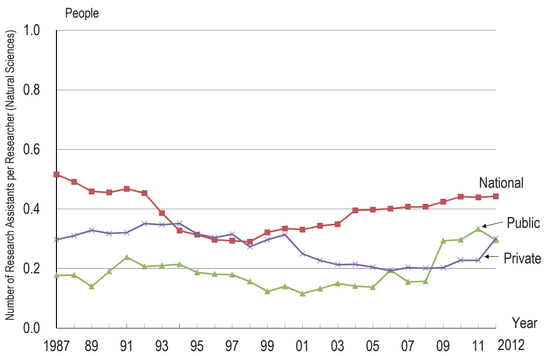
(2) Number of research assistants per researcher

In this section, the ratio of the number of research assistants per researcher (regular researchers: other than external non-regular researchers) by field of their affiliation is examined in order to determine whether or not the values differ depending on the type of university (national, public and private). (See Chart 2-3-5.)

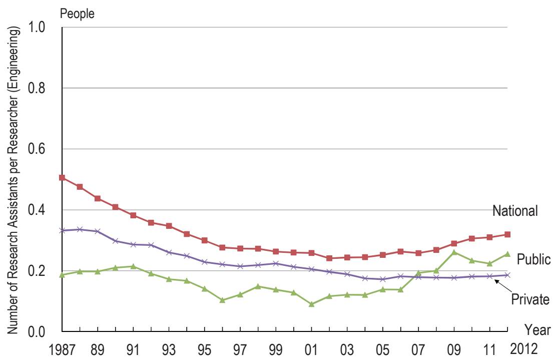
The number of research assistants per researcher is large in national universities in every field. In the field of engineering, although the number had been decreasing over the long term for both national and private universities, the trend has been flat in recent years. In the field of "medical sciences", the number of research assistants per researcher is small, and the difference with the research assistants per teacher in Chart 2-3-6 is significant. This difference, however, is due to the huge number of "medical staff and others" in this field compared to the other fields. In other words, the large number of researchers or the large denominator, rather than the small number of research assistants, influenced the result.

Chart 2-3-5: Trends in the number of research assistants per researcher by type of university in each academic field

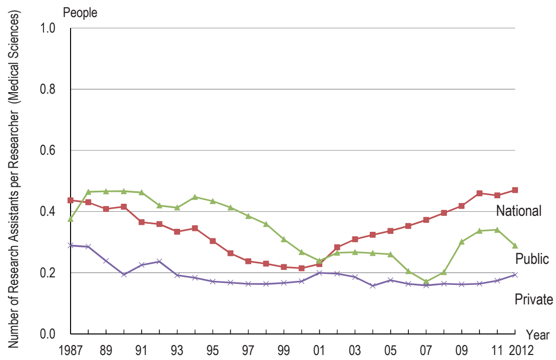
(A) Natural sciences



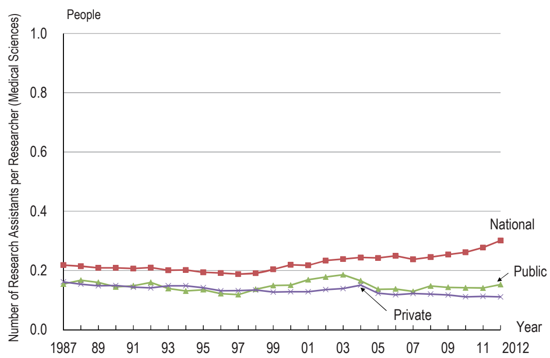
(B) Engineering



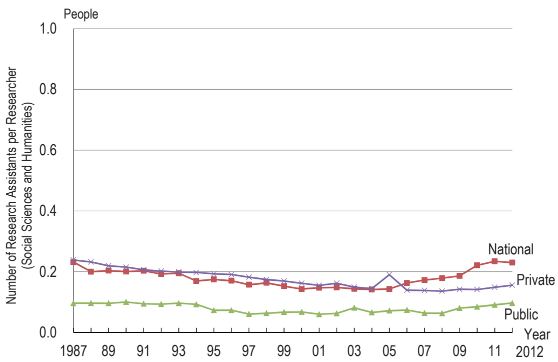
(C) Agriculture



(D) Medical sciences



(E) Social sciences and humanities



Source: Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"

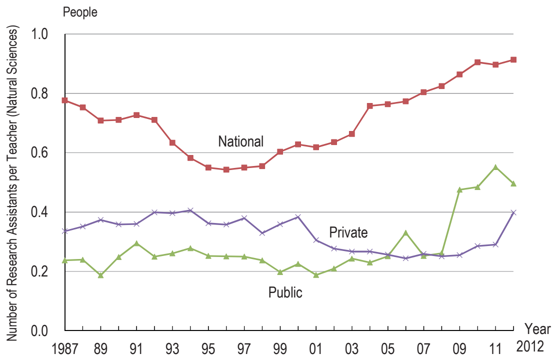
(3) Number of research assistants per teacher

Regular researchers are composed of (1) teachers, (2) doctoral course students and (3) medical staff and others, and the proportion of (2) and (3) differs depending on the field. Therefore, in this section, (2) and (3) were excluded from the coverage on the purpose of removing their influence. And the number of research assistants per teacher by field of their affiliation is examined in order to determine whether or not the values differ depending on the type of university (national, public and private).

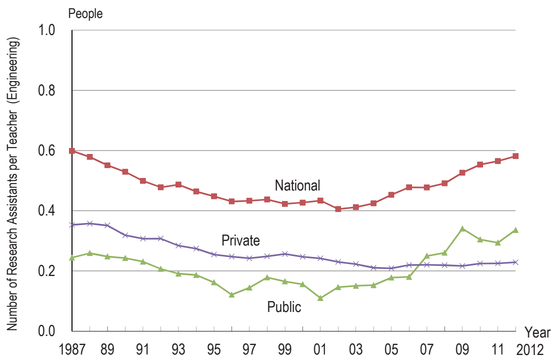
In every field, the number of research assistants at national universities is large and rising. In addition, the number of research assistants per teacher in the field of "natural sciences" and "agriculture" of "national universities" has a similar tendency of a decreasing trend until the 1990s which begins to rise in 2000. In the other fields as well, a rising trend at national universities becomes apparent during the mid-2000s (Chart 2-3-6).

Chart 2-3-6: Trends in the number of research assistants per teacher by type of university in each academic field

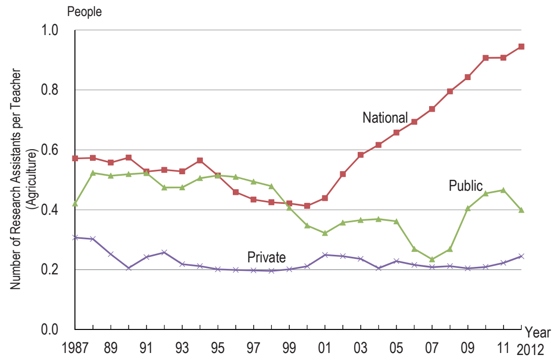
(A) Natural sciences



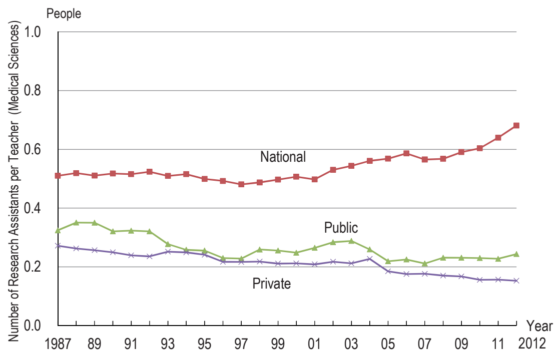
(B) Engineering



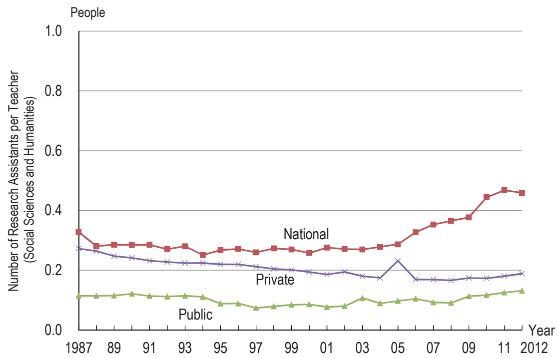
(C) Agriculture



(D) Medical sciences



(E) Social sciences and humanities



Source: Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"

Chapter 3: Higher Education

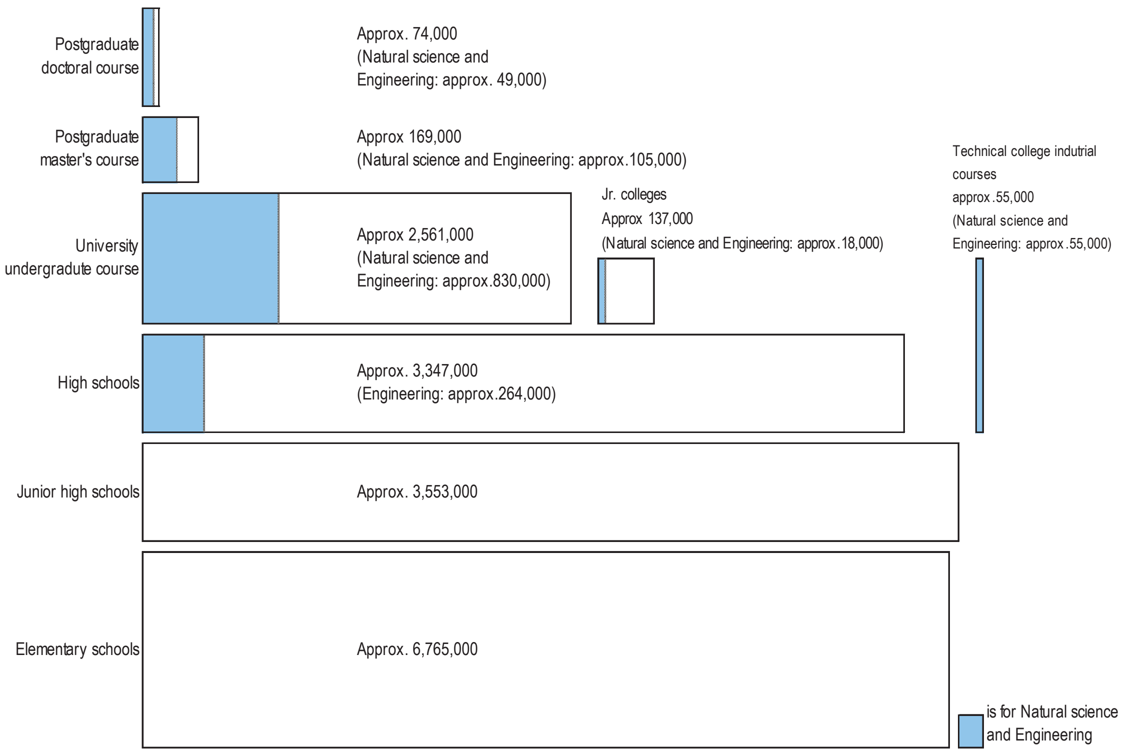
The cultivation of human resources relevant to science and technology is one of the most important basic infrastructures for promoting science and technology. This chapter describes the cultivation of human resources for science and technology in school education, mainly looking at conditions in universities and colleges as higher education institutions. Here, an international comparison of the enrollment status at each phase of higher education, career options after graduation or leaving school, the present situation of adult education, and of degree awarded is attempted.

3.1 The status of the number of students in Japan's education institutions

Chart 3-1 shows the total numbers of students and pupils in school education for the FY 2012, in order to gain an overall impression of the education system in Japan. The height of each bar in the graph represents the length of time in terms of course terms in each educational institution and the area of each bar of the graph indicates the number of the students and the pupils enrolled there.

The number of children in elementary schools is about 6,765,000, that of pupils in junior high schools are about 3,553,000, and that of high school students are about 3,347,000 (including only the regular courses). The number of undergraduate students is about 2,561,000 (including approx 830,000 in the field of "Natural science and engineering"), and that of college students is about 137,000 (including approx 18,000 in the field of "Natural science and engineering"). The number of master's program students in graduate schools is about 169,000 (including approx 105,000 in the field of "Natural science and engineering") and that of doctoral program students is about 74,000 (including approx 49,000 in the field of "Natural science and engineering")

Chart 3-1: The present status of the number of students and pupils, etc. in school education (for the FY 2012)



Note: 1) Conceptual representation indicating the breakdown of the number of students and pupils enrolling in the regular courses of each education institution and, of these, the number of students and pupils enrolled in Natural sciences and Engineering (regions shown in blue).
2) "Natural sciences and engineering" for universities and colleges or graduate schools is the total of Natural sciences, Engineering, Agricultural sciences, Medical science, and Dentistry and Pharmaceutical science.
3) "Natural sciences and Engineering" in junior colleges means the "Industrial department".
4) The height of each bar in the graph represents the length of time in terms of course terms for each educational institution and the area of each bar of the graph indicates the number of the students and the pupils enrolled.
5) The number of students in the postgraduate master's course and postgraduate doctoral course excludes the students in professional graduate school program.
Source: MEXT, "Report on School Basic Survey"

3.2 The status of students in Higher Education institutions

Key Points

○ The number of newly enrolled undergraduates in Japan had been roughly unchanged since about 2000, but in FY2012 it decreased by 1.2% versus the previous year, to about 605,000. The number newly enrolled in private universities and colleges was high, constituting about 80% of the total. Classified by field, students majoring in "Natural science and engineering" comprised about 30% of the total.

○ The number of students newly enrolled in master's programs in FY 2012 totaled 75,000. This figure represented a decrease of 5.5% compared to the previous fiscal year and a continuing decline following a peak in 2010. Those newly enrolled in national universities and colleges constituted about 60% of the total. Classified by field, students majoring in "Natural science and engineering" accounted for about 60% of the total.

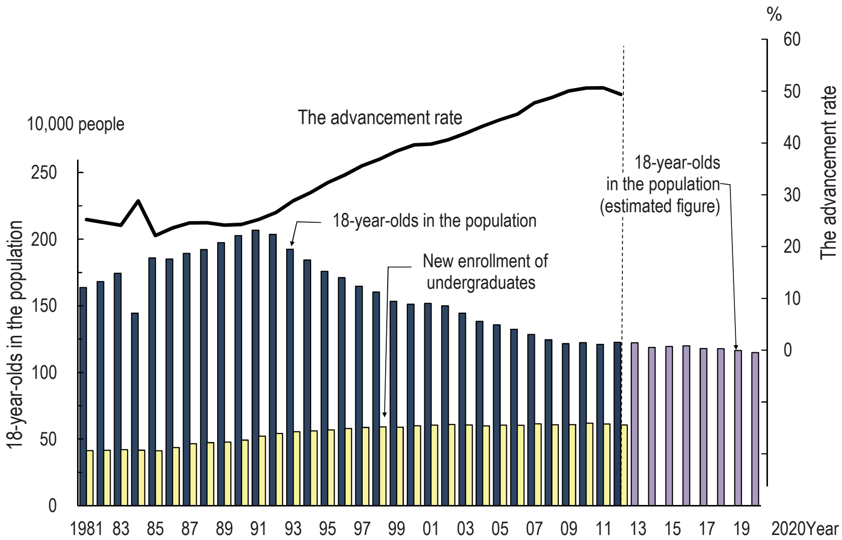
○ The number of people newly enrolled in doctoral programs has been decreasing since peaking in 2003. Although it increased by 3.6% over the previous year in FY 2010, it continued to decline in 2011 and 2012, falling to 16,000. The number newly enrolled in national universities and colleges was high and constituted about 70% of the total. Classified by field, students majoring in "Natural science and engineering" accounted for about 70% of the total.

3.2.1 New enrollment of undergraduates

The number of 18-year-olds in the population has been decreasing from about 2,068,000 in 1991, which marked the peak. It is expected that this trend of decreasing will continue and estimated that the numbers will decline to about 1,149,000 in 2020, which 55.5% of the peak (see Chart 3-2-1).

Under circumstances of young people increasingly wanting to proceed to higher education and an increase in the number of student places, the number of students newly enrolled for undergraduate studies had shown continuing increases. However, its growth began to slow in the early 2000s. This number stood at 605,000 in FY 2012. The advancement rate (the ratio of the number newly enrolled to the total of 18-year-olds) is 49.4%, which represents a decrease of 1.3 percentage points compared to the previous year.

Chart 3-2-1: 18-year-olds in the population and the transition of the numbers newly enrolled for undergraduate studies



Note: 1) 18-year-olds in the population is by medium estimation.
2) The number newly enrolled for undergraduate studies is the number of students who enrolled in a university or college in the year noted and were still registered as of May 1 (the date of the survey) the following year.
3) The advancement rate is the ratio of the numbers newly enrolled for undergraduate studies against 18-year-olds in the population.

Source: 1) 18-year-olds in the population: <until 2007>Ministry of International Affairs and Communications, Statistics Bureau, "Population Estimates" (as of October in every year).
<After 2011>National Institute of Population and Social Security research, "Population Projections for Japan: January 2012"
2) The numbers newly enrolled for undergraduate studies: MEXT, "Report on School Basic Survey"

Chart 3-2-2 (A) shows changes in new enrollment of undergraduates by major fields. New enrollment of undergraduates in Japan has been largely unchanged since FY 2000. The number in FY 2012 was 605,000, representing a continuing decreasing trend that began in 2010.

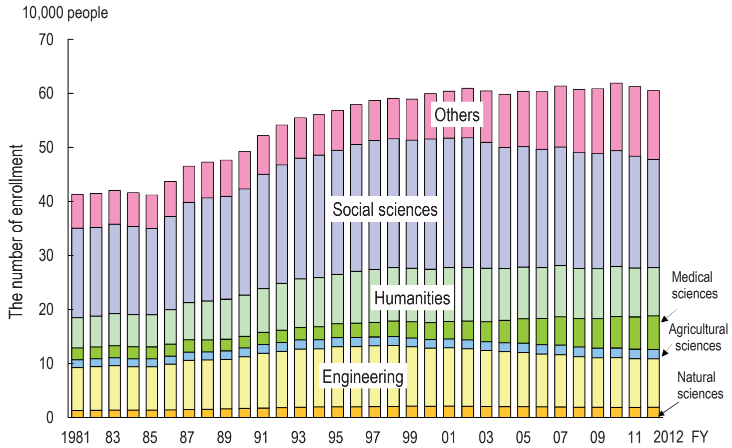
Breaking down the number of new enrollment for the most recent available years, the field of “Social sciences” had 200,000 newly enrolled students while “Humanities” had 89,000. In the “Natural science and engineering” fields, “Engineering” had about 90,000 newly enrolled students, “Medical sciences” about 62,000, “Natural sciences” about 19,000, “Agricultural sciences” about 17,000, and “Others (the total of home economics, education, art, and others) about 128,000. Looking at changes over time, the numbers of new enrollment for “Medical sciences” and “Others” have been increasing since the early 2000s, while those “Social sciences” and “Engineering” have been decreasing.

When the number of newly enrolled undergraduates is sorted by national, public, and private universities (Chart 3-2-2 (B)), new enrollment in private universities and colleges constitutes 80% of the total. Consequently, it is thought that the number of new enrollment in private universities and colleges has a profound impact on changes in the number as a whole.

By field, students majoring in "Natural sciences and engineering" accounted for about 30% of the total. A large share of the new enrollment in private universities and colleges was in the “Social sciences”. However, the composition ratio looking at private universities and colleges as a whole shows the trend that “Social sciences” has been decreasing. Meanwhile, the large number of the new enrollment in national universities and colleges is in “Engineering”. The increase in “Others” is largely a result of the increase in the new enrollment in “private universities and colleges”.

Chart 3-2-2: The numbers newly enrolled for undergraduate studies

(A) The transition of the numbers newly enrolled for undergraduate studies by major fields



(B) The transition of the number newly enrolled is sorted by national, public and private universities and colleges

(Unit: person)

FY	Universities and colleges	Total	Humanities	Social science	Natural sciences	Engineering	Agricultural sciences	Medical sciences	Mercantile marine	Home economics	Education	Art	Others
1990	Total	492,340	76,115	196,659	16,940	95,401	16,527	21,651	222	9,218	34,946	12,230	12,431
	National	100,991	6,360	15,757	6,419	29,117	7,549	6,047	222	306	22,137	600	6,477
	Public	14,182	2,842	5,346	709	1,739	422	1,233	-	746	342	633	170
	Private	377,167	66,913	175,556	9,812	64,545	8,556	14,371	-	8,166	12,467	10,997	5,784
2000	Total	599,655	98,407	241,275	20,795	107,566	16,147	31,573	174	11,473	32,086	17,395	22,764
	National	103,054	6,969	16,760	7,414	31,792	6,987	8,403	174	292	17,569	600	6,094
	Public	23,578	4,033	7,921	1,004	3,639	685	3,874	-	561	273	812	776
	Private	473,023	87,405	216,594	12,377	72,135	8,475	19,296	-	10,620	14,244	15,983	15,894
2012	Total	605,390	89,285	200,361	18,909	89,728	17,365	62,016	-	17,624	45,399	17,084	47,619
	National	101,181	6,515	14,924	6,944	29,181	6,535	10,624	-	288	15,866	842	9,462
	Public	30,017	4,723	7,971	688	3,901	1,051	6,132	-	675	635	1,171	3,070
	Private	474,192	78,047	177,466	11,277	56,646	9,779	45,260	-	16,661	28,898	15,071	35,087

Note: The “Others” in (A) are “Mercantile marine”, “Home economics”, “Education”, “Art” and “Others”
Source: MEXT, “Report on School Basic Survey”

3.2.2 New enrollment in master's programs in graduate schools

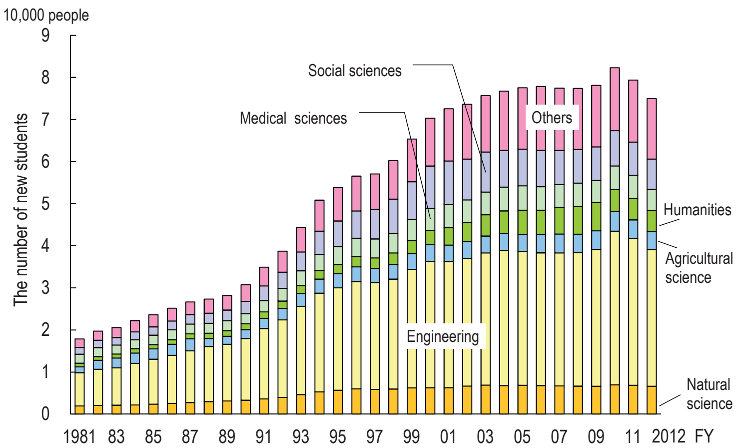
The number of new enrollments in graduate school master's programs increased greatly from FY 1990 to FY 2000, partly due to increasing focus on graduate school education since 1990. During this period, the number of new enrollments in master's programs increased by 2.3 times. This growth began to slow upon entering the 2000s. The number of students newly enrolled in master's programs totaled 75,000 in FY 2012. This figure represented a decrease of 5.5% compared to the previous fiscal year and a continuing decline following a peak in 2010.

Breaking down this number by major field of study for the most recent available year, "Engineering" had the largest share with 32,000 (43.2% of the total), followed by "Social sciences" with 7,000 (9.6%), "Natural science" with 7,000 (8.8%), and "Medical sciences" with 5,000 (6.6%). Looking at changes over time, the number of new enrollments in "Engineering," which has the largest number of new enrollments among the major fields of study, shows remarkable changes and thus has a significant influence on changes in the overall number (Chart 3-2-3 (A)). (Totals do not add up in some cases due to rounding of figures.)

Looking at the trend of the number of new enrollments in master's programs by national, public and private universities and colleges, the trend was different from that for undergraduates. National universities and colleges accounted for about 60% of the total. By major, "Natural science and engineering" accounted for the largest share at national, public and private universities and colleges. Private universities and colleges had relatively high new enrollments in "Social sciences and humanities." (Chart 3-2-3 (B))

Chart 3-2-3: The number of new enrollments in graduate school (master's program)

(A) The transition of the number of new enrollments in graduate school (master's program) by major subjects



(B) The transition of new enrollments in graduate school (master's program) is sorted by national, public and private universities and colleges

(Unit: person)

FY	Universities and colleges	Total	Humanities	Social science	Natural sciences	Engineering	Agricultural sciences	Medical sciences	Mercantile marine	Home economics	Education	Art	Others
1990	Total	30,733	2,400	2,927	3,291	14,697	2,104	1,376	55	206	2,684	713	280
	National	19,894	829	877	2,359	10,267	1,805	644	55	44	2,420	326	268
	Public	1,190	75	127	142	482	66	130	-	29	5	134	-
	Private	9,649	1,496	1,923	790	3,948	233	602	-	133	259	253	12
2000	Total	70,336	5,251	10,039	6,285	30,031	3,938	3,424	15	486	5,212	1,437	4,218
	National	41,278	1,814	2,929	4,464	19,336	3,297	1,661	15	114	4,564	366	2,718
	Public	3,307	233	389	391	1,178	185	326	-	126	17	246	216
	Private	25,751	3,204	6,721	1,430	9,517	456	1,437	-	246	631	825	1,284
2012	Total	74,985	5,063	7,206	6,625	32,424	4,310	4,986	25	437	4,635	1,982	7,292
	National	43,703	1,549	2,047	4,493	20,899	3,544	2,522	25	89	3,904	500	4,131
	Public	4,924	196	500	598	1,834	140	730	-	107	21	300	498
	Private	26,358	3,318	4,659	1,534	9,691	626	1,734	-	241	710	1,182	2,663

Note: The "Others" in (A) are "Mercantile marine", "Home economics", "Education", "Art" and "Others"
Source: MEXT, "Report on School Basic Survey"

3.2.3 New enrollment in doctoral programs in graduate schools

The number of new enrollments in graduate school doctoral programs had been declining since peaking in FY 2003, but in FY 2010 it increased by 3.6% from the previous year. However, it had a continuous decrease in FY 2011 and FY 2012 to stand at 16,000.

Breaking down this number by major field of study for the most recent available year, “Medical sciences” and “Engineering” had large shares, accounting for 6,000 (38.9% of the total) and 3,000 (17.7%), respectively. “Natural science,” “Humanities,” and “Social sciences” each had around 1,000 new enrollments.

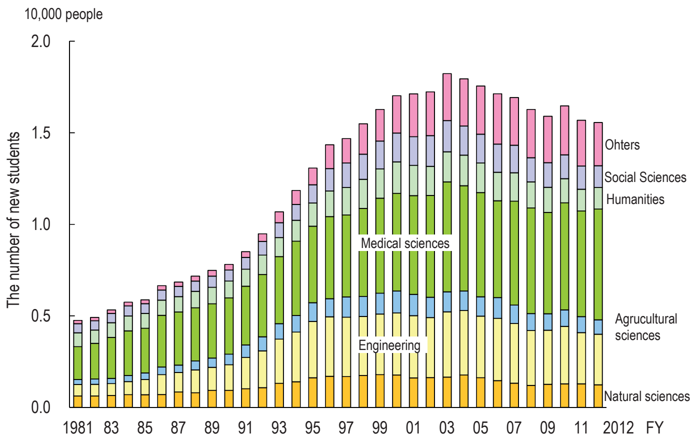
Looking at changes over time, the number has fallen or remained flat for all majors since the first half of the 2000s, Decreases are particularly conspicuous in “Engineering” and “Social sciences and humanities” (Chart 3-2-4 (A)).

A look at the numbers of new enrollments in graduate school doctoral programs in national, public, and private universities shows that national universities have a roughly 70% share of the total. By major, national universities have shares of between 80 and 90% in the fields of “Natural science,” “Engineering,” and “Agricultural sciences” and a 60% share of “Medical sciences.” Thus, a high percentage of students majoring in “Natural science and engineering” enrolled in national universities.

The number of new enrollments in graduate school doctoral programs has increased largely since the beginning of the 1990s. This resembles the increase in the number of new enrollments in graduate school master’s programs. The number of new enrollments in master's programs had been flat since the mid-2000s, while that of enrollments in doctoral programs had been decreasing since peaking in 2003. Both the number of new enrollments in master’s programs and that of new enrollments in doctoral programs similarly increased in FY 2010 but showed continuous decreases in FY 2011 and FY 2012 (Chart 3-2-4(B)).

Chart 3-2-4: The numbers of new enrollments in graduate school (doctoral program)

(A) The transition of the numbers of new enrollments in graduate school (doctoral program) by major subjects



(B) The transition of new enrollments in graduate school (doctoral program) is sorted by national, public and private Universities and Colleges

(Unit: person)

FY	Universities and colleges	Total	Humanities	Social science	Natural sciences	Engineering	Agricultural sciences	Medical sciences	Mercantile marine	Home economics	Education	Art	Others
1990	Total	7,813	917	606	929	1,399	580	3,076	-	21	165	24	96
	National	5,170	368	244	776	1,182	522	1,830	-	12	116	24	96
	Public	417	53	31	36	31	16	239	-	6	5	-	-
	Private	2,226	496	331	117	186	42	1,007	-	3	44	-	-
2000	Total	17,023	1,710	1,581	1,764	3,402	1,192	5,339	-	61	373	117	1,484
	National	11,931	761	638	1,461	2,732	1,070	3,710	-	0	246	47	1,266
	Public	941	71	95	126	172	36	364	-	23	9	17	28
	Private	4,151	878	848	177	498	86	1,265	-	38	118	53	190
2012	Total	15,557	1,183	1,186	1,233	2,759	794	6,051	-	52	494	173	1,632
	National	10,322	552	548	1,006	2,177	682	3,787	-	8	330	81	1,151
	Public	1,032	58	70	103	117	25	509	-	17	1	33	99
	Private	4,203	573	568	124	465	87	1,755	-	27	163	59	382

Note: The “Others” in (A) are “Mercantile marine”, “Home economics”, “Education”, “Art” and “Others”
Source: MEXT, “Report on School Basic Survey”

3.2.4 The ratio of female students

In FY 2012, the number of female students enrolling in undergraduate studies was 267,000, or 44.1% of all new enrollment. This figure represented a 13.9 percentage point increase compared to the 30.2% figure of FY 1990 (Chart 3-2-5 (B)). Looking at this situation by field, that with the largest share was "Humanities"; however, this share has shown little movement over time. Following is "Medical sciences," which has grown by approximately four times since FY 1990 and is showing the greatest increase compared to the other fields (Chart 3-2-5 (A)).

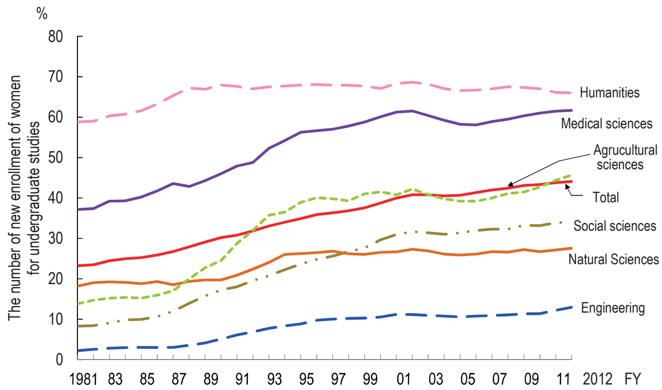
Looking next at the ratio of new enrollment of female students for graduate programs, this ratio was 28.8% in FY 2012. In terms of major field of study, the fact that much of the new enrollment is in "Humanities" resembles the situation for undergraduate studies; however, the share for "Medical sciences" is also large. This share, which stood at 22.9% in FY 1990, grew to 53.4% in FY 2012, a figure that surpasses that of males.

As for the ratio of new enrollment of female students for doctoral programs, this ratio stood at 31.4% in FY 2012, which is 2.6 percentage points higher than the ratio of female students for master's programs in the same fiscal year. In terms of major field of study, "Humanities" has a large ratio. It deserves noting that, in the case of "Natural science," female students in master's programs have a larger percentage, while for "Engineering," female students in doctoral programs have a larger percentage (Chart 3-2-5 (B)).

Although the percentage of females among all students newly enrolled in undergraduate studies had been rising until the first half of the 1990s, this growth has slowed in recent years. On the other hand, the percentage of females that are seeking even higher education (i.e., in doctoral programs) is growing.

Chart 3-2-5: The ratio of new enrollment of female students for undergraduate studies

(A) The transition of the ratio of new enrollment of female students for graduate studies



(B) The transition of the ratio of new enrollment of female students in graduate studies by departments・master's program・doctoral program, major fields and major subjects

(Unit:%)

	FY	Total	Humanities	Social sciences	Natural sciences	Engineering	Agricultural sciences	Medical sciences	Others
Undergraduate students	1990	30.2	67.9	17.3	19.7	5.1	24.5	46.0	59.1
	2000	38.8	67.1	29.6	26.5	10.5	41.5	60.1	62.6
	2012	44.1	66.0	34.1	27.6	13.0	45.7	61.7	60.0
Master's programs	1990	16.1	46.3	25.2	12.5	3.4	11.8	22.9	41.4
	2000	26.3	55.0	30.8	21.6	9.0	33.9	52.0	46.9
	2012	28.8	60.3	39.5	20.3	10.4	33.9	53.4	47.7
Doctoral programs	1990	15.5	34.0	22.4	7.0	4.6	12.1	14.7	36.6
	2000	26.8	52.5	30.1	15.6	9.9	25.8	27.6	39.3
	2012	31.4	54.4	33.8	16.5	14.5	34.3	33.1	41.0

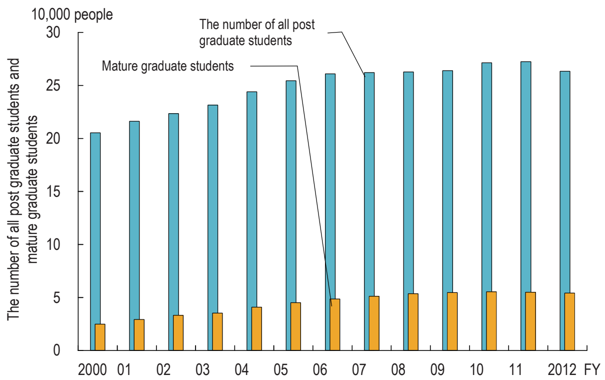
Source: MEXT, "Report on School Basic Survey"

3.2.5 Mature students in higher education institutions

Utilization of higher education institutions to give opportunities for the reeducation of people in the working world who are highly motivated to study is helpful to advance the cultivation of excellent human resources and use them. Moreover, it contributes to energizing society as a whole.

Of all postgraduate students in Japan for the FY 2012, the number of working people was 54,000, which accounts for 20.6%. The number of mature graduate students consistently increased until peaking in FY 2010. It is currently declining at a rate of 1.5% compared to the previous fiscal year (Chart 3-2-6).

Chart 3-2-6: The transition of the number of mature graduate students in Japan

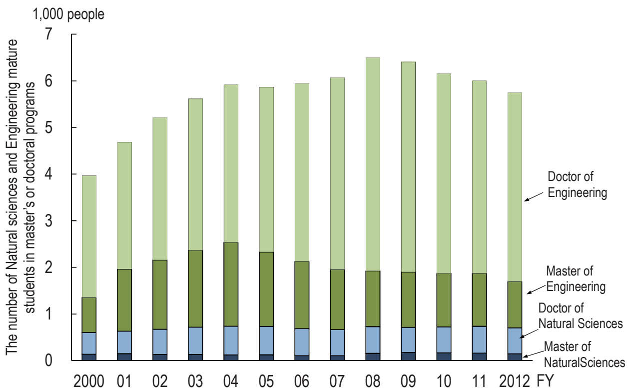


Note: 1) "Mature" is the persons who enter into employment for taking current income such as pay or wage as of May 1st in each year, and include retired employees and house wives.
2) Postgraduate students here are persons who are registered in a master's program and the preliminary term of a doctoral program, or in a doctoral program and the latter term of doctoral program, and in professional graduate schools.
Source: MEXT, "Report on School Basic Survey"

Looking at the number of mature graduate students in "Natural sciences" and "Engineering" by degree, 4,050 were enrolled in doctoral programs in "Engineering" in FY2012; this figure continues a decreasing trend that follows a peak in FY 2008. The number of mature graduate students in master's programs in "Engineering" has been on a downward trend since FY2004. At 994 in FY2012, there was about one-fourth as many mature students in master's programs as there were in doctoral programs.

Mature students enrolled in doctoral courses in "Natural sciences" during FY2012 numbered 555. Those in master's courses in "Natural sciences" numbered 148. The number of mature students in doctor of natural science courses has been decreasing since FY 2004, while that for mature students in master of natural science courses has been decreasing since FY 2009 (Chart 3-2-7).

Chart 3-2-7: The transition of Natural sciences and Engineering mature graduate students



Source: MEXT, "Report on School Basic Survey"

3.3 Career options for students in Natural sciences and Engineering

Key Points

- ○Looking at the career paths of undergraduate students in "Natural sciences and engineering" after graduating, in FY 2012 the share of "persons who entered employment" was the largest at 48.4%. It was followed by "persons who proceeded with higher education" at 37.7%. It should be noted that 97.7% of "persons who entered employment" were "persons who enter indefinite-term employment" as regular employees.
- ○Looking at the career paths of master's course students in "Natural sciences and engineering" after graduation, in FY 2012 "persons who entered employment" accounted for 84.3% of the total. Of "persons who entered employment," 99.1% were "persons who enter indefinite-term employment."
- ○Looking at the career paths of doctoral course students in "Natural sciences and engineering" after graduation, in FY 2012 "persons who entered employment" showed a high figure of 73.7%. However, 72.8% of "persons who entered employment" were "persons who enter indefinite-term employment," which is a slightly low figure when compared to the "persons who enter indefinite-term employment" figures for undergraduate course graduates and master's course graduates.
- ○Looking at the industrial classifications in which graduates receiving bachelor's degrees in natural sciences and engineering obtained employment, over 50% of those obtaining employment during the 1980s went to work in a manufacturing industry. In recent years, however, that percentage fell into the 30s, and in 2012 it was only 29.3%.
- ○In the case of students obtaining master's degrees in natural sciences and engineering, the percentage obtaining employment in "manufacturing" was at the 70% level in the 1980s; however, this figure fell to the 60% level from the mid-1990s and stood at 56.2% in 2012. The percentage obtaining employment in education (employed at schools, etc.) shrank from the 4% level to the 1% level.
- ○About 30% of those obtaining doctoral degrees in natural sciences and engineering have been obtaining employment in manufacturing industries. In 2012, the figure was 28.9%. For those obtaining employment in "education (persons obtaining employment in schools, etc.)," this figure was around 50% in the mid-1980s but fell to under 30% entering the 2000s. It stood at 35.3% in 2012. The figure for "research (persons obtaining employment in academic or R&D institutions, etc.) was 14.8% in 2012.
- ○Looking at graduates of undergraduate, master's, and doctoral courses in "Natural sciences and engineering" who entered employment by industrial classification, many become "persons who engage in specialized and technical work." In the case of those with master's or doctoral degrees, they have accounted for almost 90% of those obtaining employment. For those with bachelor's degrees, the long-term trend has been downwards. In recent years, their percentage has been in the 70s.
- ○A breakdown of "persons who engage in specialized and technical work" shows that while almost all graduates of undergraduate or master's courses are "engineers," many of those who are graduates of doctoral courses are also "researchers" or "teachers."

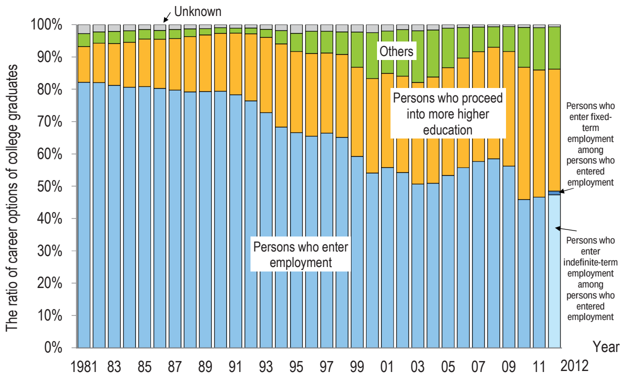
3.3.1 The status of employment and continuing education among students of Natural sciences and Engineering

This section describes career options particularly for students of "Natural sciences" and "Engineering". "Persons who enter employment" as used herein represents those who get jobs with routine income. Persons who get temporary or part time jobs are included in "Others". Moreover, beginning in 2012, "persons who entered employment" are being classified into "persons who enter indefinite-term employment" and "persons who enter fixed-term employment." Here, "person who enters indefinite-term employment" refers to a person who obtains employment for a period that is not determined, while "fixed-term employment" refers to a person who obtains employment with a set employment period of at least one year and with prescribed working hours of 30 to 40 hours per week. These data was based on a survey of the employment status of students for whom universities and colleges could provide information at the time of the survey being conducted (as of May 1st of respective years).

(1) Career options of college graduates

Looking at the career options of "Natural sciences and Engineering" college graduates for the FY 2012 (Chart 3-3-1), the percentage of "persons who entered employment" was 48.4%, which is the biggest share, and that of "persons who proceeded with more higher education" was 37.7% in the second place. The percentage of "persons who entered employment" was approximately 80% in the 1980s, however, it largely declined in the 1990s. In recent years, it had been increasing, but in 2010 it declined sharply, while the number of graduates pursuing further education increased. Partly due to the influence of upgrading and expanding graduate schools since the late 1990s, the percentage of people proceeding to further education has been trending upward. It deserves noting that "persons who enter indefinite-term employment" account for 97.7% of "persons who entered employment," and that almost all of these are employed as regular employees.

Chart 3-3-1: Career options of "Natural sciences and Engineering" college graduates

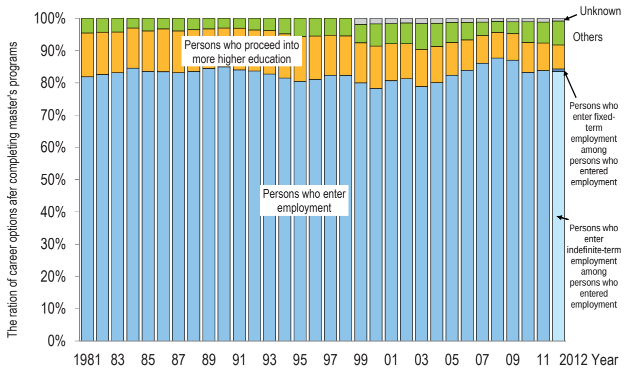


Note: 1) Chart indicates the number of people graduating in March of each year.
2) This chart includes both "persons who entered employment" and "persons who proceeded with more higher education" in the "number of persons who entered employment".
3) Persons who entered employment are persons who work for current income
4) Person who enters indefinite-term employment: A person who obtains employment for a period that is not determined or limited
5) Person who enters fixed-term employment: A person who obtains employment with a set employment period of at least one year and with prescribed working hours of around 30 to 40 hours per week
6) Persons who proceeded with more higher education are persons who proceeded to undergraduate schools, etc. Persons who enrolled in special training schools and schools overseas are excluded.
7) Unclear: Deceased/Unknown
8) The others: Do not fall under above mentioned
Source: MEXT, "Report on School Basic Survey"

(2) Career options of persons who complete master's programs

Looking at career options of persons who complete master's programs in "Natural sciences and Engineering" over the long term, the composition ratio did not show a big change until the early 2000s and the percentage of "persons who entered employment" accounted for about 80% of the total. The percentage had been increasing since the beginning of the 2000s but decreased slightly in 2010; since then, it has leveled out, standing at 84.3% in 2012. In addition, "persons who enter indefinite-term employment" accounted for 99.1% of "persons who entered employment"; almost all of these are employed as regular employees. The percentage of "persons who proceeded with higher education" had been decreasing since the early 2000s, but increased slightly in 2010 before leveling out; it stood at 7.4% in 2012 (Chart 3-3-2).

Chart 3-3-2: Career options of persons who complete master's programs in "Natural sciences and Engineering"



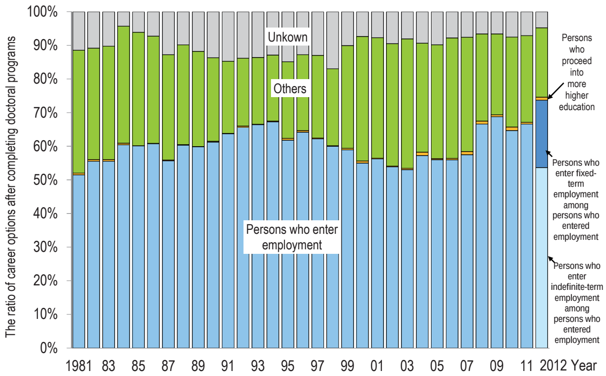
Note: Same as Chart 3-3-1
Source: MEXT, "Report on School Basic Survey"

(3) Career options of people who complete doctoral programs

「Looking at the career paths of doctoral course students in “Natural sciences and engineering” after graduation (Chart 3-3-3), the percentage of “persons who entered employment” had been decreasing significantly since 2000 but has been increasing in recent years. In 2012, the percentage of “persons who entered employment” was high at 73.7%. However, 72.8% of “persons who entered employment” were “persons who enter indefinite-term employment,” which is a slightly low figure when compared to the “persons who enter indefinite-term employment” figures for undergraduate course graduates and master’s course graduates. It is thought that the figure for “persons who enter fixed-term employment” among graduates of doctoral courses includes postdocs and fixed-term researchers.

Furthermore, while the percentages for “others” are large when compared to undergraduate and master’s course graduates, they have been falling since 2000.

Chart 3-3-3: Postdoctoral career options in natural sciences and engineering



Note: Same as for Chart 3-3-1.
Sources: MEXT, "School Basic Survey."

Chart 3-3-3 shows "Postdoctoral career options in natural sciences and engineering." The percentage of "Other" is higher than it is for those completing bachelor's or master's degrees. "Other" as used here refers to the sum of "medical residents," "persons enrolled in special course schools and schools abroad," "persons with temporary jobs" and "Not applicable" in the School Basic Survey. The following are two probable reasons that the percentage of "Other" is high.

One factor is the effect of career path classifications for postdoctoral fellows. It is unclear whether the School Basic Survey classifies postdoctoral fellows as "persons obtaining employment," "persons obtaining temporary work" or "Not applicable." The employment patterns of postdoctoral fellows are diverse; in some cases, they are employed for terms of a few months at a time. They might therefore be classified as "persons obtaining temporary work" or "Not applicable."

The second reason is probably the effect of graduates with undetermined career paths at the time of the survey. Unlike graduates with bachelor's and master's degrees, most doctoral graduates aim for academic careers. Hiring by businesses in Japan generally takes place during a set period each year. Hiring for academic posts, however, occurs throughout the year. Many doctoral graduates seeking academic careers may therefore have not yet established their career paths as of May 1 of the year following graduation when the School Basic Survey is performed. Having neither obtained employment nor proceeded to further education, those people would likely be classified as "Not applicable." In actuality, in FY 2012, the percentage of “Others” (“Not applicable persons” of 1,016 persons) was the largest percentage at approximately 80%. Moreover, it is possible that a certain number of people exist whose employment status could not be determined by their schools, as they did not give a response in the employment status survey because their status had yet to be determined at that time (such people are considered “unknown”).

From the above, it can be concluded that the high percentage of “others” among graduates of doctoral courses in the field of natural sciences and engineering comes from the fact that their career paths differ from those of undergraduate and master’s course graduates.

In order to obtain more detailed information, it would be necessary to conduct ongoing follow-up surveys to analyze which occupations and industries human resources with doctoral degrees work in, as is done in the U.S.

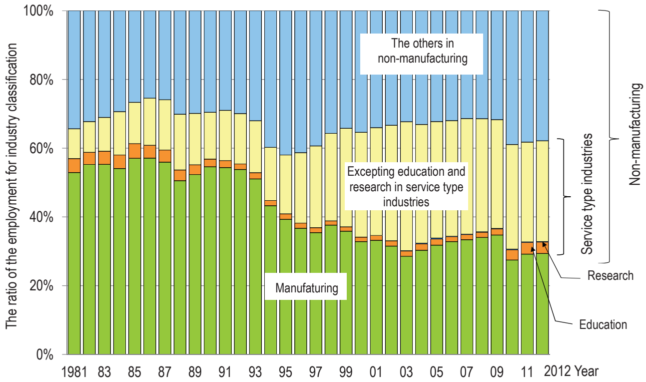
3.3.2 The employment status of students of Natural sciences and Engineering by industry classification

This section shows the place of employment by industry classification of the students described in section 3.3.1, “The status of employment and continuing education among students of Natural sciences and Engineering”. The industry classification used herein is the “Japan Standard Industry Classification: JSIC” which determines an industry by the main services of its business enterprises (The revision of JSIC was conducted in 1993, 2002 and 2007 and all were applied from the next year). "Education" as used in the JSIC refers to "school education," which includes elementary schools, junior high schools, high schools, universities and colleges. And “Research” means “Academic and R&D institutes”, which refers to business premises doing academic, experimental and R&D research.

(1) College graduates entering employment

Looking by industry classification at changes in the percentage of bachelor's degree recipients in "Natural science and engineering" who enter employment (Chart 3-3-4), the percentage of employment in "Manufacturing" was in the 50s during the 1980s. In recent years, however, the percentage fell to the 30s, and in 2012 it dropped to 29.3%. Meanwhile, the percentage of employment in "Service-type industry" within "Non-manufacturing" increased from the 10s to the 30s. Of this, “Education” shrank from the 4% level to the 1% level. “Research” had remained at the 1% level ever since measurements of it began but rose to the 3% level in recent years; it stood at 3.3% in 2012. Additionally, the percentage in "Other non-manufacturing" grew large beginning in 2010.

Chart 3-3-4: College graduates in Natural sciences and Engineering entering employment

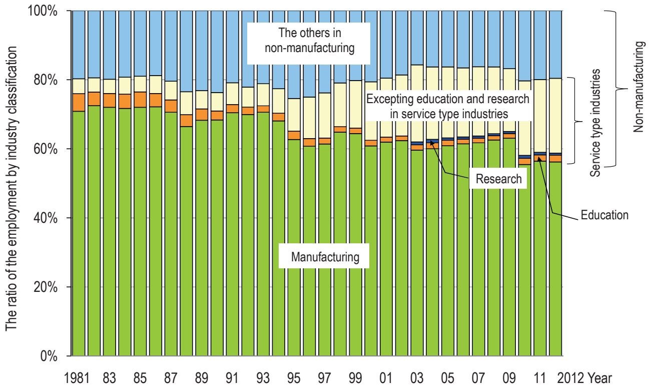


Note: 1) Includes both “persons who entered employment” and “persons who proceeded with more higher education” in the “number of persons who entered employment”.
2) 1981 - 2001
Service-type industry: "Service industry" in Japan Standard Industry Classification (1993 revision)
Education/research: In Japan Standard Industry Classification (1993 revision), "Education" within "Service industries."
2002 – 2006
Service-type industry: In Japan Standard Industry Classifications (revised in 2002), “Information and communication industry”, “Catering establishment, Service industry”, “Medical services, Welfare”, “Education, Study-support service” excludes “School education”: “Combined services”, “unclassified other services” excepting “Academic field/R&D”
Education/research: "School education" within "Education, Study-support services" and "Academic field/R&D" within "Unclassified other services"
2007 -
Service-type industry: In Japan Standard Industry Classifications (revised in 2007), refers to “Academic research, Specialty services” excluding “Academic field/R & D institutions”: “Lodging industry, Catering establishment”, “Living-related services” and “Education, Study-support services” without “School education”: “Medical services, Welfare”, “Combined services”, “unclassified other services” and “Information and communication services”
Education/research: In Japan Standard Industry Classification (2007 revision), "Academic field/R&D institutions" within "Academic research, Specialty services" and ""School education" within "Education, Study-support services"
Source: MEXT, “Report on School Basic Survey”

(2) Master's degree program graduates entering employment

Looking by industry classification at the change in the percentage of graduates from master's degree programs in "Natural sciences and Engineering" entering employment, the percentage finding employment in "Manufacturing" was at the 70% level during the 1980s but trended at the 60% level from the second half of the 1990s; it stood at 56.2% in 2012. The percentage of employment in the "Service-type industry" of "Non-manufacturing" has increased from the 10% to the 20% level. However, the share of "Education" within this category has been decreasing from the 4% level; it stood at 2.0% in 2012. And "Research" is under 1% (Chart 3-3-5).

Chart 3-3-5: Graduates from master's degree programs in Natural sciences and Engineering entering employment

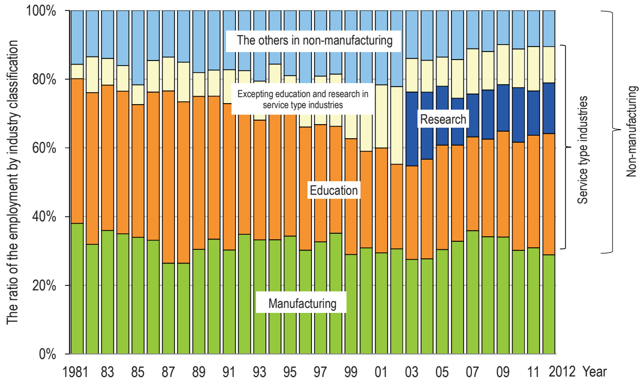


Note: Same as Chart 3-3-4
Source: MEXT, "Report on School Basic Survey"

(3) Doctoral graduates entering employment

Looking by industry classification at changes in the percentage of doctoral graduates in "Natural sciences and Engineering" entering employment, the percentage obtaining employment in "Manufacturing" has generally been around 30%. In 2012, it was 28.9%. The percentage obtaining employment in "Non-manufacturing" was higher than this throughout all periods. Within "Non-manufacturing," the percentage in "Service-type industry" began increasing during the 2000s. In 2012, it was 60.6%. Regarding "Education" among "Service-type industry," this percentage was around 50% in the mid-1980s but fell to under 30% entering the 2000s. It stood at 35.3% in 2012. In 2012, it accounted for 35.3%. The percentage of doctoral graduates finding employment in "Research," which has been measured since 2003, has been large compared with those of graduates receiving bachelor's and master's degrees. In 2012, it was 14.8%; however, this percentage is shrinking (Chart 3-3-6).

Chart 3-3-6: Doctoral graduates in Natural sciences and Engineering entering employment



Note: Same as Chart 3-3-4
Source: MEXT, "Report on School Basic Survey"

3.3.3 The employment status of Natural sciences and Engineering students

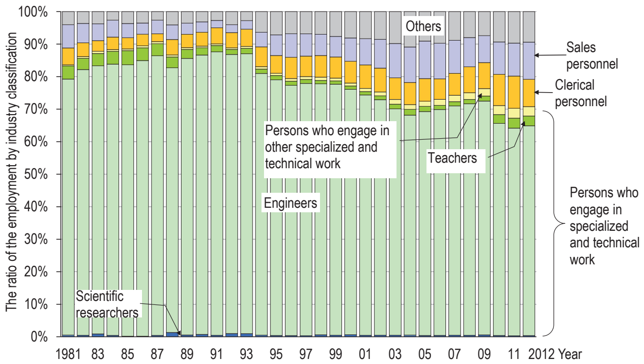
This section shows the place of employment by occupation classification of the students described in section 3.3.1, "The status of employment and education continuance on Natural sciences and Engineering students". Occupation classification referred to herein means the "Japan Standard Occupational Classification" and it classifies individual occupations. Therefore, it is without regard for the business activities of Business enterprises which individuals belong to.

"Researchers" as used herein means "persons who engage in research which requires specialized and scientific knowledge for research and testing in facilities such as laboratories and test stations." "Engineers" mean "persons who engage in scientific and technical work which applies specialized, scientific knowledge and means for production such as project management, supervision and research." "Teachers" are "persons who engage in education and advocacy for students in facilities which provide education such as schools and kindred class of school education". Teachers at universities and colleges are included in this category.

(1) College graduates entering employment

Looking by occupation classification at the employment percentage of "Natural sciences and engineering" college graduates, "Persons who engage in specialized and technical work" was at 80–90% during the 1990s and dropped to the 70s during the 2000s. Breaking this down further, "Engineers" have accounted for a large percentage, but this has been declining over the long term. In 2012, they accounted for 64.5%. The percentage of "persons who engage in clerical work and "sales personnel," on the other hand, has been increasing (Chart 3-3-7).

Chart 3-3-7: The status of Natural sciences and Engineering college graduates by occupation

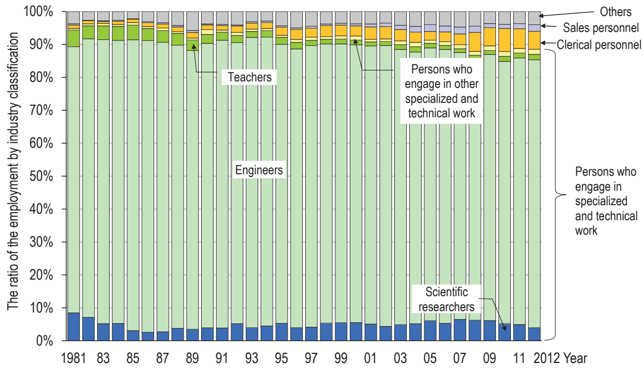


Note: Following a 2011 revision of classifications, researchers are now called "Researchers" rather than "Scientific researchers."
Source: MEXT, "Report on School Basic Survey"

(2) Master's degree program graduates entering employment

Looking at the employment percentage of persons who completed master's program in Natural sciences and Engineering by occupation classification, "persons who engage in specialized and technical work" is approximately 90% of the total and consistently accounts for the large portion. Looking at a breakdown here, "Engineers" has trended at around 80% and thus accounts for a large share. "Researchers" had been trending at around 5 to 6% in recent years, but stood at 3.9% in 2012. The percentage of "Teachers" has been decreasing in the long term, hovering at the 1% level during recent years. On the other hand, "persons who engage in clerical work" has continued to increase slightly (Chart 3-3-8).

Chart 3-3-8: The status of the employment of persons who completed master's program in Natural sciences and Engineering by occupation

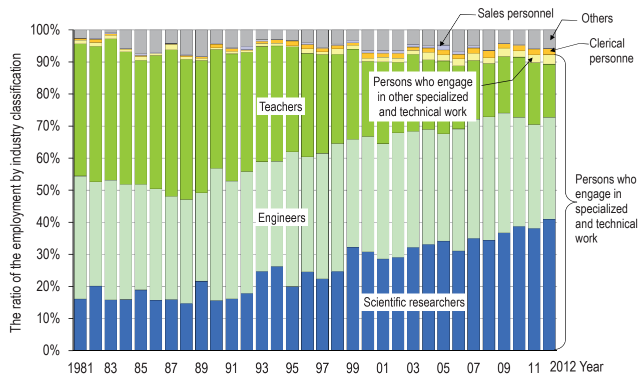


Note: Following a 2011 revision of classifications, researchers are now called "Researchers" rather than "Scientific researchers."
Source: MEXT, "Report on School Basic Survey"

(3) Doctoral graduates entering employment

Looking at the employment percentage of doctoral graduates in Natural sciences and Engineering by occupation classification, "persons who engage in specialized and technical work" comprise a high level of over 90%. A breakdown shows that the percentage of "Engineers" was at 30–40%, while that of "Researchers" was under 20%. Beginning around 2000, however, it began to increase, rising to 41.0% in 2012, thereby surpassing "Engineers." Conversely, the percentage of "Teachers," which had been at around 40%, has been decreasing, falling to 16.6% in 2012 (Chart 3-3-9).

Chart 3-3-9: The status of the employment of doctoral graduates in Natural sciences and Engineering by occupation



Note: Following a 2011 revision of classifications, researchers are now called "Researchers" rather than "Scientific researchers."
Source: MEXT, "Report on School Basic Survey"

3.4 International comparison of degree awarded

Key Points

○Looking at numbers of persons who acquired bachelor's degrees per one million of population, Japan stood at 4,372 in FY 2012. In terms of figures for the most recent available year in the surveyed countries, Korea had the largest number with 6,017. Following were the U.K. with 5,927 and the U.S. with 5,547.

○Looking at the number of persons who acquired master's degrees per 100 million of population in each country, Japan had a small number with 581 (FY 2009). In terms of figures for the most recent available year in the surveyed countries, the U.K. was far ahead of the others with 3,727; the U.S. also had a large number with 2,362 (FY 2008).

○Looking at the number of persons who acquired doctoral degrees per 100 million of population in each country, Japan had 124 (FY 2009), which was small in comparison with the other countries. In terms of figures for the most recent available year in the surveyed countries, the U.K. had the largest number with 323, followed by Germany with 313.

○The number of people who acquires doctoral degrees in Japan had been growing when viewed over the long term. However, this growth slowed upon entering the 2000s and began decreasing after peaking in FY 2006.

3.4.1 International comparison of the number of bachelor's degrees, master's degrees and doctorates degrees awarded

This section looks at the numbers of bachelor's, master's, and doctoral degrees awarded per 100 million of population in each of the surveyed countries. Here, the number of persons awarded degrees is calculated as the number of people who newly received an academic degree for each year. Given that there are differences in the content of degrees from country to country, this discussion focuses on those people who have acquired degrees equivalent to bachelor's, master's, and doctoral degrees awarded in Japan (for details, see the cautionary notes in each chart).

In recent years, Germany has begun adopting the common European standards for undergraduate (bachelor's) and graduate (master's) degrees in addition to its traditional first university degree, the Diplom. Traditionally, only those passing a national examination (the Diplom exam) after graduating had been counted as degree holders. In the most recent year, however, those passing the national exam, those completing specialized college, and those receiving first university degrees were all counted.

In addition, data on master's degrees is now calculated.

(1) Number of bachelor's degrees awarded per 1 million of population

Looking at numbers of persons who acquired bachelor's degrees per one million of population, Japan stood at 4,372 in FY 2012. The country with the largest number for the most recent available year was Korea with 6,017. Following were the U.K. with 5,927 and the U.S. with 5,547.

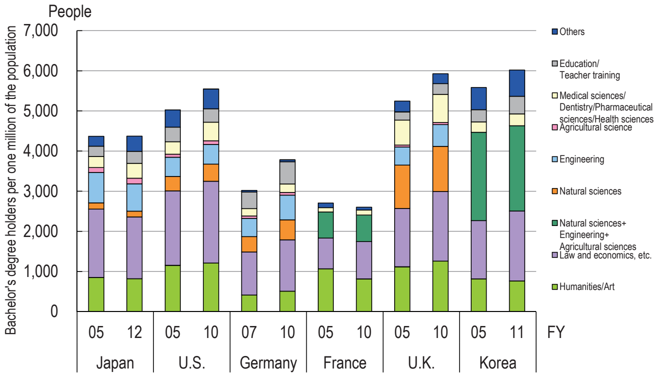
On the other hand, countries with lower figures than Japan for the most recent available year were Germany (3,784) and France (2, 601).

A comparison of growth rates between FY 2005 (FY 2007 in the case of Germany) and the most recent available year shows that Germany had the largest with 1.25 times, followed by the U.K. with 1.13 times and Korea with 1.08 times. Japan's growth rate stayed flat while France's declined.

When the composition ratio is divided according to subjects of special study, such as "Natural science and engineering" ("Natural sciences," "Engineering," "Agricultural sciences" and "Medical sciences," etc.) and "Social sciences and humanities" ("Social science," "Art," "Law," etc.), each country had a large percentage in "Social sciences and humanities". The percentage in France was particularly high, accounting for 70%. In Japan and the U.S., it accounted for about 60%. In contrast, it accounted for around 40% in Korea, about the same as "Natural science and engineering". In the U.K., "Natural science and engineering" accounts for about 50%.

Chart 3-4-1: The international comparison of the number of bachelor's degrees awarded per one million of the population

(A) Bachelor's degrees awarded



Note: <Japan> Accounted for college graduates as of March in the year noted. "Others" are "General education course", "International relations" and "Mercantile marine". 2011 is used for 2012 population data.

<U.S.> Accounted for bachelor's degrees awarded in the year starting from September of the year represented. "Science of medicine, Dentistry, Pharmaceutical sciences and Health sciences" include "Veterinary medicine". "Others" includes "Military science" and "Interdisciplinary science". Field classifications are based on the classification method used in "International Comparison of Education Statistical Indicators."

<Germany> The number of successful applicants for the Diplom Examination in the winter term of the year indicated and the summer term of the following year, the number of successful applicants for Teacher Testing (national exam), the number completing specialized college, and the number receiving bachelor's degrees (standard three-year course).

<France> The number of college graduates in the year represented (calendar year). Bachelor's degree of national universities and colleges (3 years) and first degree in Science of medicine/Dentistry/Pharmaceutical sciences. The number of conferred "Diplome de docteur" (5 – 8.5 years).

<U.K.> Accounted for the number of first degrees awarded from universities and higher education colleges

<Korea> The number of college graduates of March in the year represented. "Humanities/Art" is for "Humanities" alone, and "Art" is included in "Others".

Source: U.S.: NCES, IPEDS, "Digest of Education Statistics."
Other countries: MEXT, "International Comparison of Education Statistical Indictors."
Population of each country is the same as for Reference Statistics A.

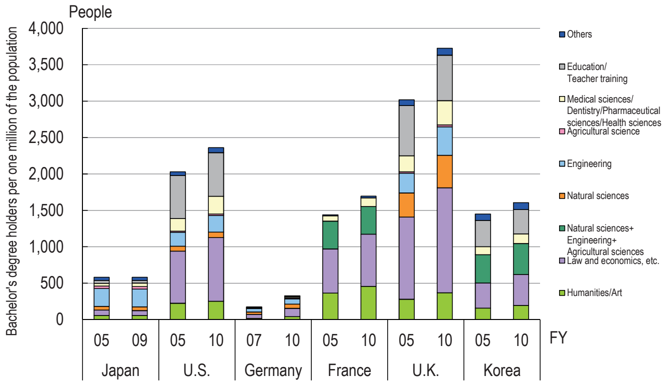
(2) Number of master's degrees awarded per 1 million of population

Looking at the number of persons who acquired master's degrees per 100 million of population in each country, Japan had a small number with 581 (FY 2009). In terms of figures for the most recent available year, the U.K. was far ahead of the others with 3,727; the U.S. also had a large number with 2,362 (FY 2008). Moreover, France and Korea had numbers that were three times Japan's, recording 1,695 and 1,607, respectively. It should be noted that Germany had the lowest number with 327, a figure resulting from the fact that its master's course system had only recently been institutionalized.

A comparison of growth rates between FY 2005 (FY 2007 in the case of Germany) and the most recent available year of each country shows that Germany had the largest with 1.89 times. Following were the U.K. with 1.23 times, France with 1.18 times, and Korea with 1.11 times. On the other hand, Japan's rate has been flat.

As for composition ratio by field of study in Japan, natural science and engineering accounted for about 60%, double the share in bachelor's degrees. Humanities and social sciences accounted for less than half. In the other countries, the ratio was roughly the same as that for bachelor's degrees awarded. They did not show the degree of change that Japan did.

(B) Master's degrees awarded



Note: <Japan> Accounted for the number of master's degrees awarded from April of the year represented to March of the following year.

<U.S.> Accounted for the number of master's degrees awarded in the year starting from September of the year represented.

<Germany> Accounted for the number of master's degrees (standard one- or two-year course) awarded in the winter term of the year indicated or the summer term of the following year

<France> The number of master's degrees awarded (5 years) in the year represented (calendar year). Accounted for "Natural sciences", "Engineering" and "Agricultural sciences" together.

<U.K.> Accounted for the number of advanced academic degrees awarded from universities and higher education colleges in the year represented (calendar year).

<Korea> The number of master's degrees awarded from March of the year represented to February of the following year. Accounted for "Natural sciences", "Engineering" and "Agricultural sciences" together.

Source: The same as Chart 3-4-1

(3) Number of doctoral degrees awarded per 1 million of population

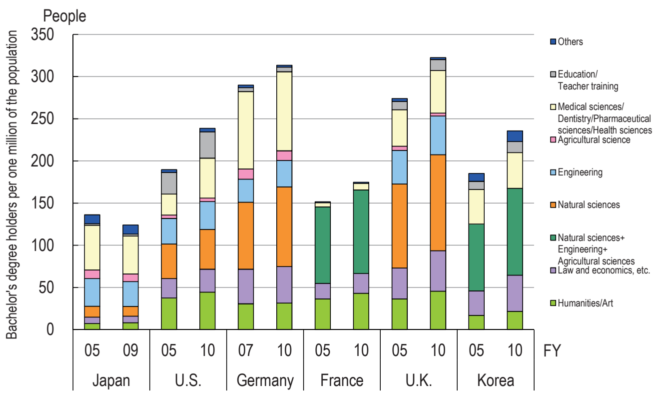
When looking at the number of doctoral degrees awarded in each country per one million heads of the population, Japan had about 124 (in FY 2009), which is less than in other countries. The country with the highest number was the U.K. with 323, followed by Germany with 313. The number for the U.S. was 239 and that for Korea was around the same at 236. The number for France was 175.

A comparison of growth rates between FY 2005

(FY 2007 in the case of Germany) and the most recent available year of each country shows that Japan’s rate is declining at 0.91 times. The country with the strongest growth was Korea at 1.27 times, followed by the U.K. with 1.18 times, France with 1.15 times, and Germany with 1.08 times. The U.S. had growth of 1.26 times (see the cautionary notes for Chart 3-4-1 (C) regarding data on the U.S.).

As for composition ratio by field of study, in case of doctoral degrees awarded, the percentage for natural sciences and engineering was high in every country. The ratio was especially high in Japan at about 80%. "Medical sciences / Dentistry / Pharmaceutical sciences/Health sciences" accounted for the largest share of that figure. The percentage for natural science and engineering was high in Germany as well, accounting for about 70% of the total. As in Japan, "Medical sciences/Dentistry/Pharmaceutical sciences/Health sciences" accounted for a large share, although "Natural sciences" did so as well. In France, the ratio of bachelor's and master's degrees awarded in "Social sciences and humanities" was high. For doctoral degrees, however, natural science and engineering accounted for about 60%.

(C) Doctoral degrees awarded



Note: <Japan> Accounted for the number of doctoral degrees awarded from April of the year represented to March of the following year.

<U.S.> Accounted for the number of doctoral degrees awarded in the year starting from September of the year represented. Here, figures for doctoral degrees awarded subtract figures for “legal economics,” “medicine, dentistry, pharmacy, and health care,” and “others” of first-professional degrees (bachelor of medicine and bachelor of law) from figures for “doctor’s degrees” that are noted in the “Digest of Education Statistics 2012.”

<Germany> Accounted for the number of successful applicants in the examination for doctoral degree in winter term of the year represented and summer term of the following year.

<France> The number of doctoral degrees awarded (8 years) in the year represented (calendar year). Accounted for “Natural sciences”, “Engineering” and “Agricultural sciences” together.

<U.K.> Accounted for the number of advanced academic degrees awarded from universities and higher education colleges in the year represented (calendar year).

<Korea> The number of doctoral degrees awarded from March of the year represented to February of the following year. Accounted for “Natural sciences”, “Engineering” and “Agricultural sciences” together.

Source: The same as Chart 3-4-1

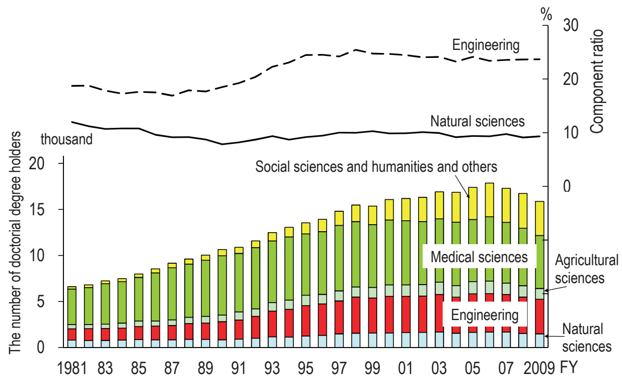
3.4.2 Doctoral degrees awarded in Japan

This section examines trends surrounding doctoral degrees awarded in Japan by major field of study.

A look at Chart 3-4-2 shows that the number of doctorates awarded in FY 2009 was 15,872. When viewed over the long term, the number had been showing continual increases; however, this growth slowed upon entering the 2000s and began decreasing after peaking in FY 2006.

A breakdown of the number for FY 2009 by major field of study shows medical sciences (medicine, dentistry, pharmacy, and health care) had the highest share with 5,762, or 36.3% of the total. Engineering accounted for 3,758 (23.7%) and natural science for 1,480 (9.3%).

Chart 3-4-2: Changes in number of doctoral degrees awarded



Note: 1) “Medical sciences” is for “Science of medicine”, “Dentistry”, “Pharmaceutical sciences” and “Health sciences”.
2) “Education”, “Art” and “Home economics” are included in “Education”.

Source: Until the FY 1986, surveyed by Education Research Center, Hiroshima University “Higher Education Statistical Data (1989)”
After the FY 1987, surveyed by MEXT

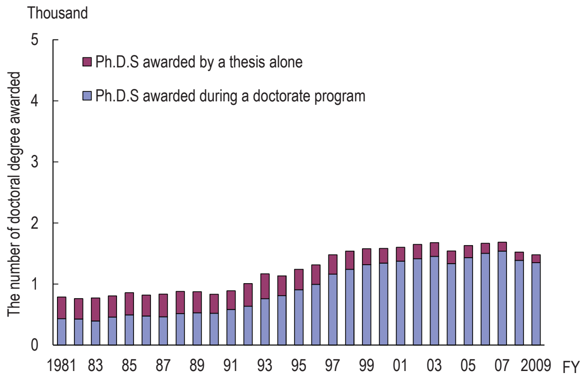
Chart 3-4-3 shows changes in the number of doctoral degrees awarded in natural sciences and engineering by a breakdown of degrees awarded during a doctorate program and those awarded by a thesis alone.

In 2009, the number of doctoral degrees awarded in natural sciences broke down into 1,352 awarded during a doctoral program and 128 conferred by a thesis alone. Looking at the breakdown of Ph.D.s awarded during a doctoral program and Ph.D.s awarded by a thesis alone, the number of Ph.D.s awarded during a doctoral program exceeds the number of Ph.D.s conferred by a thesis alone throughout the years. It should be noted that the increase in the number of degrees awarded in recent years has been almost entirely due to those awarded during a doctorate program; however, this number is decreasing following a peak in FY 2006.

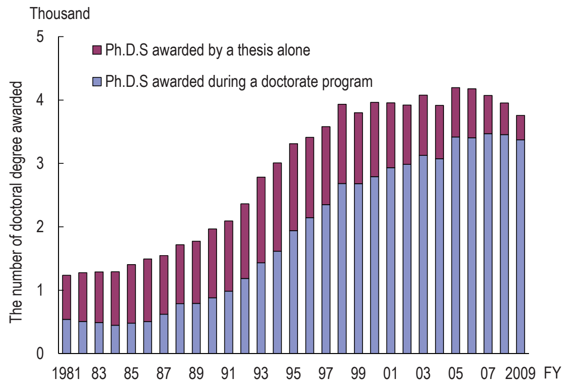
In 2009, the number of doctoral degrees awarded in engineering broke down into 3,372 awarded during a doctoral program and 386 awarded by a thesis alone. Looking at a breakdown, the number of degrees awarded by a thesis alone had surpassed those awarded during a doctorate program until the first half of the 1990s. However, since then, the number awarded during a doctorate program has rising remarkably, and recent increases in the number of degrees awarded are due almost entirely to such degrees. In FY 2009, 90% of all degrees awarded were those warded during a doctoral program. It should be mentioned, however, that the number of degrees awarded during a doctorate program has also begun decreasing in recent years.

Chart 3-4-3: Changes in number of doctoral degrees awarded (by degrees award during a doctorate program/by a thesis only)

(A) Natural sciences



(B) Engineering



Note: Same as Chart 3-4-2.
Source: Same as Chart 3-4-2

3.5 Foreign students in institutions of higher education

Key Points

○Looking at the state of foreign graduate students in Japan and the U.S., Japan had 16,000 foreign graduate students in 2012. Chinese graduate students accounted for the largest number, 8,000, which was half the total. In the U.S., there were 176,000 foreign graduate students in 2010. Indian students accounted for the largest number, with 62,000.

○As for where the most foreign students from the different countries enroll in institutions of higher education, the U.S. accounts for the largest numbers of students from Japan, China and Korea. The largest numbers of students from Germany and France are enrolled in the U.K. The largest number of students from the U.K. is enrolled in the U.S., and the largest number of students from the U.S. is enrolled in the U.K.

3.5.1 Foreign graduate students in Japan and the U.S.

This section discusses the state of foreign students in graduate schools, which train researchers and advanced specialist. These foreign graduate students can be considered an indicator of globalization in higher education. Chart 3-5-1 shows the number of foreign students from the top 10 countries registered in graduate schools in Japan and the U.S. each year. The fields are "Natural science and engineering" in Japan and "Science and engineering" in the U.S.

As seen in the chart, Japan had 16,000 foreign graduate students in 2012. Chinese graduate students accounted for the largest number, 8,000, which was half the total. There was a considerable gap between first and second place, with the next highest total being 1,000 (from North and South Korea).

In the U.S., there were 176,000 foreign graduate students in 2010. Indian students accounted for the largest number, with 62,000, followed by 47,000 Chinese students. The gap between first and second place was not as large proportionally as it was in Japan.

Comparing the most recent available years for Japan and the U.S., the U.S. has about 10 times as many foreign graduate students as Japan. Indian students, who rank number one in the U.S., are only in eighth place in Japan. Graduate students from European countries such as Germany, the U.K. and France did not make the top 10 in either Japan or the U.S.

Chart 3-5-1: Foreign graduate students in Japan and the U.S.

(A) Japan: Natural sciences and engineering

(Unit: people)

No.	Country/Region	2007	2008	2009	2010	2011	2012
1	China	5,464	5,592	6,014	7,211	8,089	8,138
2	Korea	1,412	1,393	1,431	1,582	1,614	1,498
3	Indonasia	599	612	703	864	916	982
4	Vietnam	474	538	664	689	765	812
5	Thailand	529	508	571	629	694	689
6	Bangladesh	624	590	597	598	555	493
7	Malaysia	300	333	370	462	484	459
8	India	182	162	199	215	255	236
9	Menggu	128	129	159	185	164	178
10	Nepal	155	159	174	177	171	164
	France	66	81	86	92	115	105
	U.S.	67	71	83	97	101	91
	Germany	32	30	32	41	39	36
	U.K.	26	27	27	20	23	32
	Total	12,343	12,518	13,458	15,274	16,368	16,220

(B) U.S.: Science and engineering

(Unit: people)

No.	Country/Region	2006	2007	2008	2009	2010
1	India	38,862	46,743	50,290	61,420	62,450
2	China	30,862	32,167	33,140	42,440	47,370
3	Korea	10,120	10,068	9,830	10,120	9,210
4	Taiwan	5,869	6,084	5,980	6,530	6,100
5	Turkey	3,407	3,420	3,330	3,480	3,260
6	Canada	2,105	2,094	2,090	3,120	2,690
7	Nepal	1,119	1,416	1,630	2,220	2,310
8	Japan	2,674	2,508	2,240	2,060	1,710
9	Mexico	1,190	1,325	1,380	1,500	1,470
10	Colombia	1,195	1,276	1,310	1,480	1,370
	U.K.	825	830	×	840	810
	France	1,021	1,035	1,020	×	×
	Germany	1,310	1,348	1,350	×	×
	Total	131,455	141,767	146,020	172,250	176,120

Note: 1) For Japan, foreign students are those without Japanese citizenship. For the U.S., foreign students are those without U.S. citizenship.
2) In the U.S. chart, "X" indicates no data were available.

Sources: <Japan> MEXT, "Report on School Basic Survey"
<U.S.> NSF, "Science and Engineering Indicators 2006, 2008, 2010, 2012"

3.5.2 Foreign students in institutions of higher education in selected countries

Chart 3-5-2 shows changes in the number of foreign students at institutions of higher education in each country. As used here, "foreign students" are students who are not citizens of their host countries (including international students). Although trends in their numbers do not change as much as those of international students, the degree to which students from different countries have a presence in various countries is examined.

Turning first to Japan's situation, in 2010, the largest number of foreign students was from China, at 87,000. It was followed by Korea, with about 26,000 students in Japan. In contrast, there were 2,000 students from the U.S., and less than 500 each from Germany and the U.K. Looking at trends, China has continued to grow at a rate that far exceeds the others. It has showed record high numbers in recent years, despite a brief lag in 2008. The other countries are also showing increasing numbers, albeit at lower levels.

Looking at the situation in the U.S., Chinese students accounted for the largest number in 2010 at 126,000. It was followed by Korea with 72,000 students, and Japan with 25,000. The numbers of students from both China and Korea have been increasing, but the number from Japan has been decreasing. Although there were about 25,000 students from Japan in the U.S. during 2010, there were far fewer, less than 10,000, from Europe.

In Germany as well, Chinese students accounted for the highest number, with 24,000 in 2010. The trend, however, has been downward since about 2006. French students account for the next largest number, with 7,000. At 5,000, the number of Korean students is also large. There are only about 2,000 Japanese students in Germany, but that is more than there are from the U.K.

Chinese students also account for the largest number in France, with 25,000 in 2010, and the number has been increasing. German students account for the next largest number, with 7,000. All the other selected countries had roughly similar numbers of students in France, i.e., about 2,000–3,000 each.

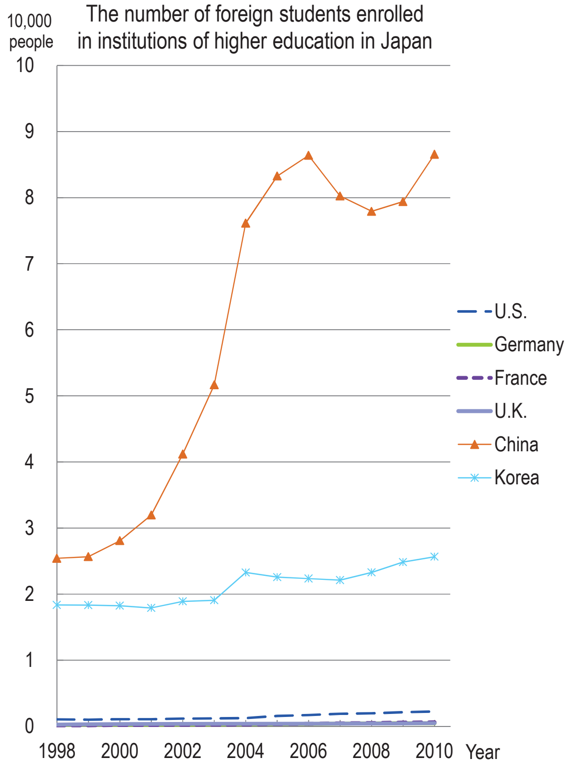
Even in the case of the U.K., China accounted for the highest number of students, exceeding 62,000 in 2010. The next largest number of foreign students, 20,000, was from Germany. The number of students from Japan has been on a downward trend during recent years. There were 4,000 Japanese students in the U.K. during the most recent available year.

There are also many Chinese students in Korea. Their number reached 46,000 in 2010 and is continuing to show consistent growth. The next largest number of students was from Japan, but they only numbered about 1,000.

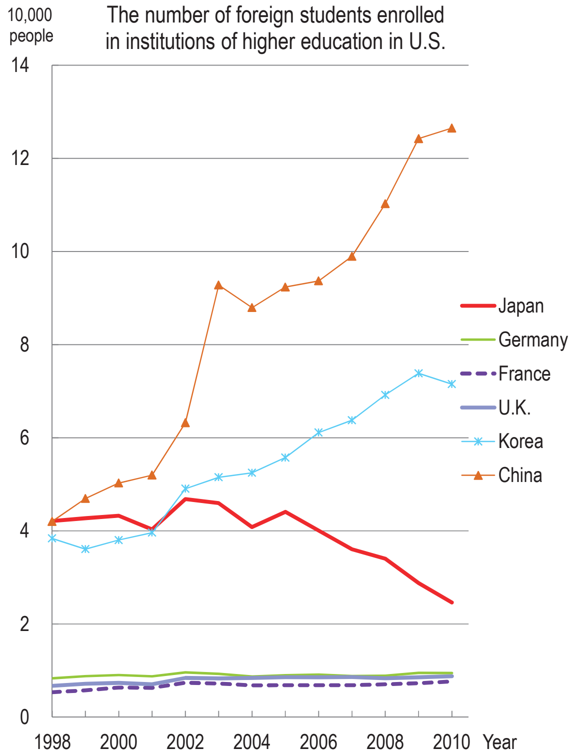
As for where the most foreign students from the different countries enroll in institutions of higher education, the U.S. accounts for the largest numbers of students from Japan, China and Korea. The largest numbers of students from Germany and France are enrolled in the U.K. The largest number of students from the U.K. is enrolled in the U.S. The largest number of students from the U.S. is enrolled in the U.K.

Chart 3-5-2 The number of foreign students enrolled in institutions of higher education in selected countries

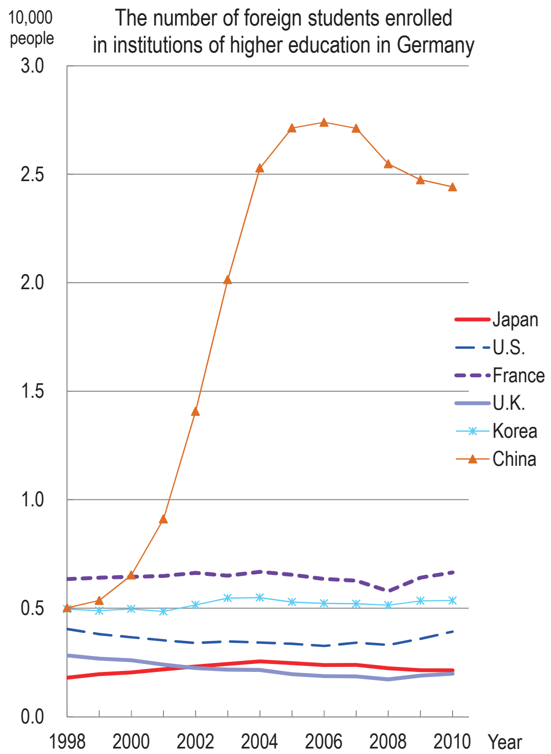
(A) Japan



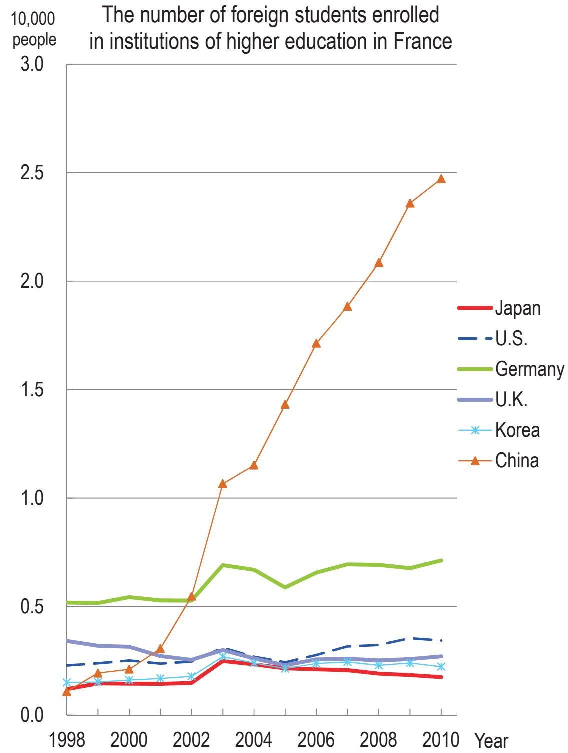
(B) U.S.



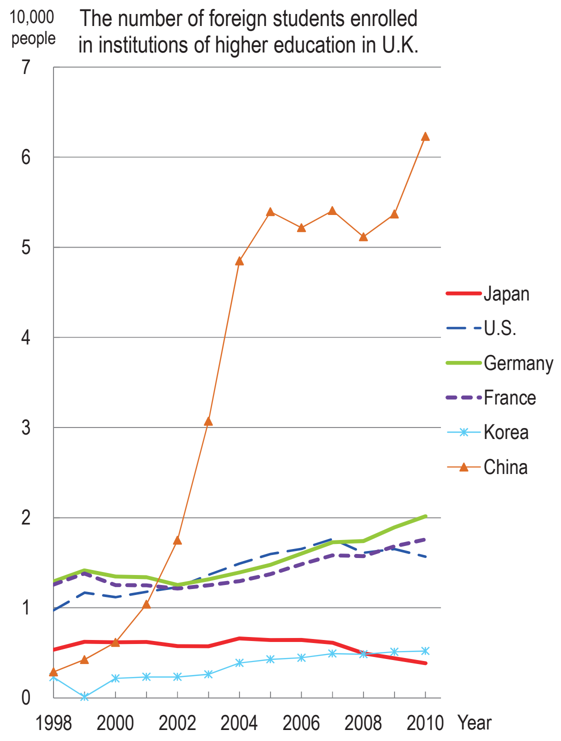
(C) Germany



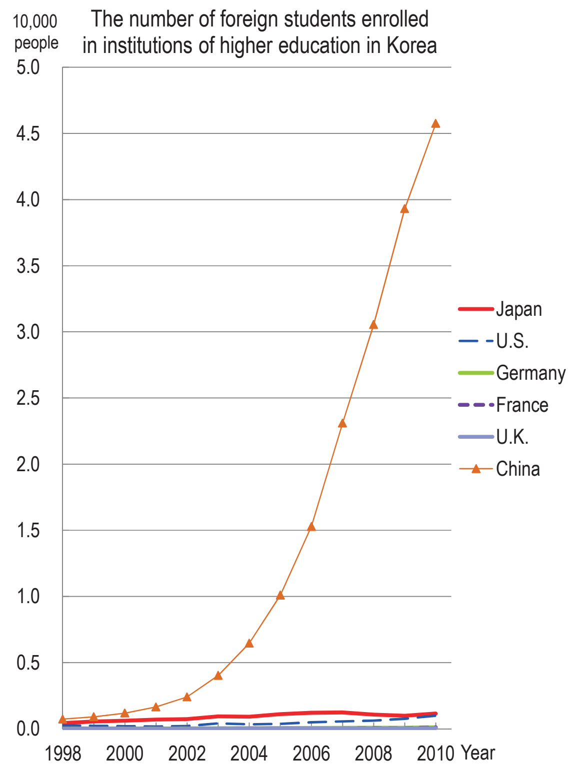
(D) France



(E) U.K.



(F) Korea



Note: Foreign students are students who are not citizens of their host countries.
For the U.S., numbers are for foreign students through 2003 and for international students (non-citizen students without permanent or long-term residency) from 2004 on.
Sources: OECD Stat (via internet)

Column: Ranking of the medal count in the International Science Olympiad

The International Science Olympiads are international competitions in science and technology for secondary students in participating countries. Their purposes are to find talented students in various countries and provide them with opportunities to develop their talents, to facilitate international interactions among students and educators and to promote the development of the relevant research areas. The results of each Olympiad are generally announced by the host country's secretariat. They are not collected in one source. The results of the Olympiads in mathematics, physics, chemistry, biology and informatics have therefore been collected here for comparison at three time points.

In the International Science Olympiads, more than one set of medals is awarded. The number of Gold, Silver and Bronze Medals awarded and the number of participants vary by Olympiad. The order of the rankings used here is determined by the number of Gold Medals won by each country. In the event of a tie in Gold Medals, rank is determined by the number of Silver Medals, and then Bronze Medals if necessary. In the event a tie is still not broken, the countries are assigned the same rank and listed in alphabetical order. The performances of major countries appearing in the Science and Technology Indicators, such as Japan, the U.S., Germany, France, the U.K., China and Korea, is noted even when they fall outside the top 10.

Looking at Chart 3-6-1, in each Olympiad the performances of East Asian nations such as China and Korea stand out. Countries such as Iran and Vietnam began appearing in the top 10 in 2000.

As for Europe, Russia and other Eastern European nations appear in the top 10 more often than Western European nations such as Germany, France and the U.K. do. Countries such as Romania and Belarus also began appearing often in the top 10 in 2000. The U.S. appears in the top 10 in almost every Olympiad.

Japan only began participating in all the Olympiads in recent years. It began participating in the Mathematical Olympiad in 1990, but it first joined in the International Physics Olympiad in 2006 and in the International Chemistry Olympiad in 2003. Japan participated in the International Olympiad in Informatics from 1994 through 1997, but then stopped before joining in again starting in 2006. It began participating in the International Biology Olympiad in 2005.

Japan thus began participating later than other countries did. However, it has posted excellent results, usually finishing in the top 10 in each Olympiad.

Japan began a support program for this type of international science and technology competition in 2004. Its goals are to provide outstanding math and science students with opportunities to learn and to contribute to the fostering of future researchers who can meet international standards. In addition, the program supports the holding of international science and technology competitions themselves.

Some universities have set up admission systems that give special weight on entrance examinations to good performances in one of the Olympiads. For the universities, this provides an opportunity to train human resources with demonstrated academic and problem-solving ability in specific fields.

(Yumiko Kanda)

Chart 3-6-1: Medal counts in the International Science Olympiads

	Mathematics														
2000					2006					2012					
Rank	County/Region	Gold	Silver	Bronze	Rank	County/Region	Gold	Silver	Bronze	Rank	County/Region	Gold	Silver	Bronze
1	China	6	-	-	1	China	6	-	-	1	Korea	6	-	-
2	Russia	5	1	-	2	Korea	4	2	-	2	U.S.	5	1	-
3	Korea	3	3	-	3	Germany	4	-	2	3	China	5	-	1
3	U.S.	3	3	-	4	Iran	3	3	-	4	Russia	4	2	-
5	Taiwan	3	2	1	4	Russia	3	3	-	5	Thailand	3	3	-
5	Vietnam	3	2	1	6	Romania	3	1	2	6	Iran	3	2	1
7	Bulgaria	2	3	1	7	U.S.	2	4	-	7	Canada	3	1	2
7	Iran	2	3	1	8	Japan	2	3	1	8	Romania	2	3	1
9	Belarus	2	2	2	9	Vietnam	2	2	2	9	India	2	3	-
10	Ukraine	2	2	-	10	Italy	2	2	-	10	North Korea	2	1	3
15	Japan	1	2	3	20	France	1	-	3	18	U.K.	1	1	4
17	Germany	1	1	2	23	U.K.	-	4	1	26	Japan	-	4	1
20	U.K.	-	2	4						34	Germany	-	2	3
43	France	-	-	3						41	France	-	1	4

Physics														
2000					2006					2012				
Rank	County/Region	Gold	Silver	Bronze	Rank	County/Region	Gold	Silver	Bronze	Rank	County/Region	Gold	Silver	Bronze
1	China	5	-	-	1	China	5	-	-	1	China	5	-	-
2	Russia	2	2	1	2	Indonesia	4	1	-	1	Taiwan	5	-	-
3	Hungary	2	-	3	2	Korea	4	1	-	3	Korea	3	2	-
4	India	2	-	2	4	U.S.	4	1	-	3	Russia	3	2	-
4	Taiwan	2	-	2	5	Taiwan	3	1	1	5	U.S.	3	2	-
6	Bulgaria	1	-	-	6	Russia	2	3	-	6	Thailand	3	1	1
6	Switzerland	1	-	-	7	Germany	2	1	2	7	Singapore	3	-	-
8	Iran	-	3	2	7	India	2	-	3	8	Japan	2	3	-
9	Korea	-	3	-	9	Canada	2	-	1	9	Belarus	2	2	1
10	U.S.	-	1	4	10	Hungary	1	4	-	9	Germany	2	2	1
					10	Iran	1	4	-	9	Hong Kong	2	2	1
					10	Thailand	1	4	-					
16	Germany	-	-	2	21	France	-	2	3	23	France	-	4	1
16	U.K.	-	-	2	23	Japan	-	1	3	28	U.K.	-	2	3
Japan was nonparticipation (joined in 2006)					33	U.K.	-	-	5					
France was nonparticipation (joined in 2001)														

Chemistry														
2000					2006					2012				
Rank	County/Region	Gold	Silver	Bronze	Rank	County/Region	Gold	Silver	Bronze	Rank	County/Region	Gold	Silver	Bronze
1	Russia	4	-	-	1	China	4	-	-	1	Korea	4	-	-
2	China	3	1	-	2	Korea	3	1	-	2	Taiwan	3	1	-
3	Hungary	2	2	-	2	Russia	3	1	-	2	India	3	1	-
3	Taiwan	2	2	-	2	Taiwan	3	1	-	2	Russia	3	1	-
5	Austria	2	1	1	5	Vietnam	2	2	-	5	China	2	2	-
5	Slovakia	2	1	1	6	Poland	2	1	1	5	Japan	2	2	-
7	U.S.	2	-	2	7	Japan	1	3	-	5	Singapore	2	2	-
8	Belarus	1	2	1	8	Canada	1	2	1	8	U.S.	1	3	-
8	Iran	1	2	1	8	Denmark	1	2	1	9	Belarus	1	2	1
8	Turkey	1	2	1	8	Germany	1	2	1	9	Czech Republic	1	2	1
8	Vietnam	1	2	1	8	India	1	2	1	9	Germany	1	2	1
					8	Singapore	1	2	1	9	Kazakhstan	1	2	1
					8	Thailand	1	2	1	9	Romania	1	2	1
					8	Ukraine	1	2	1	9	Ukraine	1	2	1
										9	Vietnam	1	2	1
12	Korea	1	1	2	18	U.S.	-	3	1	26	U.K.	-	2	2
15	Germany	-	4	-	25	France	-	2	1	40	France	-	-	4
32	France	-	-	4	26	U.K.	-	1	3					
32	U.K.	-	-	4										
Japan was nonparticipation (joined in 2003)														

Informatics														
2000					2006					2012				
Rank	County/Region	Gold	Silver	Bronze	Rank	County/Region	Gold	Silver	Bronze	Rank	County/Region	Gold	Silver	Bronze
1	Russia	4	-	-	1	China	4	-	-	1	China	4	-	-
2	Romania	2	2	-	2	Poland	3	1	-	1	Russia	4	-	-
3	Canada	2	1	1	3	Russia	3	-	1	3	Romania	3	-	1
3	China	2	1	1	4	Romania	2	1	1	3	U.S.	3	-	1
3	Iran	2	1	1	5	Belarus	2	1	-	5	Iran	2	2	-
6	Poland	2	1	-	6	Japan	2	-	1	6	Belarus	2	1	1
7	U.S.	1	2	1	7	Korea	1	3	-	7	Croatia	1	3	-
7	Vietnam	1	2	1	7	U.S.	1	3	-	7	Japan	1	3	-
9	Israel	1	2	-	9	Iran	1	2	1	7	Poland	1	3	-
10	Korea	1	1	2	9	Ukraine	1	2	1	10	Bulgar	1	2	-
19	Germany	-	2	2	27	France	-	1	2	11	Korea	1	1	2
28	U.K.	-	1	2	42	Germany	-	-	2	26	France	-	1	2
39	France	-	-	2	42	U.K.	-	-	2	26	U.K.	-	1	2
Japan was nonparticipation (joined in 2006)										32	Germany	-	1	1

Biology														
2000					2006					2012				
Rank	County/Region	Gold	Silver	Bronze	Rank	County/Region	Gold	Silver	Bronze	Rank	County/Region	Gold	Silver	Bronze
1	Korea	4	-	-	1	China	4	-	-	1	Singapore	4	-	-
2	Taiwan	3	1	-	2	Korea	3	1	-	1	U.S.	4	-	-
3	China	2	2	-	2	Taiwan	3	1	-	3	China	3	1	-
4	Russia	2	1	1	2	Thailand	3	1	-	3	Taiwan	3	1	-
5	Turkey	1	3	-	5	Singapore	2	2	-	3	Korea	3	1	-
6	Australia	1	2	1	5	U.S.	2	2	-	6	Estonskaya	2	2	-
6	Belarus	1	2	1	7	Australia	1	3	-	6	Russia	2	2	-
6	Ukraine	1	2	1	8	Turkey	1	1	2	8	Thailand	2	1	1
9	Vietnam	1	-	1	9	Ukraine	1	-	3	9	Canada	1	1	1
10	Germany	-	3	1	10	India	-	3	1	10	Slovenia)	1	-	1
10	Thailand	-	3	1	10	Iran	-	3	1					
					10	U.K.	-	3	1					
14	U.K.	-	1	3	13	Germany		2	2	11	Germany	-	4	-
Japan was nonparticipation (joined in 2005)					27	Japan			3	11	Japan	-	4	-
U.S. was nonparticipation (joined in 2004)										11	U.K.	-	4	-
France was nonparticipation (joined in 2007)					France was nonparticipation (joined in 2007)					It is unknown whether France will participate.				

Note: Team sizes for the various Olympiads are six people or fewer for Mathematics, five or fewer for Physics, four or fewer for Chemistry, four or fewer for Biology and four or fewer for Informatics.
Sources: Each Olympiad's website created by NISTEP.

Chapter 4: The output of R&D

In recent years, accountability for investments in R&D has become strongly demanded, and understanding the output of R&D has become a major theme. This chapter introduces changes in and features of the world's and main countries' R&D activities, focusing attention on scientific papers and patents as measurable output of such R&D activities.

4.1 Scientific Papers

Key Points

○The quantity of papers, which are the output of the world's research activities, has consistently shown an upward trend.

○Research activities themselves have changed from the activities of a single country into joint activities that are conducted by multiple countries. The number of internationally co-authored papers is increasing worldwide. In 2012, the international co-authorship rate stood at 55% for the U.K. and France and 53% for Germany. These figures are in contrast with 36% for the U.S. and 28% for Japan.

○Regarding the number of papers produced in Japan (the average from 2010-2012), using fractional counting (degree of contribution to the production of papers), Japan ranked third behind the U.S. and China. In terms of number of adjusted top 10% papers, Japan ranked sixth behind the U.S., China, U.K., Germany, and France. And in terms of number of adjusted top 1% papers, Japan ranked 7th behind the U.S., China, U.K., Germany, France, and Canada.

○On the other hand, when based on whole counting (degree of contribution to the production of papers: fractional counting + overseas contribution through internationally co-authored papers), Japan ranked fifth in terms of number of research papers produced, eighth in number of adjusted top 10% papers, and tenth in number of adjusted top 1% papers.

○Looking at the balance of the fields in Japan, the shares of Chemistry and Basic life sciences have decreased significantly, while that of Clinical medicine has increased significantly. Thus the makeup of fields covered in Japan's paper production is changing substantially.

○Meanwhile, looking at field portfolios by world share, Japan is weighted towards Physics, Chemistry, and Material science, with low weight on Computer science/Mathematics and Environment/Geoscience.

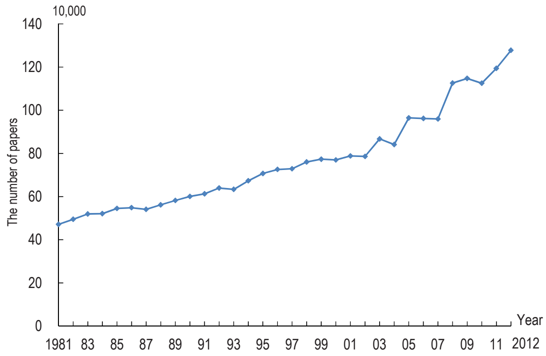
4.1.1 Quantitative and qualitative changes in research activities in the world

(1) The change in the numbers of papers

Chart 4-1-1 shows the change in the quantity of the world's papers. Revisions to the bibliographic data on papers in the Thomson Reuters database are made when necessary. Consequently, it must be remembered that the figures of the Chart for this year's chart and that of the previous "Science and Technology Indicators 2012" (August 2012) do not match.

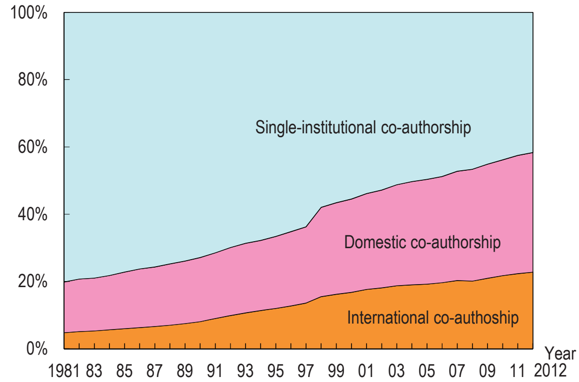
Compared with the early 1980s, the quantity of papers presented in the world has more than doubled, and the world's research activities have a consistent tendency to expand from a quantitative standpoint today. For this period, journals recorded in Databases, which have been used for analysis, were revised in order of precedence, and the numbers of the journals has been enlarged. This factor is contributing to expanding the numbers of papers as well.

Chart 4-1-1: The change in the numbers of papers in the world



Note: The analysis targeted articles, articles & proceedings (for handling as articles), letters, notes, and reviews.
Source: Compiled by NISTEP based on Thomson Reuters "Web of Science" (SCIE, CPCI: Science)

Chart 4-1-2: The change in the ratio of the co-authorship forms in the world



Note: The analysis targeted articles, articles & proceedings (for handling as articles), letters, notes, and reviews.
Source: Compiled by NISTEP based on Thomson Reuters Web of Science (SCIE, CPCI: Science)

(2) Changes in the style of the production of papers in the world and selected countries

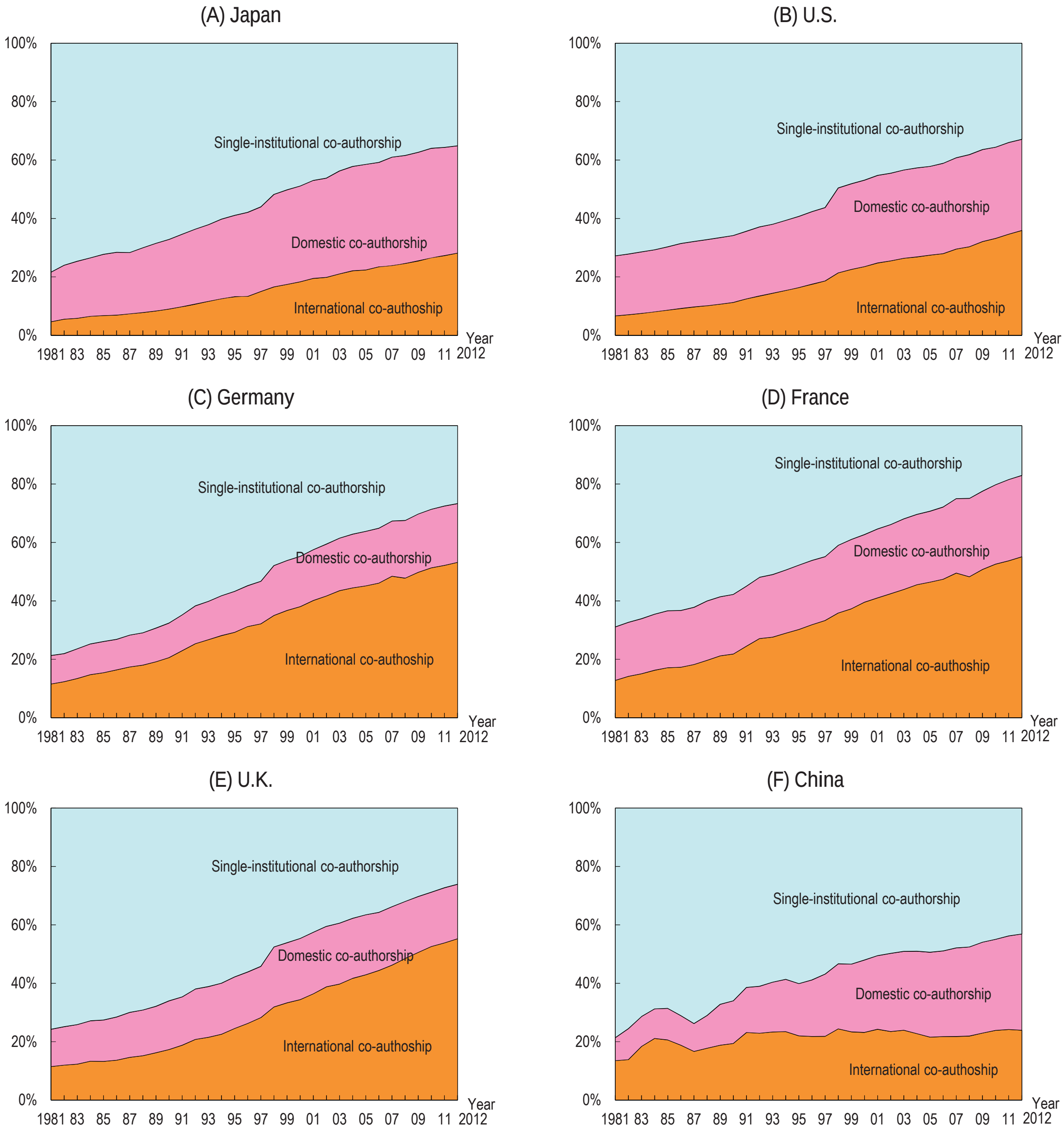
While research activities in the world have moved toward a quantitative expansion, the style of research activities has changed to a large extent. Chart 4-1-2 shows the change in form of the co-authorship of papers in main countries by the three categories: (1) Single-institutional co-authorship papers (Papers by authors who belong to a single institute), (2) Domestic co-authorship papers (Papers by authors who belong to multiple institutes located in a single country), (3) Internationally co-authored papers (Papers by authors who belong to institutes located in different countries).

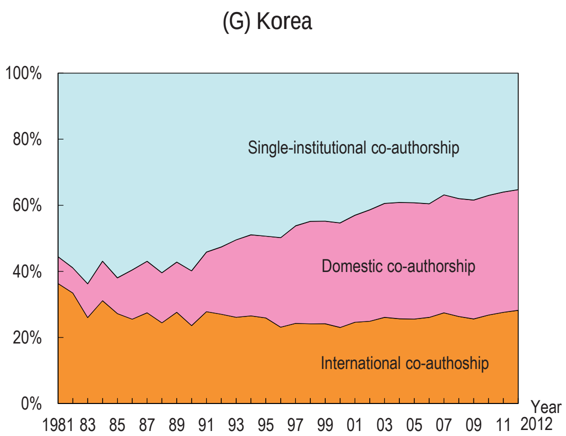
This figure shows that the ratio of single-institutional co-authorship papers has declined, and that of domestic co-authorship papers and internationally co-authored papers has increased. In the 1980s, single-institutional co-authorship papers accounted for approximately 80%, however, after that, domestic co-authorship papers and internationally co-authored papers increased. It can be said that activities for knowledge production have been done by transcending the framework of institutes and countries. As of 2012, single-institutional co-authorship papers accounted for 41.7%, domestic co-authorship papers for 35.5%, and internationally co-authored papers for 22.8%.

Chart 4-1-3 shows trends in the shares of co-authorship styles in the number of papers of the selected countries. All of the countries share the fact that the percentage of internationally co-authored papers is increasing. However, the size of this percentage varies from country to country. As of 2012, it was 28.1% for Japan and 35.9% for the U.S. These figures contrast with very high percentages in Europe, as is demonstrated by 53.2% for Germany, 55.1% for France, and 55.3% for the U.K.

On the other hand, a characteristic in Japan's co-authorship styles is that the percentage of domestic co-authorship papers has grown by 20 percentage points compared to the 1980s. This demonstrates how strong relationships among research institutions are in Japan compared to other countries.

Chart 4-1-3: The change in the ratio of the numbers of papers in main countries by co-authorship form





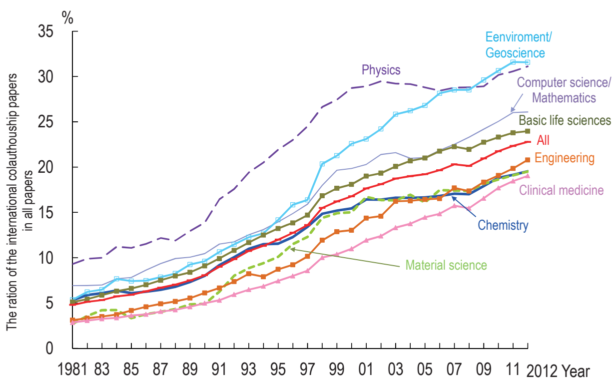
Note: The analysis targeted articles, articles & proceedings (for handling as articles), letters, notes, and reviews.
Source: Compiled by NISTEP based on Thomson Reuters "Web of Science" (SCIE, CPCI: Science)

Moreover, since internationally co-authored papers are a fruit made from international research cooperation and joint activities, they depend upon the background of each field. For example, when individual countries cannot realistically possess large-scale research facilities, joint research tends to take place primarily in countries into which large-scale international research facilities have been installed.

Chart 4-1-4 shows changes in the ratios of internationally co-authored papers in each field. In all of the fields, the percentage of internationally co-authored papers has been rising since the 1980s. As of 2012, percentages of internationally co-authored papers stood at 31.6% in Environment/Geoscience and 31.1% in Physics; these figures were high compared to the other fields. On the other hand, Clinical medicine had the lowest percentage of internationally co-authored papers with 19.0%.

Chart 4-1-4: Internationally co-authored papers by field

(A) The change in the percentage



(B) Classification fields

Category	Consolidated ESI 22 field classification
Chemistry	Chemistry
Material science	Material science
Physics	Physics, Space science
Computer science/ Mathematics	Computer science, Mathematics
Engineering	Engineering
Environment/ Geoscience	Environment/Ecology, Geoscience
Clinical Medicine	Clinical medicine, Psychiatry/Psychology
Basic life sciences	Agricultural science,Biology・Biochemistry, Immunology, Microbiology, Molecular biology・Genetics, Neuroscience・Behavioristics, Pharmacology・Toxicology, Botany・Zoology

Note: 1) The analysis targeted articles, articles & proceedings (for handling as articles), letters, notes, and reviews.
2) Used (B) for the classification fields of (A).
3) Reclassified the papers included in "Web of Science" by ESI22 classification fields and analyzed by field for the classification fields of (B). By http://www.in-cites.com/journal-list/index.html (2012 October) for the classification of journals. Analyzed ESI19 classification fields excluded Economics/Economic & Business, Multidisciplinary and Social science general.
Source: Compiled by NISTEP based on Thomson Reuters "Web of Science" (SCIE, CPCI: Science)

4.1.2 A comparison of research activities by country

(1) Method for quantifying scientific research capability at the country level

When quantifying and comparing "national scientific research capability," the increasing complexity in co-authorship styles of recent years that was mentioned above should be considered.

Thus, as is shown in Chart 4-1-5, this section ascertains scientific research capability at the country level in terms of "degree of contribution to the production of papers (i.e., degree of contribution to individual papers)" and "degree of participation in the production of papers (i.e., degree of involvement in the process of producing papers)." The former is measured using fractional counting and the latter using whole counting. The difference between the degree of contribution and degree of involvement in the production of papers can be described as the "contribution of foreign countries through internationally co-authored papers." Because the circumstances of international activities differ among nations and regions, rankings can switch around depending on the counting method used.

Moreover, a quantitative standpoint and qualitative standpoint are required when examining "national scientific research capability." Given this, number of papers is used as the quantitative standpoint and number of highly cited papers extracted from other papers (number of adjusted top 10% papers and number of adjusted top 1% papers) are used as the qualitative standpoint.

"Number of adjusted top 10% (top 1%) papers" refers to a number of papers that is obtained by extracting those papers whose number of times cited enters the top 10% (1%) in each field and then adjusted so that it is 1/10 (1/100) of the number of papers in terms of real numbers. The number is calculated for each field in this way in order to standardize differences that arise from significant variations in the average number of times cited in each field. The fields are pursuant to Chart 4-1-4.

(2) Time-series comparison of number of papers, number of adjusted top 10% papers, and number of adjusted top 1% papers by country/region

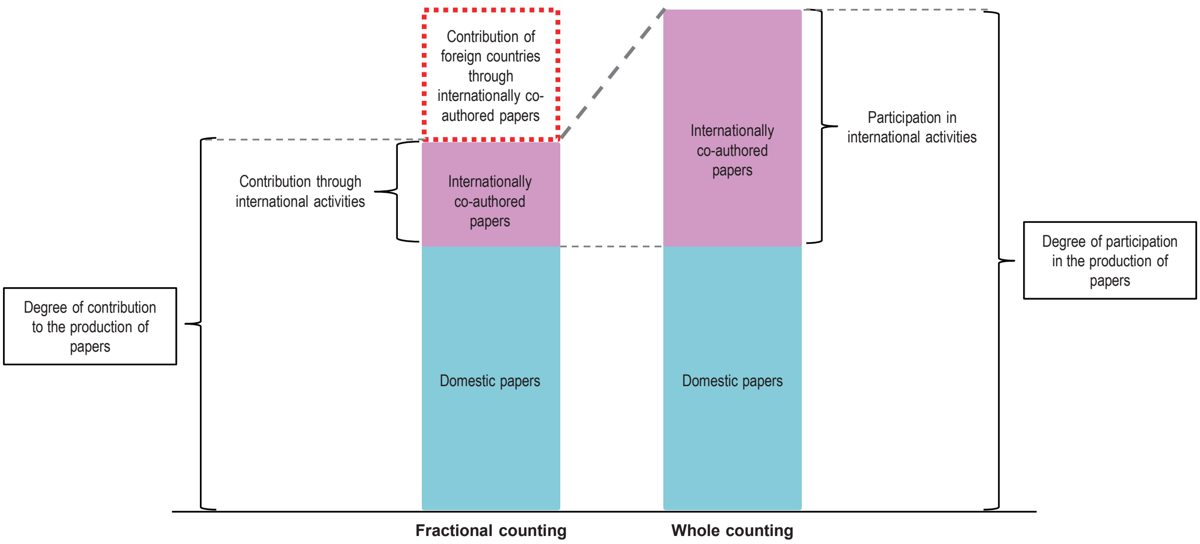
Chart 4-1-6 shows number of papers, number of adjusted top 10% papers, number of adjusted top 1% papers, and international ranking for individual countries and regions based on fractional counting and whole counting.

Japan's number of papers (average for 2010 to 2012) ranked third when based on fractional counting. Japan ranked sixth in the number of adjusted top 10% papers and seventh in the number adjusted top 1% papers.

On the other hand, when based on whole counting, Japan ranked fifth in terms of number of research papers produced, eighth in number of adjusted top 10% papers, and tenth in number of adjusted top 1% papers.

Chart 4-1-5: Fractional counting and whole counting

(A) Conceptual diagram of the method for ascertaining scientific research capability at the country level



(B) Fractional counting and whole counting

	Fractional counting method	Whole counting method
The ways of counting	● Calculated at the country level using weighting at the institution level ● For example, if Japanese University A, Japanese University B, and American University C produce a co-authored paper, counting is weighted at one-third for each institution and thus aggregated as two-thirds for Japan and one-third for the U.S. Accordingly, a single paper is treated as a single paper even if multiple institutions are involved.	● Calculated in terms of particitation (or non-particitation) at the country level ● For example, if Japanese University A, Japanese University B, and American University C produce a co-authored paper, counting becomes one for Japan and one for the U.S. Accordingly, a single paper is counted several times if several institutions are involved.
Significance of counting number of papers	Ascertainment of the "degree of contribution to the production of papers internationally"	Ascertainment of the "degree of particitation in the production of papers internationally"
Significance of counting number of adjusted top 10% (top 1%) papers	Ascertainment of the "degree of contribution to the production of highly influential papers internationally"	Ascertainment of the "degree of particitation in the production of highly influential papers internationally"

Note: "Number of adjusted top 10% (top 1%) papers" refers to a number of papers that is obtained by extracting those papers whose number of times cited enters the top 10% (1%) in each field for each year and then adjusted so that it is 1/10 (1/100) of the number of papers in terms of real numbers. For details see the method calculation used for number of adjusted top 10% papers described in section 2-2 (7) of NISTEP "Benchmarking Scientific Research 2012" (Research Material No. 218). Fields are based on the explanatory remarks of Chart 4-1-3 (B). Numbers of times cited are values as of the end of 2012.

Chart 4-1-6: Number of papers, number of adjusted top 10% papers, and number of adjusted top 1% papers by country/region: Top 25 countries/regions

(A) Fractional counting

All fields	1990 - 1992 (Average)		
	The number of papers		
	Fractional counting		
Country/Region	The number of papers	Share	World rank
U.S.	200,740	32.5	1
U.K.	47,461	7.7	2
Japan	46,644	7.6	3
Germany	40,192	6.5	4
Russia	36,092	5.8	5
France	30,309	4.9	6
Canada	24,924	4.0	7
Italy	16,935	2.7	8
India	14,133	2.3	9
Australia	12,090	2.0	10
Netherlands	11,426	1.8	11
Spain	10,063	1.6	12
Sweden	8,984	1.5	13
China	8,188	1.3	14
Switzerland	7,164	1.2	15
Israel	5,327	0.9	16
Belgium	5,140	0.8	17
Poland	4,916	0.8	18
Denmark	4,279	0.7	19
Czech Republic	3,817	0.6	20
Finland	3,724	0.6	21
Brazil	3,435	0.6	22
Austria	3,431	0.6	23
South Africa	3,137	0.5	24
Taiwan	3,114	0.5	25

All fields	2000 - 2002 (Average)		
	The number of papers		
	Fractional counting		
Country/Region	The number of papers	Share	World rank
U.S.	210,237	26.9	1
Japan	66,637	8.5	2
U.K.	55,075	7.0	3
Germany	52,399	6.7	4
France	37,652	4.8	5
China	29,868	3.8	6
Italy	27,176	3.5	7
Canada	24,906	3.2	8
Russia	21,528	2.8	9
Spain	19,346	2.5	10
Australia	16,560	2.1	11
India	16,499	2.1	12
Netherlands	13,949	1.8	13
Korea	13,465	1.7	14
Sweden	11,004	1.4	15
Taiwan	9,576	1.2	16
Brazil	9,421	1.2	17
Switzerland	9,387	1.2	18
Poland	8,237	1.1	19
Belgium	7,173	0.9	20
Israel	7,132	0.9	21
Turkey	6,303	0.8	22
Finland	5,615	0.7	23
Denmark	5,485	0.7	24
Austria	5,452	0.7	25

All fields	2010 - 2012 (Average)		
	The number of papers		
	Fractional counting		
Country/Region	The number of papers	Share	World rank
U.S.	258,421	21.6	1
China	137,624	11.5	2
Japan	64,579	5.4	3
Germany	61,731	5.1	4
U.K.	58,502	4.9	5
France	44,022	3.7	6
India	40,627	3.4	7
Italy	40,310	3.4	8
Korea	37,226	3.1	9
Canada	36,777	3.1	10
Spain	34,151	2.8	11
Brazil	28,622	2.4	12
Australia	27,582	2.3	13
Russia	22,207	1.9	14
Taiwan	21,593	1.8	15
Turkey	20,365	1.7	16
Netherlands	19,595	1.6	17
Iran	18,456	1.5	18
Poland	16,251	1.4	19
Switzerland	12,793	1.1	20
Sweden	11,886	1.0	21
Belgium	10,094	0.8	22
Israel	7,712	0.6	23
Denmark	7,656	0.6	24
Greece	7,652	0.6	25

All fields	1990 - 1992 (Average)		
	The number of adjusted top 10% papers		
	Fractional counting		
Country/Region	The number of papers	Share	World rank
U.S.	31,769	51.6	1
U.K.	5,096	8.3	2
Japan	3,617	5.9	3
Germany	3,260	5.3	4
Canada	2,803	4.5	5
France	2,651	4.3	6
Netherlands	1,477	2.4	7
Italy	1,288	2.1	8
Australia	1,184	1.9	9
Sweden	1,127	1.8	10
Switzerland	962	1.6	11
Russia	561	0.9	12
Spain	539	0.9	13
Denmark	511	0.8	14
Israel	492	0.8	15
Belgium	478	0.8	16
Finland	371	0.6	17
India	356	0.6	18
China	305	0.5	19
Norway	286	0.5	20
Austria	242	0.4	21
New zealand	221	0.4	22
Taiwan	196	0.3	23
Poland	165	0.3	24
Brazil	140	0.2	25

All fields	2000 - 2002 (Average)		
	The number of adjusted top 10% papers		
	Fractional counting		
Country/Region	The number of papers	Share	World rank
U.S.	32,532	41.7	1
U.K.	6,266	8.0	2
Germany	5,389	6.9	3
Japan	4,767	6.1	4
France	3,676	4.7	5
Canada	2,857	3.7	6
Italy	2,373	3.0	7
Netherlands	1,907	2.4	8
China	1,788	2.3	9
Australia	1,699	2.2	10
Spain	1,521	1.9	11
Switzerland	1,388	1.8	12
Sweden	1,272	1.6	13
Korea	934	1.2	14
Belgium	767	1.0	15
India	744	1.0	16
Denmark	722	0.9	17
Israel	709	0.9	18
Taiwan	673	0.9	19
Finland	610	0.8	20
Austria	494	0.6	21
Brazil	418	0.5	22
Russia	399	0.5	23
Norway	357	0.5	24
Singapore	350	0.4	25

All fields	2010 - 2012 (Average)		
	The number of adjusted top 10% papers		
	Fractional counting		
Country/Region	The number of papers	Share	World rank
U.S.	37,733	31.5	1
China	10,965	9.1	2
U.K.	8,013	6.7	3
Germany	7,992	6.7	4
France	4,909	4.1	5
Japan	4,809	4.0	6
Canada	4,279	3.6	7
Italy	4,138	3.5	8
Spain	3,442	2.9	9
Australia	3,359	2.8	10
Netherlands	2,963	2.5	11
Korea	2,402	2.0	12
Switzerland	2,045	1.7	13
India	1,994	1.7	14
Taiwan	1,528	1.3	15
Sweden	1,406	1.2	16
Belgium	1,292	1.1	17
Denmark	1,105	0.9	18
Iran	1,073	0.9	19
Brazil	1,055	0.9	20
Singapore	929	0.8	21
Turkey	874	0.7	22
Austria	810	0.7	23
Israel	784	0.7	24
Poland	700	0.6	25

All fields	1990 - 1992 (Average)		
	The number of adjusted top 1% papers		
	Fractional counting		
Country/Region	The number of papers	Share	World rank
U.S.	3,615	58.7	1
U.K.	503	8.2	2
Germany	307	5.0	3
Japan	275	4.5	4
Canada	237	3.9	5
France	237	3.8	6
Netherlands	133	2.2	7
Australia	111	1.8	8
Switzerland	106	1.7	9
Sweden	95	1.5	10
Italy	93	1.5	11
Russia	51	0.8	12
Denmark	49	0.8	13
Israel	40	0.6	14
Belgium	38	0.6	15
Finland	31	0.5	16
Spain	30	0.5	17
Austria	22	0.4	18
New zealand	21	0.3	19
India	18	0.3	20
Norway	18	0.3	21
China	12	0.2	22
South Africa	12	0.2	23
Ireland	9	0.1	24
Poland	9	0.1	25

All fields	2000 - 2002 (Average)		
	The number of adjusted top 1% papers		
	Fractional counting		
Country/Region	The number of papers	Share	World rank
U.S.	3,957	50.7	1
U.K.	658	8.4	2
Germany	500	6.4	3
Japan	367	4.7	4
France	309	4.0	5
Canada	254	3.3	6
Netherlands	180	2.3	7
Italy	179	2.3	8
Switzerland	161	2.1	9
Australia	139	1.8	10
China	136	1.7	11
Spain	106	1.4	12
Sweden	105	1.3	13
Israel	65	0.8	14
Denmark	65	0.8	15
Korea	62	0.8	16
India	57	0.7	17
Belgium	55	0.7	18
Finland	48	0.6	19
Austria	42	0.5	20
Taiwan	38	0.5	21
Russia	25	0.3	22
Singapore	25	0.3	23
Norway	25	0.3	24
Brazil	23	0.3	25

All fields	2010 - 2012 (Average)		
	The number of adjusted top 1% papers		
	Fractional counting		
Country/Region	The number of papers	Share	World rank
U.S.	4,480	37.4	1
China	979	8.2	2
U.K.	862	7.2	3
Germany	802	6.7	4
France	451	3.8	5
Canada	412	3.4	6
Japan	394	3.3	7
Italy	363	3.0	8
Australia	323	2.7	9
Netherlands	296	2.5	10
Spain	279	2.3	11
Switzerland	223	1.9	12
Korea	182	1.5	13
India	147	1.2	14
Sweden	125	1.0	15
Belgium	117	1.0	16
Taiwan	116	1.0	17
Denmark	111	0.9	18
Turkey	109	0.9	19
Singapore	108	0.9	20
Iran	96	0.8	21
Israel	72	0.6	22
Austria	66	0.5	23
Finland	58	0.5	24
Brazil	57	0.5	25

(B) Whole counting

All fields	1990 - 1992 (Average)		
	The number of papers		
	Whole counting		
Country/Region	The number of papers	Share	World rank
U.S.	213,961	34.6	1
U.K.	52,930	8.6	2
Japan	49,204	8.0	3
Germany	45,970	7.4	4
Russia	37,648	6.1	5
France	34,873	5.6	6
Canada	28,438	4.6	7
Italy	19,539	3.2	8
India	14,832	2.4	9
Australia	13,506	2.2	10
Netherlands	13,309	2.2	11
Spain	11,406	1.8	12
Sweden	10,663	1.7	13
China	9,305	1.5	14
Switzerland	9,199	1.5	15
Israel	6,446	1.0	16
Belgium	6,331	1.0	17
Poland	5,967	1.0	18
Denmark	5,217	0.8	19
Czech Republic	4,391	0.7	20
Finland	4,340	0.7	21
Austria	4,103	0.7	22
Brazil	4,069	0.7	23
South Africa	3,418	0.6	24
Taiwan	3,410	0.6	25

All fields	2000 - 2002 (Average)		
	The number of papers		
	Whole counting		
Country/Region	The number of papers	Share	World rank
U.S.	241,059	30.8	1
Japan	74,092	9.5	2
U.K.	69,608	8.9	3
Germany	67,457	8.6	4
France	48,797	6.2	5
China	34,338	4.4	6
Italy	33,641	4.3	7
Canada	32,116	4.1	8
Russia	26,611	3.4	9
Spain	23,968	3.1	10
Australia	21,005	2.7	11
Netherlands	18,874	2.4	12
India	18,350	2.3	13
Korea	15,473	2.0	14
Sweden	15,187	1.9	15
Switzerland	14,100	1.8	16
Brazil	11,559	1.5	17
Poland	10,680	1.4	18
Taiwan	10,674	1.4	19
Belgium	10,303	1.3	20
Israel	9,379	1.2	21
Denmark	7,857	1.0	22
Austria	7,575	1.0	23
Finland	7,425	1.0	24
Turkey	7,055	0.9	25

All fields	2010 - 2012 (Average)		
	The number of papers		
	Whole counting		
Country/Region	The number of papers	Share	World rank
U.S.	317,594	26.5	1
China	157,420	13.1	2
Germany	89,147	7.4	3
U.K.	87,615	7.3	4
Japan	76,028	6.3	5
France	64,230	5.4	6
Italy	54,161	4.5	7
Canada	52,352	4.4	8
Spain	46,651	3.9	9
India	46,178	3.9	10
Korea	43,748	3.6	11
Australia	39,312	3.3	12
Brazil	33,625	2.8	13
Netherlands	30,345	2.5	14
Russia	27,553	2.3	15
Taiwan	24,697	2.1	16
Switzerland	23,017	1.9	17
Turkey	22,745	1.9	18
Iran	20,548	1.7	19
Poland	20,450	1.7	20
Sweden	19,728	1.6	21
Belgium	16,937	1.4	22
Denmark	12,481	1.0	23
Austria	11,944	1.0	24
Israel	11,075	0.9	25

All fields	1990 - 1992 (Average)		
	The number of adjusted top 10% papers		
	Whole counting		
Country/Region	The number of papers	Share	World rank
U.S.	34,304	55.7	1
U.K.	6,094	9.9	2
Germany	4,160	6.8	3
Japan	4,022	6.5	4
Canada	3,466	5.6	5
France	3,392	5.5	6
Netherlands	1,828	3.0	7
Italy	1,721	2.8	8
Australia	1,437	2.3	9
Sweden	1,414	2.3	10
Switzerland	1,397	2.3	11
Spain	723	1.2	12
Russia	711	1.2	13
Israel	696	1.1	14
Denmark	694	1.1	15
Belgium	679	1.1	16
Finland	473	0.8	17
China	437	0.7	18
India	421	0.7	19
Norway	376	0.6	20
Austria	346	0.6	21
Poland	280	0.5	22
New zealand	277	0.4	23
Taiwan	231	0.4	24
Brazil	220	0.4	25

All fields	2000 - 2002 (Average)		
	The number of adjusted top 10% papers		
	Whole counting		
Country/Region	The number of papers	Share	World rank
U.S.	37,903	48.6	1
U.K.	8,815	11.3	2
Germany	7,888	10.1	3
Japan	5,862	7.5	4
France	5,475	7.0	5
Canada	4,172	5.3	6
Italy	3,515	4.5	7
Netherlands	2,855	3.7	8
Australia	2,469	3.2	9
China	2,363	3.0	10
Switzerland	2,335	3.0	11
Spain	2,236	2.9	12
Sweden	1,992	2.6	13
Belgium	1,303	1.7	14
Korea	1,214	1.6	15
Denmark	1,179	1.5	16
Israel	1,114	1.4	17
India	961	1.2	18
Finland	949	1.2	19
Russia	921	1.2	20
Austria	832	1.1	21
Taiwan	824	1.1	22
Brazil	665	0.9	23
Norway	609	0.8	24
Poland	549	0.7	25

All fields	2010 - 2012 (Average)		
	The number of adjusted top 10% papers		
	Whole counting		
Country/Region	The number of papers	Share	World rank
U.S.	48,447	40.4	1
U.K.	14,141	11.8	2
China	14,116	11.8	3
Germany	13,722	11.4	4
France	8,882	7.4	5
Canada	7,388	6.2	6
Italy	7,100	5.9	7
Japan	6,742	5.6	8
Spain	6,000	5.0	9
Australia	5,663	4.7	10
Netherlands	5,572	4.6	11
Switzerland	4,538	3.8	12
Korea	3,483	2.9	13
Sweden	3,099	2.6	14
Belgium	2,790	2.3	15
India	2,751	2.3	16
Denmark	2,263	1.9	17
Taiwan	2,090	1.7	18
Austria	1,930	1.6	19
Brazil	1,876	1.6	20
Israel	1,501	1.3	21
Poland	1,500	1.3	22
Singapore	1,483	1.2	23
Finland	1,445	1.2	24
Norway	1,380	1.2	25

All fields	1990 - 1992 (Average)		
	The number of adjusted top 1% papers		
	Whole counting		
Country/Region	The number of papers	Share	World rank
U.S.	3,907	63.4	1
U.K.	630	10.2	2
Germany	400	6.5	3
Japan	321	5.2	4
France	320	5.2	5
Canada	320	5.2	6
Netherlands	175	2.8	7
Switzerland	158	2.6	8
Italy	142	2.3	9
Australia	142	2.3	10
Sweden	132	2.1	11
Denmark	71	1.2	12
Russia	66	1.1	13
Israel	65	1.1	14
Belgium	57	0.9	15
Spain	50	0.8	16
Finland	43	0.7	17
Austria	35	0.6	18
Norway	27	0.4	19
New zealand	26	0.4	20
China	23	0.4	21
India	23	0.4	22
Poland	18	0.3	23
Brazil	16	0.3	24
South Africa	15	0.3	25

All fields	2000 - 2002 (Average)		
	The number of adjusted top 1% papers		
	Whole counting		
Country/Region	The number of papers	Share	World rank
U.S.	4,595	58.9	1
U.K.	1,004	12.9	2
Germany	795	10.2	3
France	524	6.7	4
Japan	491	6.3	5
Canada	433	5.6	6
Italy	321	4.1	7
Netherlands	305	3.9	8
Switzerland	295	3.8	9
Australia	247	3.2	10
Sweden	199	2.6	11
China	195	2.5	12
Spain	183	2.3	13
Denmark	127	1.6	14
Belgium	123	1.6	15
Israel	113	1.4	16
Finland	95	1.2	17
Korea	90	1.1	18
Austria	86	1.1	19
India	80	1.0	20
Russia	79	1.0	21
Norway	55	0.7	22
Taiwan	53	0.7	23
Poland	50	0.6	24
Brazil	49	0.6	25

All fields	2010 - 2012 (Average)		
	The number of adjusted top 1% papers		
	Whole counting		
Country/Region	The number of papers	Share	World rank
U.S.	6,021	50.2	1
U.K.	1,871	15.6	2
Germany	1,694	14.1	3
China	1,411	11.8	4
France	1,088	9.1	5
Canada	972	8.1	6
Italy	869	7.3	7
Netherlands	776	6.5	8
Australia	708	5.9	9
Japan	704	5.9	10
Spain	700	5.8	11
Switzerland	682	5.7	12
Sweden	414	3.5	13
Belgium	383	3.2	14
Korea	358	3.0	15
Denmark	331	2.8	16
Austria	271	2.3	17
India	263	2.2	18
Taiwan	224	1.9	19
Poland	206	1.7	20
Norway	204	1.7	21
Israel	201	1.7	22
Finland	201	1.7	23
Brazil	196	1.6	24
Singapore	192	1.6	25

Note: The analysis targeted articles, articles & proceedings (for handling as articles), letters, notes, and reviews.
Source: Compiled by NISTEP based on Thomson Reuters "Web of Science" (SCIE, CPCI: Science)

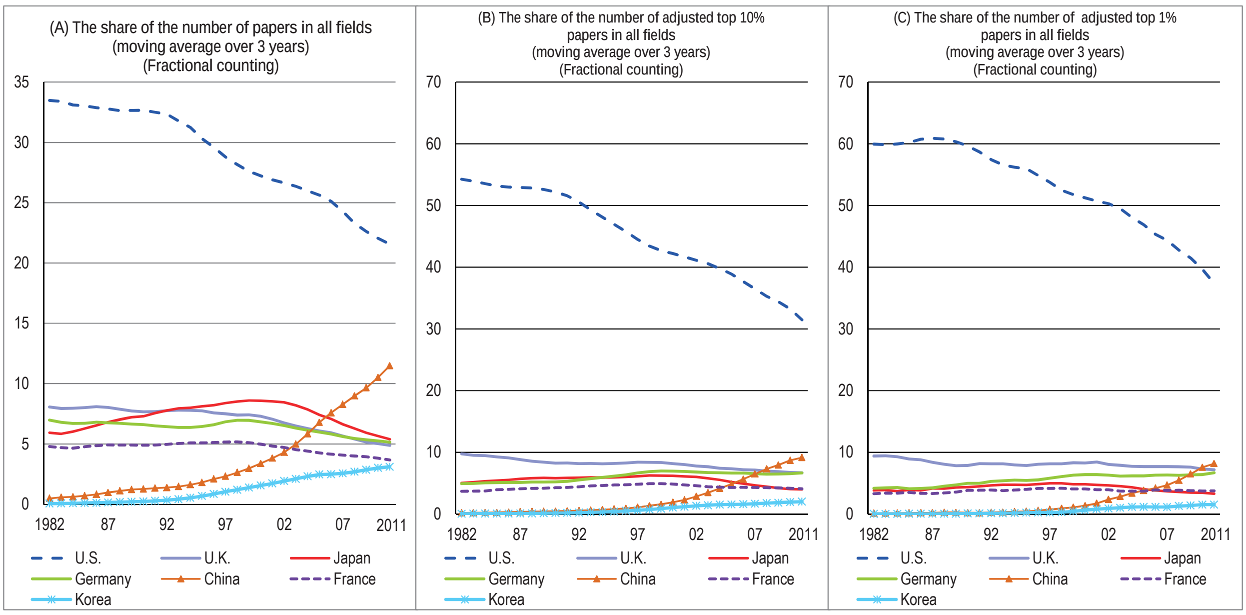
(3) Time-series trends in share of number of papers, share of number of adjusted top 10% papers, and share of number of adjusted top 1% papers in the selected countries

Chart 4-1-7 compares the selected countries' shares of the number of papers using fractional counting in order to ascertain each country's research activities in quantitative terms.

The first chart shows the shares of the number of papers. Here, it is apparent that the U.S. has consistently had a much larger share than the other countries since the 1980s. However, this share has been shrinking since the 1980s as the shares of the others have been growing. Between the 1980s and the early 2000s, Japan's share grew to surpass those of the U.K. and Germany, and for a while ranked number two in the world. However, China's share has been growing rapidly since the second half of the 1990s, while those of not only the U.S. but also Japan, the U.K., Germany, and France have been declining. As of 2011 (average of 2010 to 2012), the top three positions are held by the U.S., China, and Japan.

The next charts show changes in the shares of the numbers of adjusted top 10% papers and adjusted top 1% papers as qualitative indicators. Like the number of papers, the U.S. once again has shares that far exceed those of the other countries. However, it is apparent that the U.S. has far higher shares of the numbers of adjusted top 10% papers and adjusted top 1% papers. However, these shares have been on a continuous and gradual downward track since the 1980s. On the other hand, the growth of China's shares for both the numbers of adjusted top 10% papers and adjusted top 1% papers has been remarkable since the second half of the 1990s. Japan saw its shares increase gradually from the 1980s into to the early 2000s; however, these shares have been decreasing rapidly since then. Meanwhile, Germany has gained attention for steadily increasing its shares, particularly of the number of adjusted top 1% papers since the 1980s. Amid such time-series changes among the countries, as of 2011 (average of 2010 to 2012), Japan ranked sixth behind the U.S., China, U.K., Germany, and France in terms of number of adjusted top 10% papers, and ranked 7th behind the U.S., China, U.K., Germany, France, and Canada in terms of number of adjusted top 1% papers.

Chart 4-1-7: Changes in the number of papers, number of adjusted top 10% papers, and number of adjusted top 1% papers of the selected countries
(All fields, fractional counting, three-year moving average)



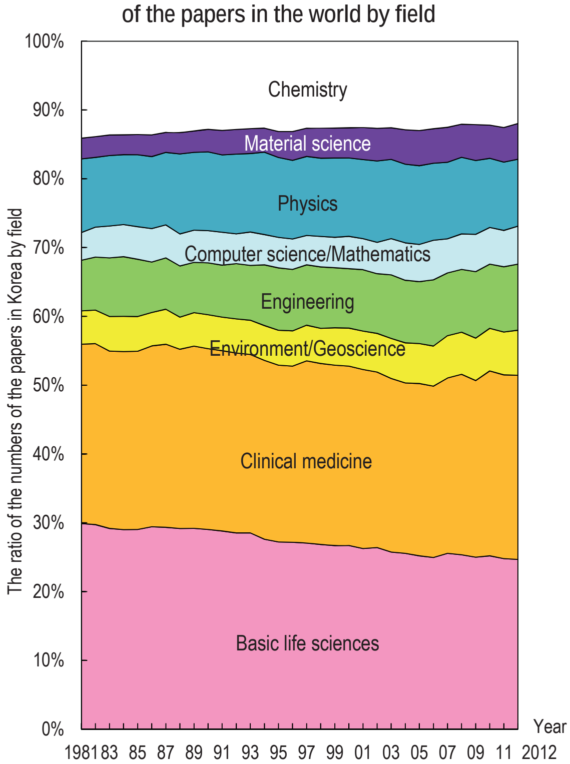
Note: The analysis targeted articles, articles & proceedings (for handling as articles), letters, notes, and reviews. Three-year moving averages of share of papers in all fields (if 2011, average of 2010, 2011, and 2012). Fractional counting used.
Source: Compiled by NISTEP based on Thomson Reuters "Web of Science" (SCIE, CPCI: Science)

4.1.3 The characteristics of the research activities of main countries

(1) International field balance in the world

While there are a variety of fields of research activities, the number of papers and the number of times cited are influenced by whether emphasis is placed on the production of papers in each field of research activities, by whether the number of researchers is large or small, and by whether the numbers of past papers that each paper refers to is large or small on average. Therefore, in the case of comparing countries, it is also important not only to look at the total number of papers and the number of times cited but also to understand the research activities of each field.

Chart 4-1-8: The change in the ratio of the numbers of the papers in the world by field



Note: The analysis targeted articles, articles & proceedings (for handling as articles), letters, notes, and reviews. Fractional counting used. The fields are in accordance with the note of Chart 4-1-4 (B).
Source: Compiled by NISTEP based on Thomson Reuters "Web of Science" (SCIE, CPCI: Science)

First, Chart 4-1-8 shows the change in the ratio of the numbers of papers which each field occupies throughout the world. Comparing 2012 with 1981, Basic life sciences have fallen by 5.1 percentage points, Chemistry by 2.1 percentage points and Physics by 0.9 percentage points. On the other hand, Material science has increased its share by 2.1 percentage points, Engineering by 2.2 percentage points, Environment/Geoscience by 1.7 percentage points, Computer science/Mathematics by 1.5 percentage points and Clinical medicine by 0.7 percentage points.

Although there have been minor changes, the life science related fields such as Basic life sciences and Clinical medicine have retained their characteristic of accounting for about half of all papers.

(2) Field balances of the selected countries

Next, Chart 4-1-9 shows changes in the field balances of the selected countries in order to provide a look at the domestic makeup of those countries. It should be noted that the shares for each field within the counties were obtained with fractional counting.

In Japan, Basic life sciences, Chemistry and Physics accounted for large shares in the early 1980s. Comparing 2012 with 1981, however, Chemistry has fallen by 10.6 percentage points and Basic life sciences by 6.2 percentage points. On the other hand, Clinical medicine increased its share 16.8 percentage point share, and Environment/Geoscience and Material science have expanded by approximately 2 percentage points.

In the U.S., changes are seen in Basic life sciences (5.1 percentage point decrease), Chemistry (1.5 point decrease), Physics (1.5 point decrease), and Clinical medicine (4.8 point increase).

In Germany, changes are seen in Chemistry (4.4 percentage point decrease), Basic life sciences (5.8 point decrease), Environment/Geoscience (3.6 point increase), Physics (1.8 point increase), and Clinical medicine (2.5 point increase).

In France, changes are seen in Chemistry (2.9 percentage point decrease), Clinical medicine (5.4 point decrease), Basic life sciences (6.2 point decrease), Engineering (5.0 point increase), Computer science/Mathematics (3.8 point increase), Environment/Geoscience (2.9 point increase), and Material science (2.2 point increase).

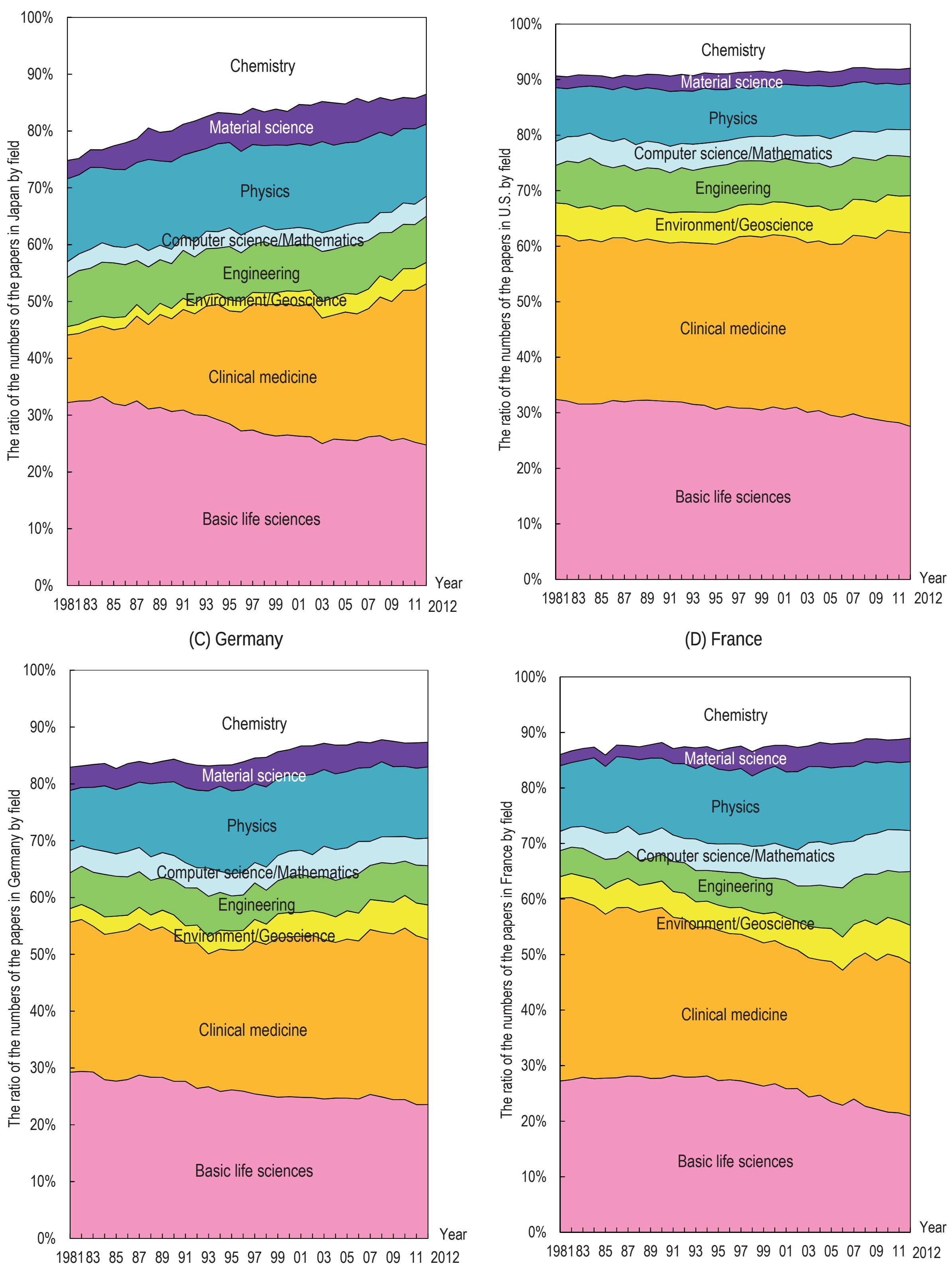
In the U.K., changes are seen in Basic life sciences (7.2 percentage point decrease), Chemistry (3.8 point decrease), Clinical medicine (3.4 point increase), Environment/Geoscience (2.5 point increase), and Computer science/Mathematics (1.5 point increase).

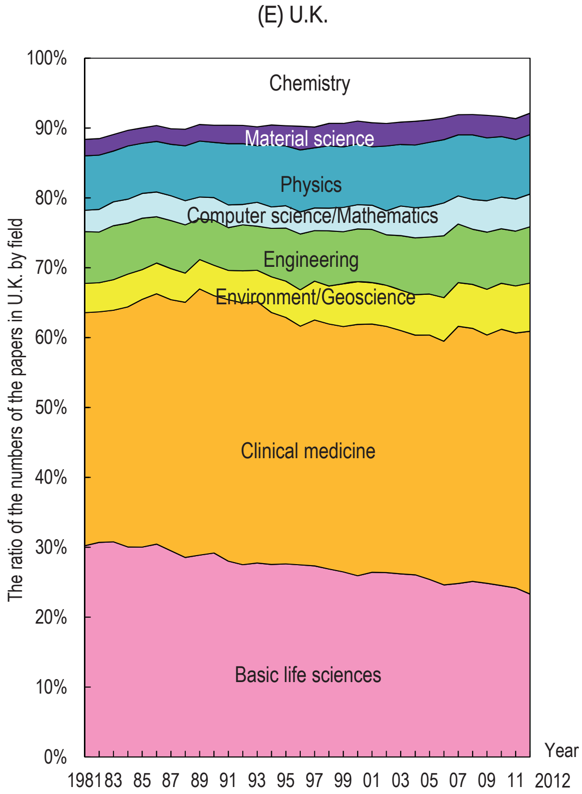
As for China, its shares for the life sciences (Basic life sciences and Clinical medicine) are lower than those of the other selected nations.

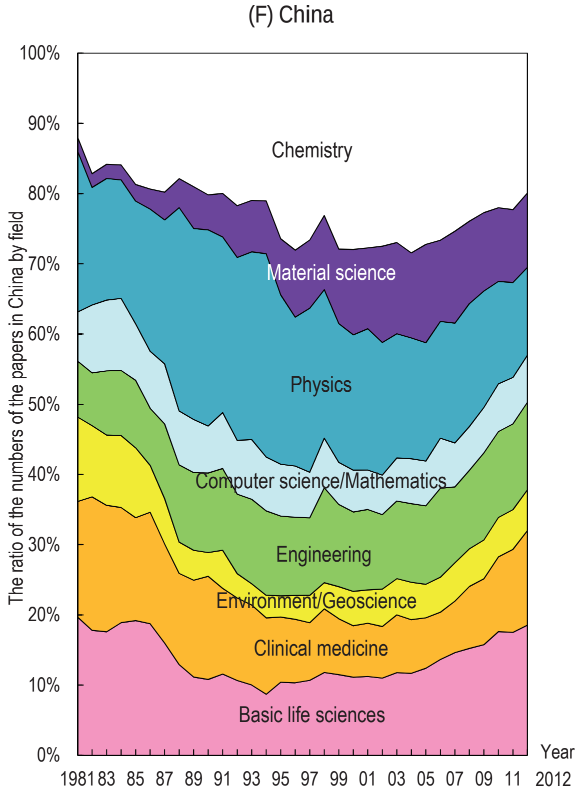
Chart 4-1-9: The change in the ratio of the numbers of the papers in main countries by field

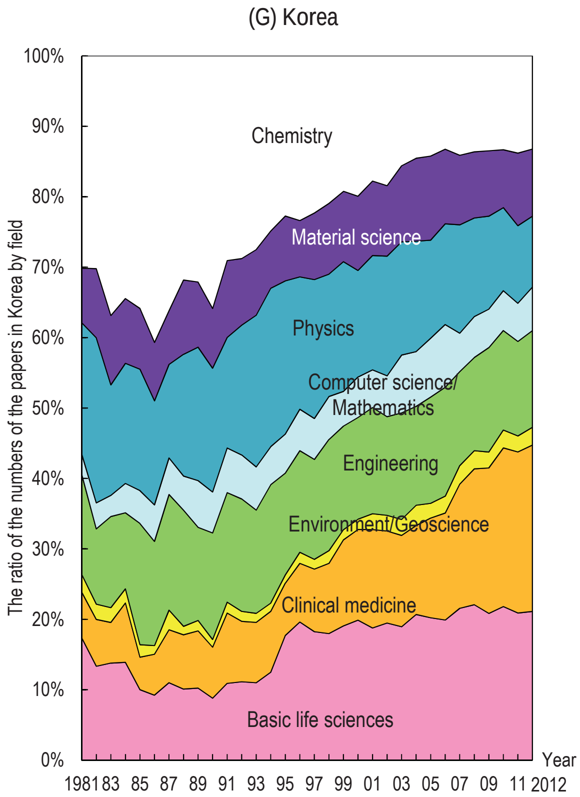
(A) Japan

(B) U.S.









Note: The analysis targeted articles, articles & proceedings (for handling as articles), letters, notes, and reviews. Fractional counting used. The fields are in accordance with the note of Chart 4-1-4 (B).
Source: Compiled by NISTEP based on Thomson Reuters "Web of Science" (SCIE, CPCI: Science)

(3) Field balances of the selected countries in the world

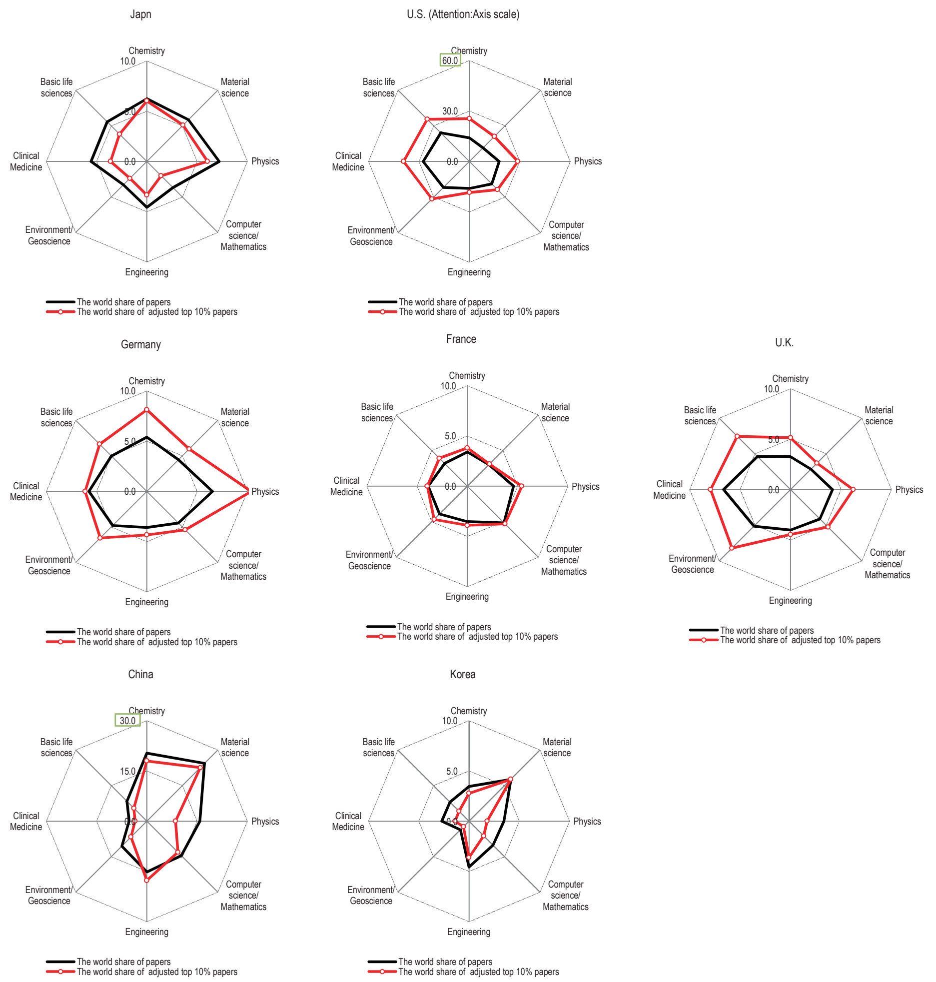
Chart 4-1-10 shows the field balances of the selected countries in the world. Field portfolios (2010 to 2012, fractional counting) were prepared for shares of number of papers and number of adjusted top 10% papers of the selected countries and compared.

Japan has a portfolio in which the weights of Physics, Chemistry and Material science are heavy, while those of Computer science/Mathematics and Environment/Geoscience are light. In Chart 4-1-9 (A), the share of Clinical medicine in Japan's papers is shown to have increased, and the share of Chemistry and Basic life sciences has declined. However, when it comes to the share against the numbers of papers for each field in the world, it can be seen that Chemistry is higher than Clinical medicine in Japan.

The U.S. and U.K. are strong in Clinical medicine, Basic life sciences, and Environment/Geoscience; Germany is strong in Chemistry and Physics; and France is strong in Computer science/Mathematics. China has a particularly strong presence in both the paper shares and adjusted top 10% papers shares in Material science and Chemistry.

Comparing paper shares and adjusted top 10% papers shares shows that countries are divided into those having higher adjusted top 10% paper shares than paper shares (the U.S., Germany, France, and the U.K.) and those having lower adjusted top 10% paper shares than paper shares (Japan, China, and Korea). Looking at the adjusted top 10% paper shares, the strengths and weaknesses of each country are highlighted by their field balances in terms of paper shares.

Chart 4-1-10: A comparison of the share of the papers and adjusted top 10% papers in main countries by field (%, 2010–2012, fractional counting)



Note: The analysis targeted articles, articles & proceedings (for handling as articles), letters, notes, and reviews. Fractional counting used. The fields are in accordance with the note of Chart 4-1-4 (B). Numbers of times cited are values as of the end of 2012.
Source: Compiled by NISTEP based on Thomson Reuters "Web of Science" (SCIE, CPCI: Science)

4.2 Patents

Key Points

- ○The number of world patent applications showed a significant downturn in 2009 resulting from the economic downturn sparked by the Lehman Brothers' bankruptcy. However, the number increased again from 2010 and reached 2.14 million in 2011.
- ○The number of annual applications to Japan has been on a downward trend since the mid-2000s. In 2009, in particular, the number of applications fell by 10% compared with 2008, and this trend has been continuing thereafter, with the number standing at 340,000 in 2011. Applications from residents account for approximately 80%.
- ○The number of applications to the U.S. had trended flat in recent years, but saw continuous increases in 2010 and 2011 to reach 500,000. The numbers of applications from residents and non-residents were roughly equal, accounting for one half each.
- ○The number of applications to China in 2011 reached 530,000, a figure that surpassed that of the U.S. Residents accounted for approximately 80% of this number. The number of applications made by applicants within China is showing particularly strong growth.
- ○The applications to a resident country is more frequent compared to the applications to a non-resident countries. In Japan, the number of applications to JPO in has been decreasing in recent years. It stood at 290,000 in 2011, which is approximately 75% of the peak year (2000).
- ○Looking at the number of patent families, throughout the 1980s and the 1990s, the U.S. ranked in 1st and Japan ranked in 2nd; however, entering the 2000s, Japan has ranked in 1st and the U.S. in 2nd.
- ○Looking at Japan's technology field balance as of 2008, Japan has high weights in electrical engineering and general machinery in international comparison. On the other hand, Japan has lower weights in biotechnology/pharmaceuticals and bio/medical devices in international comparison.
- ○As of 1981, at least 90% of patent family applications from Japan went to the U.S. or Europe. However, applications to China have been increasing since the 1990s. As of 2007, applications to the U.S. accounted for 46%, those to China accounted for 20%, and those to the European Patent Office accounted for 13%.

4.2.1 The patent applications in the world
(1) The number of patent applications in the world

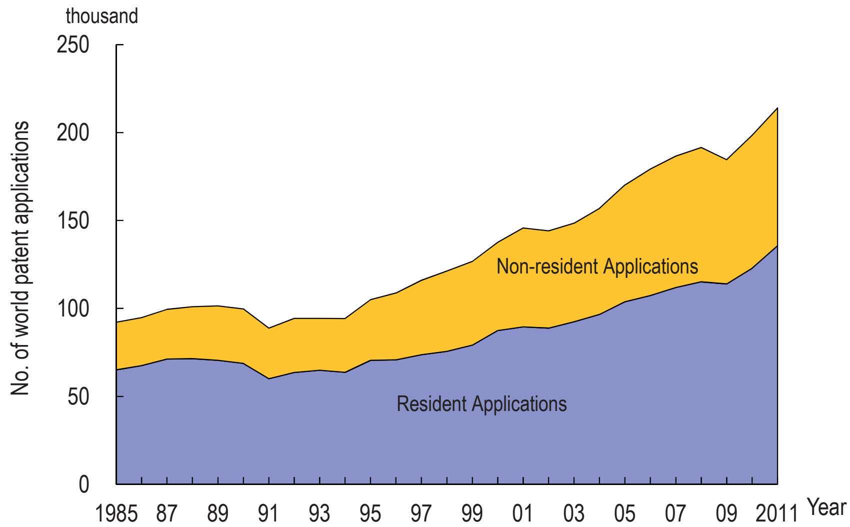
Chart 4-2-1 shows changes in the numbers of patent applications to about 230 countries and regions. The data are obtained from the "Statistics on Patents" by the WIPO (World Intellectual Property Organization) and are current as of November 2012. Here, the applications are divided to show resident applications, which mean that the first applicants make applications directly to countries or regions in where they live, and Non-resident applications, which mean that the first applicants make applications to countries and regions where they do not have residency.

The numbers of patent applications include by both direct applications to patent authorities in each country or region; and PCT (Patent Cooperation Treaty) applications. As for PCT applications, applications have been transferred to the national/regional phase, were counted.

The number of world patent applications has increased at an average annual rate of about 5% since the mid-1990s. It stood at 2.14 million in 2011. Non-resident applications, which occupied about 30% in the mid 1980s, have increased more than that of resident applications at a rapid pace, and have occupied about 40% of the total numbers of applications in recent years.

The number of world patent applications showed a significant downturn in 2009 resulting from the economic downturn sparked by the Lehman Brothers' bankruptcy. However, the number has been increasing again since 2010.

Chart 4-2-1: The change in the numbers of patent applications in the world



Note: (1) Resident applications means that first applicants make applications directly to countries or regions in where they live or do PCT applications.
(2) Non-resident applications mean that applicants make applications directly to countries or regions in where they do not live or do PCT applications.
(3) PCT applications mean applications made through PCT (Patent Cooperation Treaty) international patent application.
Source: WIPO, "WIPO statistics database" (Last updated: November 2012)

(2)The situation of patent applications in main countries

Next, the patent applications to and from the main countries are shown.

Here, the patent applications to Japan, the U.S., Europe, China, Korea, Germany, France and the U.K. are covered. The patent applications to these eight patent authorities account for about 80% of the patent applications in the entire world.

Chart 4-2-2 (A) breaks the number of applications to the selected countries into two categories: those from residents and those from non-residents.

The chart shows that the number of annual applications to Japan is third after the U.S. and China, but has been on a downward trend since the mid-2000s. In 2009, in particular, the number of applications fell by 10% compared with 2008, and this trend has been continuing thereafter, with the number standing at 340,000 in 2011. Looking at the breakdown, the resident applications to the JPO from resident applicants, who have their residency in Japan, accounts for over 84%.

The number of applications to the U.S. had trended flat between 2007 and 2009, but saw continuous increases in 2010 and 2011 to reach 500,000. The numbers of applications from residents and non-residents were roughly equal, accounting for one half each. This is considered to show that the U.S. market is always attractive to overseas. The provisional application system, which was introduced in 1995, is considered to be a reason that the numbers of applications has increased.

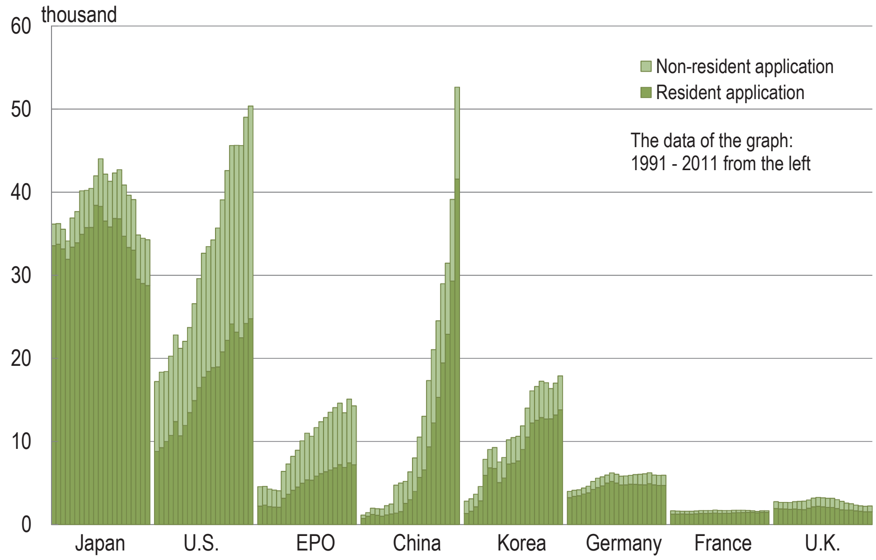
With the exception of 2009, the number of applications to the European Patent Office had been increasing each year. However, in 2011, the number fell by 6% compared to 2010 to 140,000. The numbers of applications to Germany, France, and the U.K. have not shown any major changes compared to other countries and have trended flat for the most part. The fact that patent applications can be made to each country that has ratified the European Patent Convention through applications to the European Patent Office is likely accountable for the flat or downward trend in individual countries.

The number of applications to SIPO has drastically increased. They increased by an annual average of about 23% over 10 years (2002–2011). In 2011, there were about 530,000 patent applications, more than the number to the U.S. The number of applications from residents was about 50% in the first half of the 2000s, but in 2011 it was about 80%. This indicates that applications from applicants in China have especially increased.

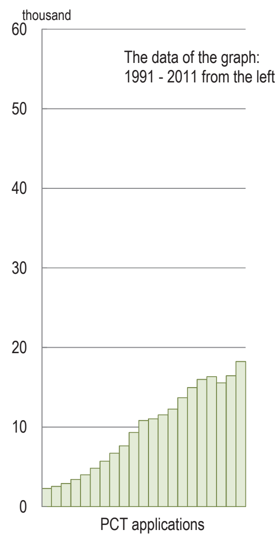
Chart 4-2-2 (B) shows numbers of PCT applications. PCT applications can be seen as a bundle of patent applications to the various patent authorities. One PCT application is the same as an application to multiple patent authorities. The number of PCT applications had seen little change in recent years; however, in 2011 it increased by 11% compared to 2010, reaching 180,000.

Chart 4-2-2: The situation of patent applications to and from main countries

(A) The numbers of patent applications to main countries (1991–2011)



(B) The change in the numbers of patent applications (1991–2011)



Note: 1) Regarding the breakdown of the numbers of applications, in the case of Japan, it is divided according to: “direct applications from Residents” to the JPO, which is from those who live in Japan, and “direct applications from Non-residents” to the JPO, which is from those who do not live in Japan (for instance, those who live in the U.S.).
2) The value of “applications from Residents” of the EPO has not been included since 1996.

The next Chart shows the situation of patent applications from main countries (Chart 4-2-2 (C)). Here, the numbers of applications are divided into two categories and shown as applications to the country of residence and applications to a country of non-residence. Direct applications to patent authorities in each county or region; and PCT patent applications which are transferred to the national/regional phase were counted. In all countries, applications to the EPO were counted as non-resident applications.

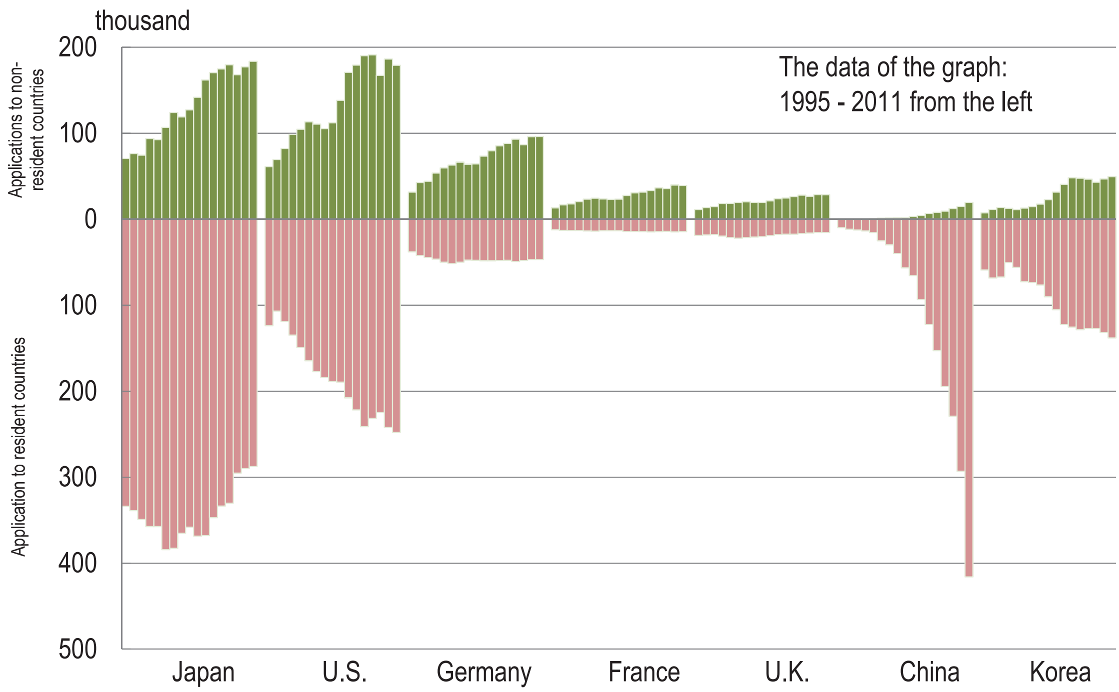
This analysis calculates the number of applications for each country by using the country that the first applicant or assignee belongs to. For instance, if there is a joint application with an applicant (the first) in Japan and an applicant (the second) in the U.S., only Japan is counted.

In Japan, the U.S., China and Korea, there are more applications to the country of residence than there are to countries of non-residence. Approximately 60% of the total numbers of applications from Japan are to the JPO.

Looking at changes in the number of applications to a country of residence, the number for Japan has been decreasing in recent years. It stood at 290,000 in 2011, which is approximately 75% of the peak year (2000). The number for China has been growing remarkably, reaching 420,000 in 2011. The U.S. and Korea increased through 2007, but increases have been very small in recent years. In Germany, France and the U.K., the numbers of applications to the country of residence have been almost flat or a little bit decreased. One of the factors is considered to be that a certain number of patent applications, which have been applied for to the patent authorities of the country of residence, are now being applied for to the EPO.

Looking at the number of applications to a country of non-residence, the number of applications from Japan ranks with that of the U.S. at the top internationally with 180,000 in 2011. The number of applications from the U.S. has been decreasing in recent years. It deserves noting that China has been increasing its number of patent applications to a resident country, but its number to non-resident countries remains small at just 20,000 in 2011.

(C)The numbers of patent applications from main countries (1995–2011)



Note: 1) Regarding the breakdown of the numbers of applications, in the case of Japan, "Applications to resident countries" refer the applications to the JPO applied by applicants who live in Japan, and "Applications to non-resident countries" refer the applications, applied by applicants who live in Japan, to other countries.
2) Every country includes the numbers of the applications to the EPO.
3) Includes PCT applications transferred domestically.
Source: WIPO, "WIPO statistics database" (Last updated: November 2012)

4.2.2 International comparison of number of patent applications using patent families

One difficulty in international comparison of numbers of patent applications is the fact that patents are territorial, and thus applicants make applications to multiple countries when seeking to establish rights for an invention. Consequently, when counting patent applications from "Country A," the possibility exists that duplicated patent applications to several countries are being counted. Additionally, when considering applications to Country A, there is a tendency for applications from Country A to have the largest share (the so-called "home advantage").

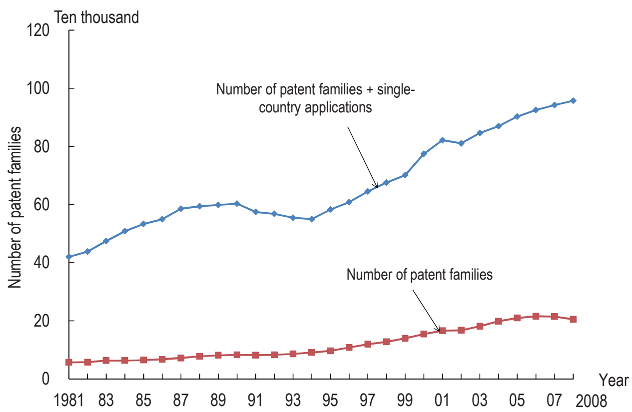
Given these characteristics of patent applications, the analysis here will be based on patent families in order to improve the international comparability. The analysis was made using PATSTAT (September 2012 version) of the European Patent Office (EPO). Details concerning the method for patent family analysis are provided in the Technical Notes below. "Patent families" refers to groups of patent applications that are made to two or more countries that are tied directly or indirectly by priority rights. Ordinarily, patents for which applications with the same content are made to multiple countries belong to the same patent family. Accordingly, counting patent families makes it possible to prevent double counting of the same patent. In other words, it is thought that the number of patent families is roughly the same as the number of inventions.

Additionally, counting patent families makes it possible to make a collective count of applications to patent offices around the world, rather than just applications to specific countries. Although PCT application numbers are commonly used when making international comparisons of patent application numbers, PCT applications provide a limited view of overseas applications from a certain country. From the standpoint that it measures the number of inventions produced by each country in an internationally comparable form, analysis using patent families is thought to provide useful indicators when comparing the technical capabilities of each country.

The following presents two values. The first is a number that adds the number of patent applications to one country only (single-country applications) to the number of patent families (patent applications to two or more countries), and the other is the number of patent families. In the following discussion, the former will be referred to as "number of patent families + single-country applications" and the latter as "number of patent families." In the case of a patent family, the application is submitted to two or more countries with the intention of protecting rights in countries outside that in which the inventor or applicant resides; thus, the invention is considered to have higher value than that for a single-country application.

Chart 4-2-3 shows time-series changes in the number of patent families + single-country applications and number of patent families. The number of patent families + single-country applications, which stood at around 400,000 in 1981, saw gradual growth that brought it up to approximately 960,000 in 2008. The number of patent families stood at 57,000 in 1981 and approximately 210,000 in 2008. The percentage of the number of patent families in patent family + single-country applications was less than 15% in the 1980s; however, it has continued to grow gradually and exceeded 20% in recent years.

Share 4-2-3: Changes in number of patent families + single-country applications and number of patent families.



Note: See the Technical Notes for details concerning the method used for patent family analysis.
Source: Compiled by NISTEP based on PATSTAT (September 2012 version) of the European Patent Office

Chart 4-2-4 shows the percentages of single-country applications and multiple-country applications in the patent family + single-country applications of the selected countries. In Japan, approximately 95% were single-country applications in the first half of the 1980s. From the mid-1980s, the percentage of multiple-country applications grew gradually until, as of 2008, 80% were single-country applications and 20% were multiple-country applications.

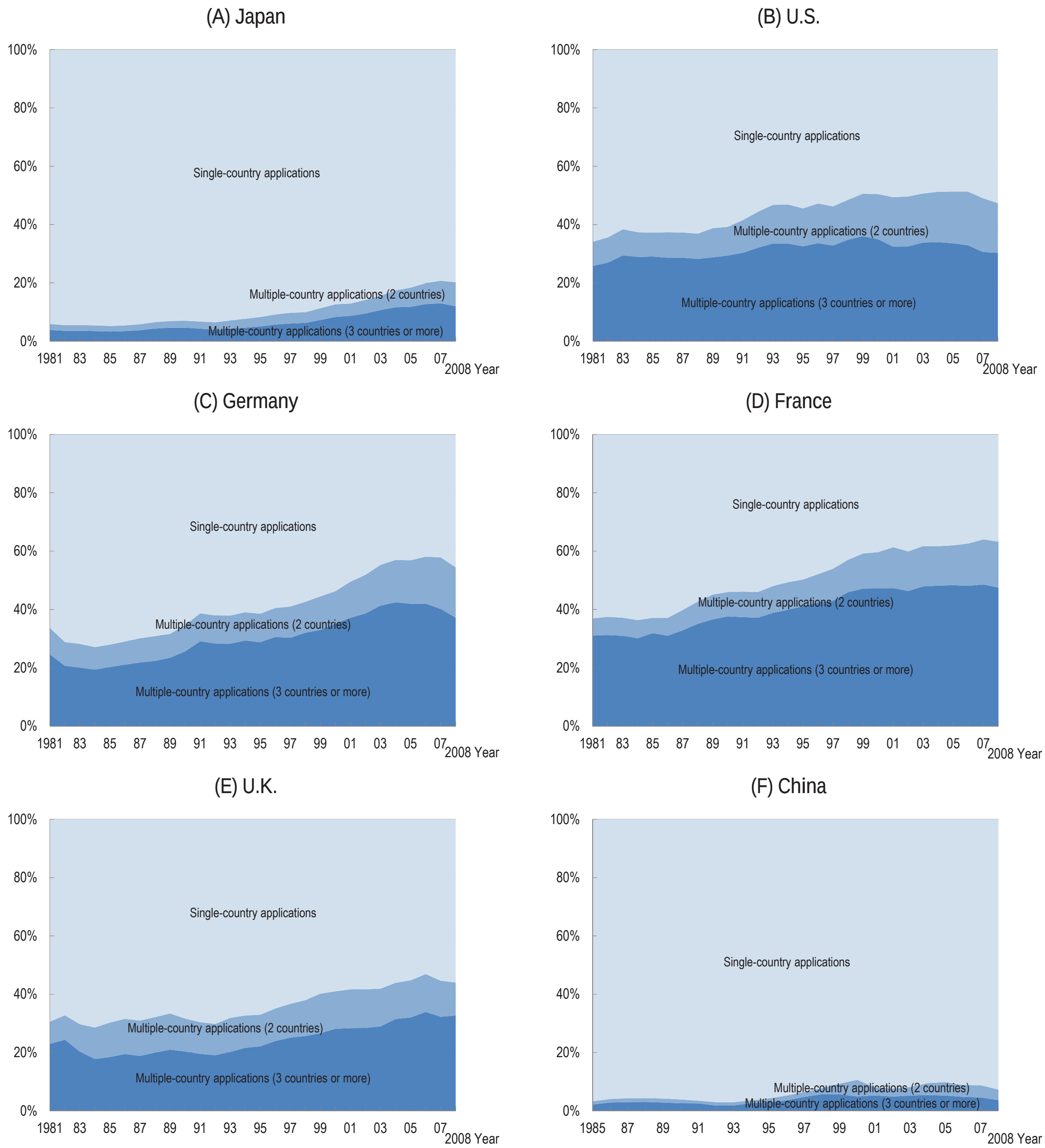
In the U.S., the percentages of single-country applications and multiple-country applications are both around 50%. This balance has not changed greatly since the second half of the 1990s.

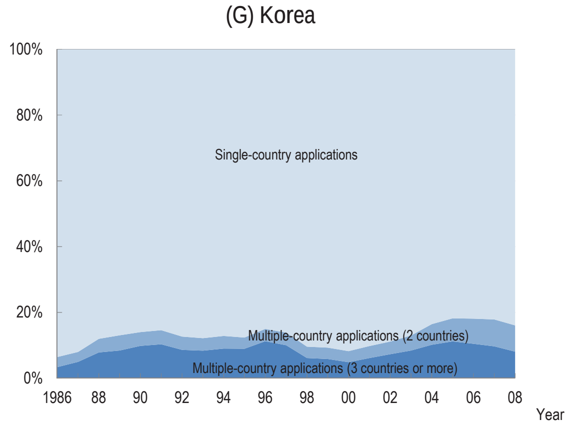
In Germany, France, and the U.K., each is seeing a long-term trend whereby the percentage of multiple-country applications is rising.

Of the three, the country with the highest percentage of multiple-country applications is France. This percentage stood at 63% in 2008.

Like Japan, the percentages of multiple-country applications of China and Korea are not very high. Although there has been a degree of fluctuation in some years, as of 2008, the percentage for China stood at roughly 7% while that for Korea was roughly 16%.

Chart 4-2-4: Percentages of number of patent families + single-country applications by number of destination countries in the selected countries





Note: See the Technical Notes for details concerning the method used for patent family analysis.
Source: Aggregated by NISTEP based on PATSTAT (September 2012 version) of the European Patent Office

4.2.3 Number of patent families, single-country applications and number of applications and number of patent families in each country/region

Chart 4-2-5 shows the number of patent families + single-country applications (A) and number of patent families (B) that were obtained with whole counting for each country and region.

Japan's number of patent families + single-country applications ranks No. 1 in all three time periods. For the 2006 to 2008 period, the next counties were, in order, China, the U.S., Korea, Germany, and Taiwan. The chart shows that the Asian countries and regions have rapidly moved up in rank during the past 20 years.

Looking at the number of patent families, throughout the 1980s and the 1990s, the U.S. ranked No. 1 and Japan ranked No. 2; however, entering the 2000s, Japan has ranked No. 1 and the U.S. No. 2. Looking at the next countries beginning with the third spot, in the 2006 to 2008 period, these were Germany followed by Korea, France, China, and Taiwan. Although China is showing remarkable increases in terms of its number of patent families + single-country applications, as can be seen in Chart 4-2-4, the majority of applications are currently directed within China. Accordingly, China ranks below the U.S., Germany, and others in terms of number of patent families.

Chart 4-2-5: Number of patent families + single-country applications and number of patent families in each country/region: The top 25 countries/regions

(A) Number of patent families + single-country applications

1986 - 1988 (Average)			
Number of patent families + single-country applications			
	Whole counting		
Country/Region	The number of papers	Share	World rank
Japan	304,517	52.8	1
Soviet	68,956	12.0	2
U.S.	52,268	9.1	3
Germany	47,702	8.3	4
U.K.	21,014	3.6	5
France	13,088	2.3	6
Italy	8,180	1.4	7
Czechoslovakia	5,500	1.0	8
Poland	5,464	0.9	9
Sweden	4,232	0.7	10
Switzerland	4,026	0.7	11
China	3,891	0.7	12
Canada	3,509	0.6	13
Netherlands	2,997	0.5	14
Romania	2,793	0.5	15
Korea	2,726	0.5	16
Austria	2,671	0.5	17
Hungary	2,510	0.4	18
Brazil	2,201	0.4	19
Finland	2,072	0.4	20
Spain	1,727	0.3	21
Ireland	1,701	0.3	22
Bulgar	1,689	0.3	23
South Africa	1,654	0.3	24
Israel	1,373	0.2	25

1996 - 1998 (Average)			
Number of patent families + single-country applications			
	Whole counting		
Country/Region	The number of papers	Share	World rank
Japan	340,930	53.0	1
U.S.	91,932	14.3	2
Germany	52,996	8.2	3
Korea	39,865	6.2	4
U.K.	22,631	3.5	5
France	14,651	2.3	6
Russia	13,025	2.0	7
China	12,027	1.9	8
Italy	9,711	1.5	9
Canada	6,417	1.0	10
Taiwan	5,561	0.9	11
Sweden	5,532	0.9	12
Switzerland	4,623	0.7	13
Netherlands	4,597	0.7	14
Finland	2,945	0.5	15
Brazil	2,886	0.4	16
Austria	2,471	0.4	17
Israel	2,435	0.4	18
Poland	2,365	0.4	19
Spain	2,209	0.3	20
Belgium	2,139	0.3	21
Australia	1,904	0.3	22
South Africa	1,803	0.3	23
Norway	1,583	0.2	24
Denmark	1,337	0.2	25

2006 - 2008 (Average)			
Number of patent families + single-country applications			
	Whole counting		
Country/Region	The number of papers	Share	World rank
Japan	320,487	34.0	1
China	149,471	15.9	2
U.S.	140,578	14.9	3
Korea	117,895	12.5	4
Germany	56,823	6.0	5
Taiwan	32,120	3.4	6
Russia	27,183	2.9	7
U.K.	23,929	2.5	8
France	19,088	2.0	9
Italy	13,682	1.5	10
Canada	11,142	1.2	11
Netherlands	7,241	0.8	12
Switzerland	6,220	0.7	13
Sweden	5,135	0.5	14
India	5,072	0.5	15
Israel	5,009	0.5	16
Brazil	4,436	0.5	17
Spain	4,228	0.4	18
Austria	3,731	0.4	19
Finland	3,556	0.4	20
Australia	3,543	0.4	21
Belgium	3,042	0.3	22
Poland	2,454	0.3	23
Denmark	2,236	0.2	24
Singapore	1,825	0.2	25

(B) Number of patent families

1986 - 1988 (Average)			
Number of patent families			
	Whole counting		
Country/Region	The number of papers	Share	World rank
U.S.	18,671	25.8	1
Japan	17,660	24.4	2
Germany	14,018	19.4	3
France	5,114	7.1	4
U.K.	4,841	6.7	5
Italy	2,393	3.3	6
Switzerland	2,119	2.9	7
Netherlands	1,595	2.2	8
Sweden	1,246	1.7	9
Canada	1,179	1.6	10
Austria	934	1.3	11
Belgium	639	0.9	12
Australia	616	0.9	13
Finland	539	0.7	14
Soviet	413	0.6	15
Denmark	394	0.5	16
Spain	324	0.4	17
Israel	314	0.4	18
Hungary	259	0.4	19
Norway	248	0.3	20
Korea	247	0.3	21
South Africa	204	0.3	22
Taiwan	169	0.2	23
China	153	0.2	24
Czechoslovakia	150	0.2	25

1996 - 1998 (Average)			
Number of patent families			
	Whole counting		
Country/Region	The number of papers	Share	World rank
U.S.	33,144	28.0	1
Japan	31,415	26.5	2
Germany	20,954	17.7	3
France	7,440	6.3	4
U.K.	6,426	5.4	5
Korea	4,867	4.1	6
Italy	3,479	2.9	7
Netherlands	2,851	2.4	8
Switzerland	2,768	2.3	9
Canada	2,701	2.3	10
Sweden	2,575	2.2	11
Finland	1,302	1.1	12
Austria	1,282	1.1	13
Belgium	1,270	1.1	14
Taiwan	998	0.8	15
Australia	975	0.8	16
Israel	870	0.7	17
Denmark	747	0.6	18
China	712	0.6	19
Spain	686	0.6	20
Norway	455	0.4	21
Russia	411	0.3	22
India	387	0.3	23
Ireland	258	0.2	24
Singapore	245	0.2	25

2006 - 2008 (Average)			
Number of patent families			
	Whole counting		
Country/Region	The number of papers	Share	World rank
Japan	61,399	29.0	1
U.S.	47,556	22.4	2
Germany	30,724	14.5	3
Korea	18,466	8.7	4
France	11,082	5.2	5
China	9,506	4.5	6
Taiwan	9,318	4.4	7
U.K.	8,752	4.1	8
Italy	5,668	2.7	9
Canada	5,600	2.6	10
Netherlands	4,929	2.3	11
Switzerland	4,197	2.0	12
Sweden	3,488	1.6	13
India	2,815	1.3	14
Austria	2,341	1.1	15
Israel	2,164	1.0	16
Belgium	2,013	0.9	17
Australia	1,939	0.9	18
Finland	1,907	0.9	19
Spain	1,769	0.8	20
Denmark	1,445	0.7	21
Russia	964	0.5	22
Singapore	940	0.4	23
Norway	733	0.3	24
Ireland	625	0.3	25

Notes: The number of applications for Australia is underestimated because the Australian patent office was excluded from aggregation. See the Technical Notes for details concerning the method used for patent family analysis.
Source: Aggregated by NISTEP based on PATSTAT (September 2012 version) of the European Patent Office

Chart 4-2-6 (A) compares each country's share of the number of patent families + single-country applications using whole counting in order to ascertain each country's application situation in quantitative terms.

First, looking at shares of the number of patent families + single-country applications, Japan has consistently had a much larger share than the other countries since the 1980s. In the first half of the 1990s, Japan's share approached 60%; however, this figure has been dropping rapidly since the mid-1990s. It stood at 34% as of 2007.

During this time, significance increases in share of the number of patent families + single-country applications have been seen in the U.S. since the second half of the 1980s, Korea since the first half of the 1990s, and China since the second half of the 1990s.

As China has rapidly increased its share of the number of patent families + single-country applications, all of the other selected countries (with the exception of Korea) have had decreasing trends in their shares since entering the 2000s. As of 2007 (average of 2006 to 2008), the top three positions are held by Japan, China, and the U.S.

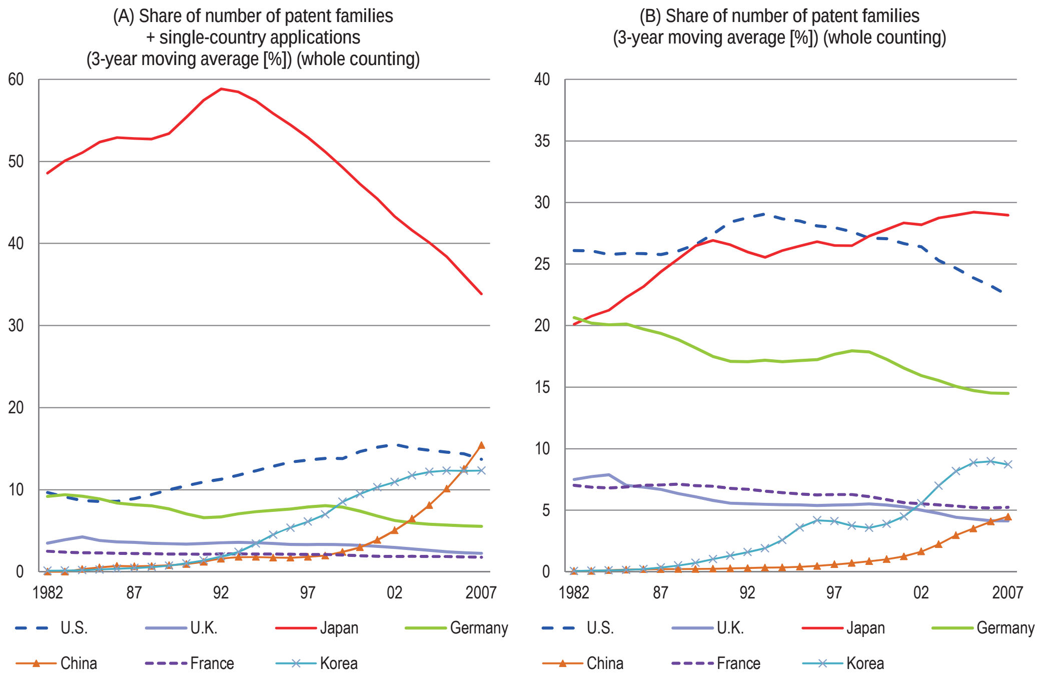
Next is an examination of changes in the number of patent families, which carries a qualitative aspect (Chart 4-2-6 (B)). Looking first at shares of the number of patent families, the U.S. maintained a 25% or greater share throughout the 1980s and 1990s; however, its share has been falling since the 2000s. On the other hand, Japan's share has been rising over the long term and reached 29% as of 2007. Japan overtook the U.S. during the second half of the 1990s before Japan took the top share in the 2000s.

Germany's share of the number of patent families resembled that of Japan during the first half of the 1980s but subsequently entered a gradual decline. Nonetheless, it ranked third behind the U.S. in 2007.

Korea's share began growing from the second half of the 1980s. This growth temporarily stopped in the second half of the 1990s but began again from the early 2000s.

China's share of the number of patent families has continued to grow since the first half of the 2000s. However, this growth has been slow compared to its share of the number of patent families + single-country applications. As of 2007, China ranked sixth in terms of share of the number of patent families.

Chart 4-2-6: Changes in shares of number of patent families + single-country applications and number of patent families among the selected countries (All technical fields, whole counting, three-year moving average)



Notes: Three-year moving averages of share of number of patent families in all technical fields (if 2007, average of 2006, 2007, and 2008); see the Technical Notes for details concerning the method used for patent family analysis.
Source: Aggregated by NISTEP based on PATSTAT (September 2012 version) of the European Patent Office

Because patent systems differ from country to country, numbers of patent families + single-country applications, that include applications made only to the countries of residence of inventors and applicants, are considered to have high dependency on the patent system of individual countries.

On the other hand, in the case of patent families, applications are thought to be submitted to two or more countries with the intention of protecting rights in countries outside those in which the inventor or applicant resides; thus, their inventions are considered to have relatively higher value among the number of patent families + single-country applications. Given this, the following analysis primarily uses patent families.

4.2.4 Technology field characteristics of patent applications of the selected countries

(1) Technology field balance in all patent families

This section discusses the results of an analysis of the number of patent families in individual technology field. For classification of technology field, technology field and correspondence tables of the International Patent Classification (IPC) presented by WIPO were used. As is shown in Chart 4-2-7, WIPO's technology field are classified into 35 detailed classifications. These were compiled into nine technology field for the purposes of this analysis.

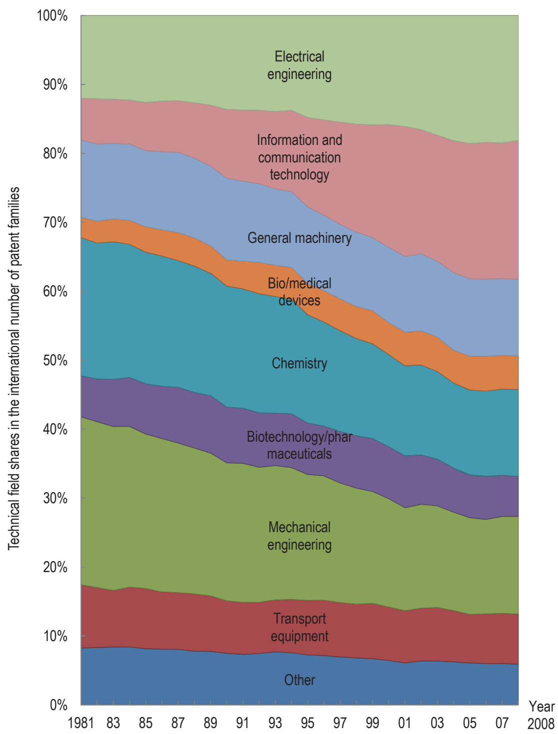
First, Chart 4-2-8 shows changes in balance of technology fields in all patent families. A comparison of 1981 and 2008 shows that mechanical engineering declined by 10.2 percentage points and chemistry declined by 7.4 points. On the other hand, information and communication technology grew by 14.1 percentage points and electrical engineering grew by 6.1 points. It is apparent that the share of information and communication technology has grown particularly rapidly since the early 1990s.

Chart 4-2-7: Technology field

Technical fields	35 detailed classifications (WIPO)
Electrical engineering	Electrical machinery, apparatus, energy
	Audio-visual technology
	Semiconductors
Information and communication technology	Telecommunications
	Digital communication
	Basic communication processes
	Computer technology
	IT methods for management
General machinery	Optics
	Measurement
	Control
Bio/medical devices	Analysis of biological materials
	Medical technology
Chemistry	Organic fine chemistry
	Food chemistry
	Basic materials chemistry
	Material, metallurgy
	Surface technology, coating
	Micro-structure and nano-technology
	Chemical engineering
	Environmental technology
Biotechnology/pharmaceuticals	Biotechnology
	Pharmaceuticals
	Macromolecular chemistry, polymers
Mechanical engineering	Handling (elevators, cranes, robots, packaging devices, etc.)
	Machine tools
	Textile and paper machines
	Other special machines
	Thermal processes and apparatus
	Mechanical elements
Transport equipment	Engines, pumps, turbines
	Transport
Other	Furniture games
	Other consumer goods
	Civil engineering

Note: See the Technical Notes for details concerning the method used for patent family analysis.
Source: Classified by NISTEP based on WIPO, IPC-Technology Concordance Table

Chart 4-2-8: Changes in technology field shares of the international number of patent families



Note: See the Technical Notes for details concerning the method used for patent family analysis.
Source: Aggregated by NISTEP based on PATSTAT (September 2012 version) of the European Patent Office

(2) Technology field balances in the selected countries

Next, Chart 4-2-9 shows changes in the technology field balances of the selected countries.

Looking at Japan's technology field balance as of 2008, Japan has high ratios in electrical engineering and general machinery in international comparison. A comparison of 1981 and 2008 figures for Japan shows that the share of electrical engineering increased by 7.8 percentage points. The share of information and communication technology also rose by 11.3 percentage points; however, its share among all technology fields was roughly the same as the field's international share. On the other hand, Japan has lower ratios in biotechnology/pharmaceuticals and bio/medical devices in terms of international comparison.

The U.S. has large shares for bio/medical devices, biotechnology/pharmaceuticals, and chemistry in international comparison. A comparison of 1981 and 2008 shows that bio/medical devices increased by 4.4 percentage points and chemistry biotechnology/pharmaceuticals increased by 1.9 percentage points. Its shares of electrical engineering and general machinery are small in international comparison.

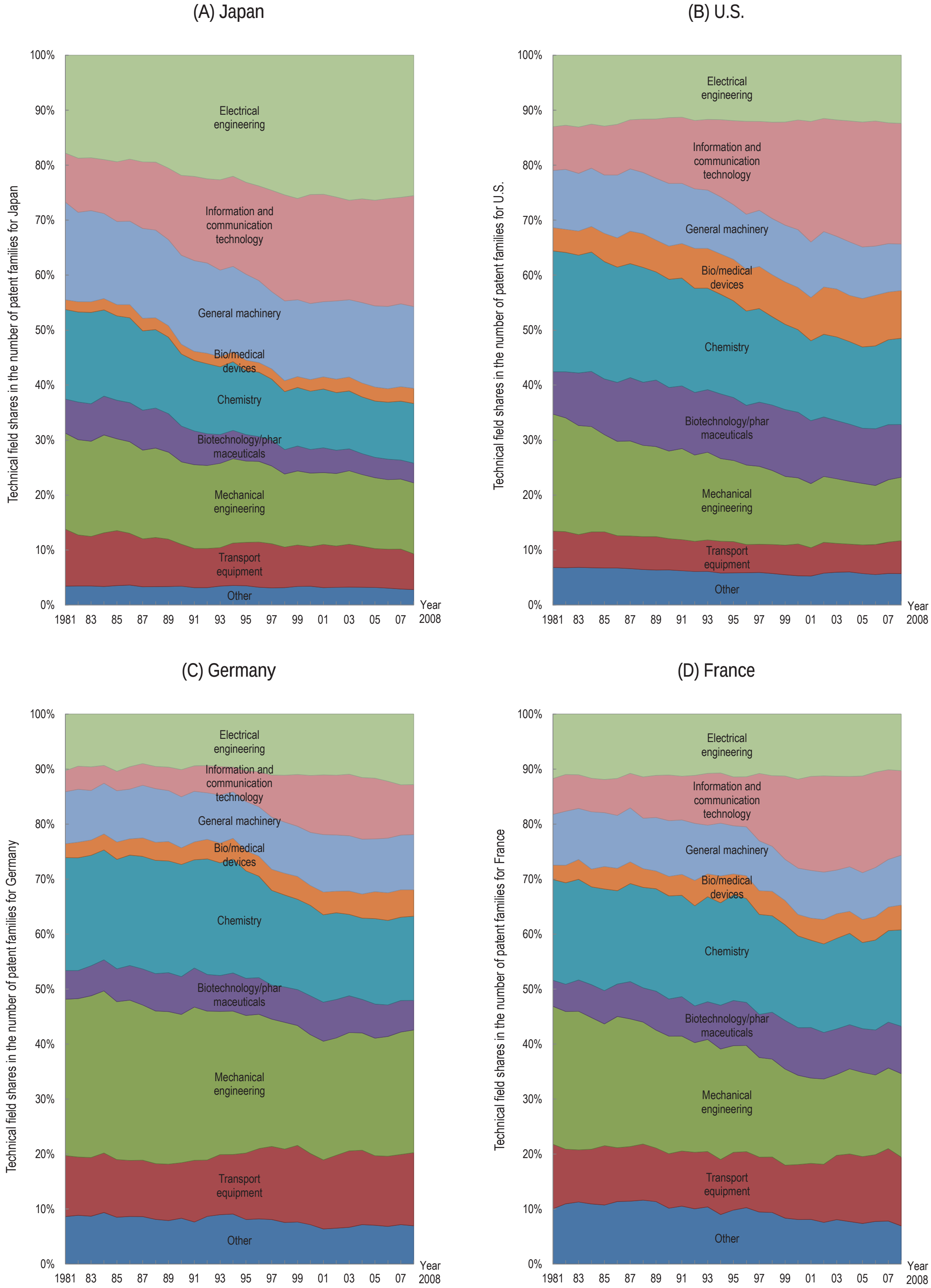
Germany has large shares for transport equipment, mechanical engineering, and chemistry in international comparison. A comparison of 1981 and 2008 shows that transport equipment increased by 2.2 percentage points while mechanical engineering decreased by 6.1 points and chemistry decreased by 5.2 points. Although information and communication technology increased by 5.3 percentage points, the share of this field in Germany is roughly half of the international share of information and communication technology (as of 2008).

France has high shares of transport equipment, biotechnology/pharmaceuticals, and chemicals in international comparison. A comparison of 1981 and 2008 shows that biotechnology/pharmaceuticals increased by 3.9 percentage points. On the other hand, mechanical engineering showed a decrease of 9.9 percentage points. Although information and communication technology increased by 8.8 percentage points, like Germany, France's share is small compared to the international share of information and communication technology.

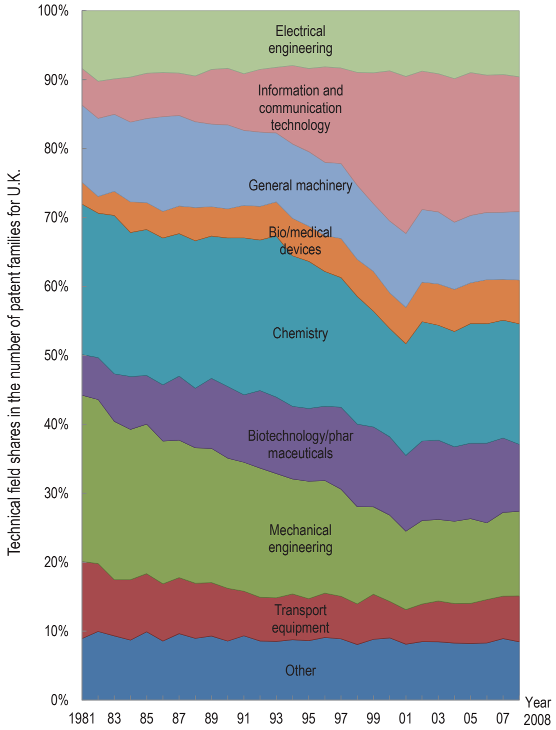
The U.K. has high shares for biotechnology/pharmaceuticals, chemistry, and bio/medical devices in international comparison. A comparison of 1981 and 2008 shows that biotechnology/pharmaceuticals increased by 3.8 percentage points and bio/medical devices increased by 3.2 points. Mechanical engineering decreased by 11.8 percentage points, transport equipment by 4.5 points, and chemistry by 4.3 points. The share of information and communication technology grew significantly by 14.2 percentage points and is roughly comparable with the international share of the field. Among the European countries, the U.K. has a high share for information and communication technology in the number of patent families.

China and Korea both have shares for information and communication technology and electrical engineering that rank high when compared to the international averages.

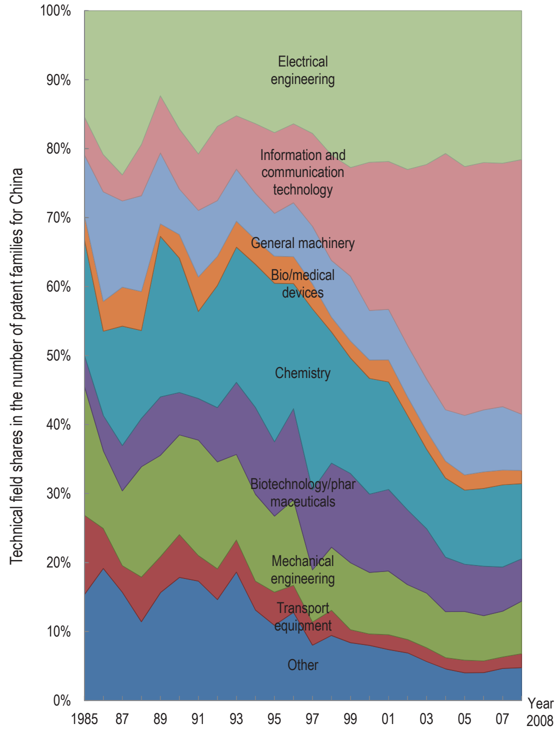
Chart 4-2-9: Changes in technology field shares of the number of patent families in the selected countries



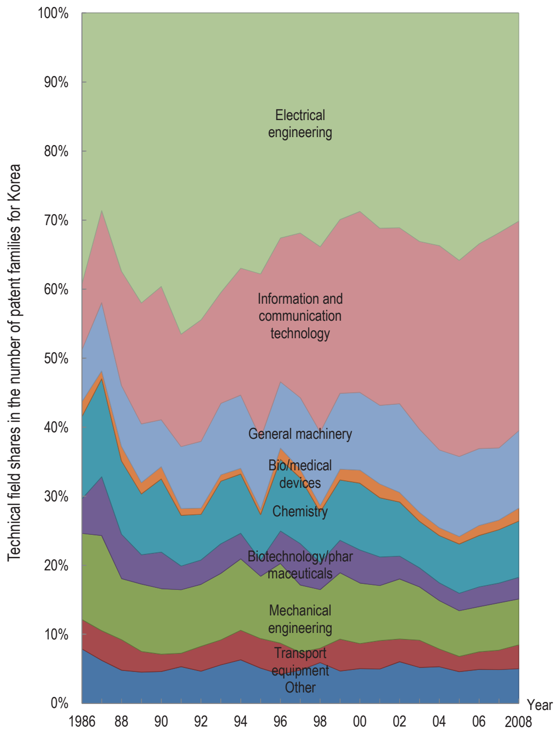
(E) U.K.



(F) China



(G) Korea



Note: See the Technical Notes for details concerning the method used for patent family analysis.
Source: Aggregated by NISTEP based on PATSTAT (September 2012 version) of the European Patent Office

(3) Technology field balances of the selected countries in the world

Chart 4-2-10 shows the technology field balances of the selected countries in the world. Specifically, it shows and compares the share of each technology field of the number of patent families of the selected countries (1996 to 1998 and 2006 to 2008; whole counting).

Japan has a portfolio with high shares for electrical engineering, general machinery, and information and communication technology and low shares for biotechnology/pharmaceuticals and bio/medical devices. The comparison of 1981 and 2008 in Chart 4-2-9 suggested that the share of information and communication technology is growing in Japan's domestic patent family. However, Japan's share in the world decreased from 32.8% to 28.7%. This is because China and Korea are rapidly increasing their international shares.

Looking at shares in the number of patent families from 2006 to 2008, the U.S. had international shares exceeding 25% in bio/medical devices, biotechnology/pharmaceuticals, chemicals, and information and communication technology. Germany had international shares exceeding 15% in transport equipment, mechanical engineering, chemistry, and other. France had international shares exceeding 7% in transport equipment, biotechnology/pharmaceuticals, and chemistry, while the U.K. had a similar international share in biotechnology/pharmaceuticals. A comparison with 1996-1998 shows that international shares are decreasing gradually or flat in many technology fields.

China and Korea are rapidly expanding their international shares. Korea, in particular, had international shares exceeding 10% in electrical engineering and information and communication technologies as of 2006-2008.

4.2.5 Destinations of patent family applications

Next, the analysis looked at time-series changes in the international expansion of patent applications from the selected countries by examining the destinations of patent family applications (excluding those to own country) (Chart 4-2-11).

Looking at Japan, at least 90% of its patent family applications went to the U.S. or Europe as of 1981; however, its applications to China have been increasing since the 1990s. As of 2007, applications to the U.S. accounted for 46%, those to China accounted for 20%, and those to the European Patent Office accounted for 13%. As for direct applications to the patent offices of individual European countries, this share has been shrinking year by year and accounted for 6% in 2007.

Looking at the U.S., as of 1981, approximately half of all patent family applications went to Europe, 20% went to North and Latin American countries other than the U.S., and 18% went to Japan. U.S. applications to Asian countries other than Japan increased from the early 1990s. As of 2007, 41% of U.S. applications went to Asian countries. A certain number of applications also went to Africa.

Looking at Germany in 2007, 20% of its applications went to Asia, 23% to the U.S., and 43% to the European Patent Office.

In France, 20% of its applications went to Asia, another 20% went to the U.S., and 33% went to the European Patent Office. And in the U.K., 23% went to Asia, 29% to the U.S., and 26% to the European Patent Office.

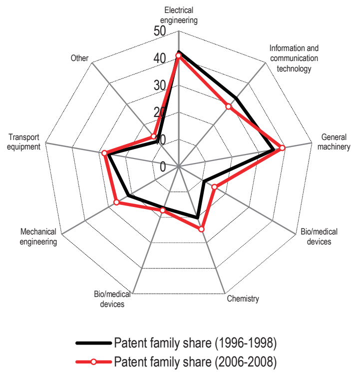
Looking at application destinations within Asia, Japan's percentage has fallen relatively while those of China and Korea have risen. As with the U.S., a certain number of applications also went to Africa.

Looking at applications from China, in the second half of the 1980s, approximately half went to Europe; following were Asia and the U.S. Subsequently, the share of applications to the U.S. has increased significantly while that to Europe has shrunk. As of 2007, 46% of applications went to the U.S., 26% to Asia, and 14% to the European Patent Office.

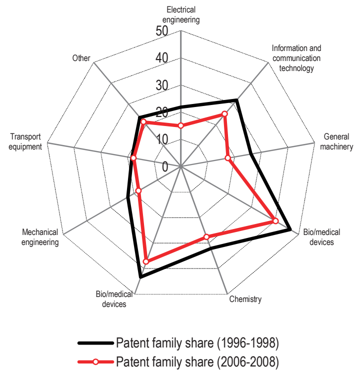
As for Korea, in the second half of the 1980s, roughly one-third went each to the U.S., Europe, and Asia (principally Japan). Subsequently, the share of applications to the U.S. has been rising. As of 2007, 52% went to the U.S. and 33% to Asia. Looking at application destinations in Asia, Japan's percentage is falling relatively while that of China is rising.

Chart 4-2-10: Comparison of shares in the number of patent families for each technology field in the selected countries
(%, 1996-1998 and 2006-2008, whole counting)

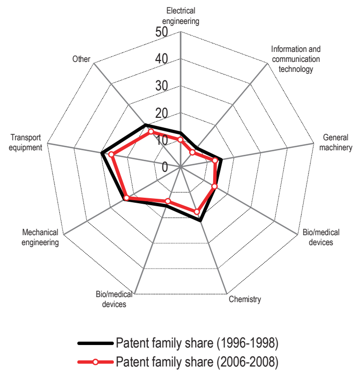
Japan (Caution Axis scale)



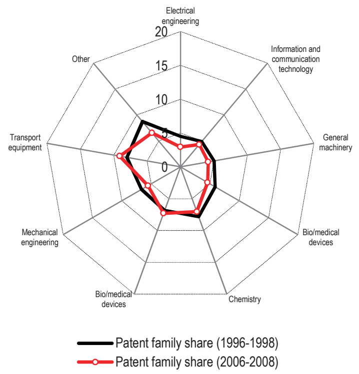
U.K. (Caution Axis scale)



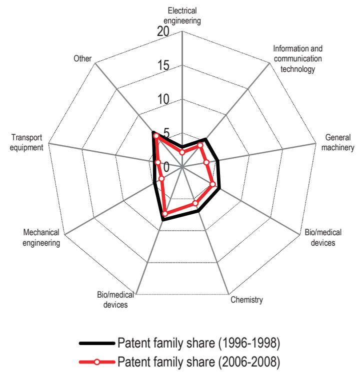
Germany (Caution Axis scale)



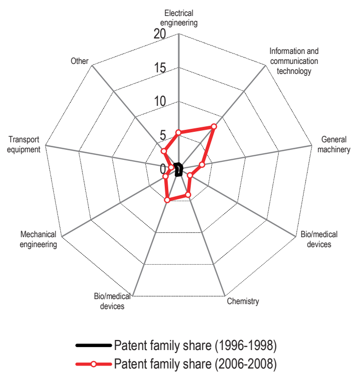
France



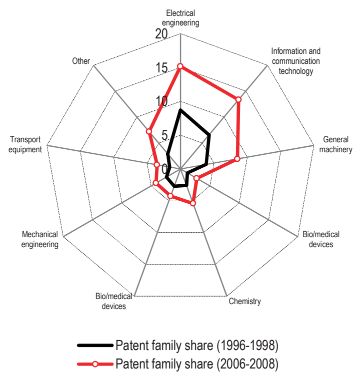
U.K.



China

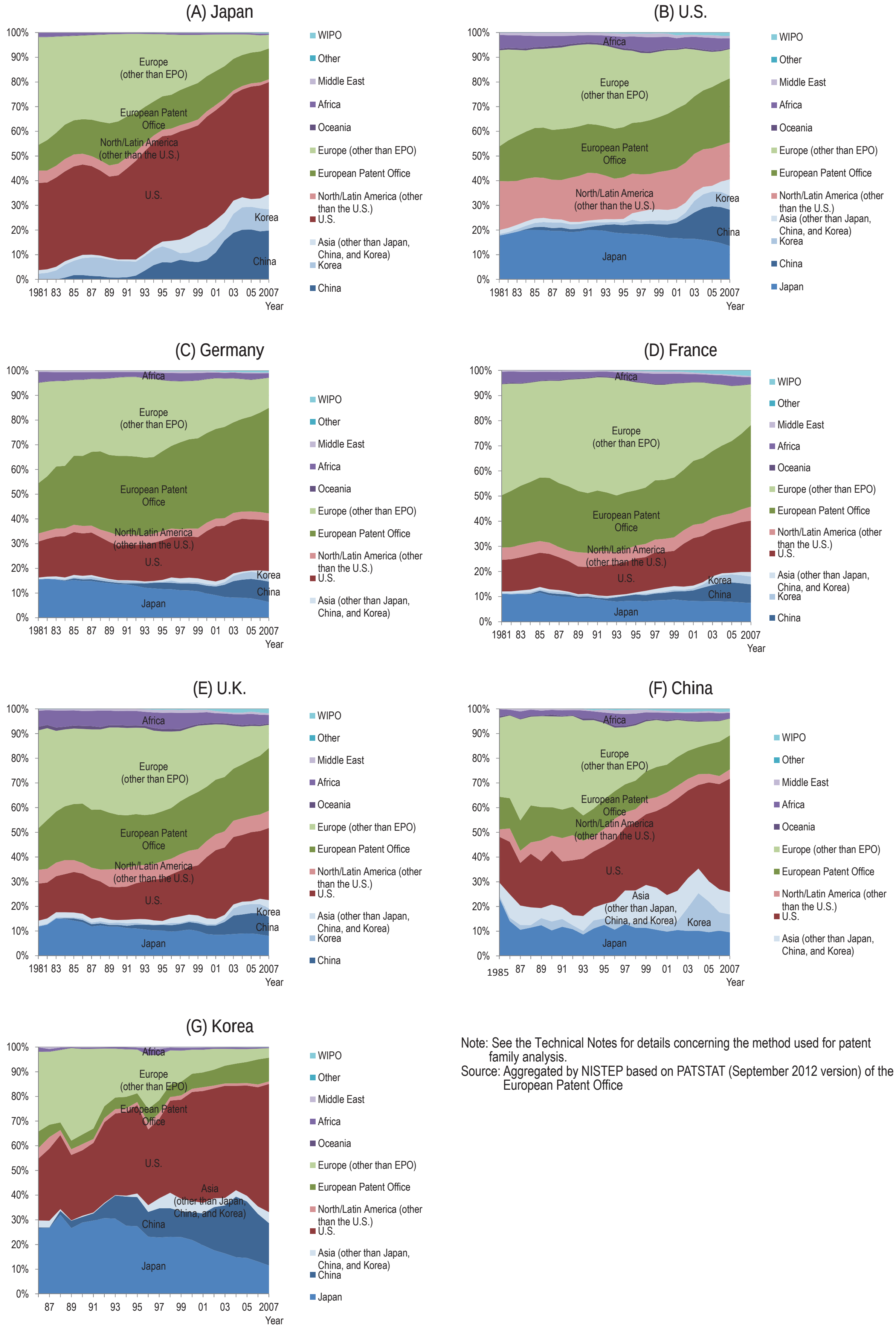


Korea



Note: See the Technical Notes for details concerning the method used for patent family analysis.
Source: Aggregated by NISTEP based on PATSTAT (September 2012 version) of the European Patent Office

Chart 4-2-11: Destinations of patent family applications from the selected countries



Note: See the Technical Notes for details concerning the method used for patent family analysis.
Source: Aggregated by NISTEP based on PATSTAT (September 2012 version) of the European Patent Office

Technical Notes: Patent family analysis

For the Japanese Science and Technology Indicators 2013, NISTEP conducted its first full-scale analysis based on patent families. This approach is intended to improve the potential for international comparison of patent application numbers.

"Patent families" refers to groups of patent applications that are made to two or more countries that are tied directly or indirectly by priority rights. Ordinarily, patents for which applications with the same content are made to multiple countries belong to the same patent family. Accordingly, counting patent families makes it possible to prevent double counting of the same patent. Additionally, counting patent families makes it possible to make a collective count of applications to patent offices around the world, rather than just applications to specific countries.

However, the results of patent family analysis are dependent upon the database used, way of defining "patent family," and method of counting patent families.

Given this, the following summarizes the method used to analyze patent families for Japanese Science and Technology Indicators 2013 for consideration when making comparisons with other analyses. It should be noted that references to "tlsXXX" in the explanation are names of tables included in PATSTAT.

A) Database used in analysis

The European Patent Office's PATSTAT (September 2012 version) was used. PATSTAT contains statistical data on over 78 million patents in more 80 countries of the world.

B) Definition of "patent family"

Although various definitions of "patent family" exist, the DOCDB patent family (tls218_docdb_fam) prepared by the European Patent Office was used in the analysis appearing in Japanese Science and Technology Indicators 2013.

C) Counting of patent families

When counting patent families, the earliest application date among applications comprising the family and inventor's country of residence were used in conformity with the OECD Patent Statistics Manual. Whole counting on a country basis was used.

D) Method for acquiring inventors' data

Given that there are many deficiencies in the inventors' data and applicants' data of PATSTAT, each patent family and country were associated as follows:

(1) A search for all patent applications comprising a patent family was conducted, and results containing information on the inventor's country of residence were used.

(2) When results did not include information on the inventor's country of residence, a search for all patent applications comprising a patent family was conducted, and results containing information on the applicant's country of residence were used.

(3) When an association with a country could not be achieved in the above-mentioned process, information on the destination of the earliest application was used based on the assumption that the initial application is made in the applicant's country of residence.

E) Identification of patent families

Of the DOCDB patent families, applications submitted to a single patent-receiving office were considered single-country patents and those for which applications were sent to two or more patent-receiving offices were considered patent families.

F) Classification of technology field

The IPC-Technology Concordance Table (http://www.wipo.int/ipstats/en/statistics/technology_concordance.html) (January 2013) issued by WIPO was used for classification of technology field using the International Patent Classification (IPC).

When multiple technology field were applicable to a single patent application, each field was calculated based on fractional counting.

G) Most recent available year for patent families

A patent family was counted only when applications were made to at least two countries. There are cases when a time lag of up to 30 months exists until the time that a patent application submitted as an international PCT application is handled domestically. Accordingly, 2008 was set as the most recent year that would allow analysis of a stable number of patent families. It should be noted that 2007 was set as the most recent available year for analysis of application destinations.

H) Other important points

- Regarding applications having information recorded in PATSTAT (i.e., a record exists in tls201_appln) but which have not been published in official bulletins, etc. (i.e., there is no applicable record in tls211_pat_publn), such applications were considered to have been dropped and therefore excluded from analysis.
- Regarding data on applications to the Australian patent office, aggregated values were considered to be abnormal values and therefore excluded from analysis.
- Short-term patents and design patents and plant patents of the U.S. were excluded from analysis.

Chapter 5: Science, technology and innovation

In recent years, there has been a strong need for initiatives that link the results of science and technology to the creation of new value through innovation. Indicators that can show the influence of science and technology on innovation have therefore become important. At this point, however, it is difficult to grasp such influence, and there is little quantitative data.

In this chapter, indicators of high-technology industry trade and medium high-technology industry trade, which give a comprehensive picture of technology trade and R&D-intensive industry showing international technological competitiveness, are examined. Next, using data on trademarks and patent families, the state of innovation in each of the countries will be considered. In addition, a comparison of the innovation activities of Japanese and the U.S. business enterprises is made based on surveys of businesses in those countries. Finally, long-term changes in Total Factor Productivity (TFP), which is frequently used as a proxy for the outcome of innovation, are examined.

5.1 Technology trade

Key Points

- ○Japan's technology trade balance as a ratio was 5.8 in 2011, with an export surplus continuing since 1993.
- ○Looking at technology trade exclusive of that between parent companies and subsidiaries, Japan's technical trade balance in 2011 was 2.2. It has had an export surplus since 2006. In the U.S., the balance was 4.2.

5.1.1 International comparison of technology trade

In general, technology exports means that the rights of using a technology[1], are given to business enterprises or individuals located in or having residence overseas in exchange for payment, and technology imports (technology introduction) means that the rights of using a technology are received from business enterprises or individuals located in or having residence in overseas in exchange for payment. This is called technology trade. It is used as an indicator for international measurement of countries' technology levels. The size of technology exports (receipts) or its ratio to the size of technology imports (payments), i.e., the technical trade balance, is used as an indicator that reflects technology strength. Because situations and conditions for technology trade differ in each country, simple comparisons are impossible. The focus here is therefore on changes over time and the correlation between the amounts of technology imports and exports for each country.

Looking at the amount of the technology trade in major countries (Chart 5-1-1 (A)), the trend for each country is not the same; however, it has generally been increasing on the whole. Looking at the trend by country, the amount of technology exports for Japan has shown an export surplus since FY 1993, which means that the amount of technology exports is higher than that of technology imports. The amount of technology exports was approximately approx. 2,385.2 billion yen and that of technology imports was about 414.8 billion in FY 2011. The amount of technology imports has been decreasing since peaking in FY 2007.

The U.S. has by far the world's largest technology export amount. In 2011, it was approximately five times that of Japan. Additionally, looking at long-term trends, both technology imports and exports had consistently increased, but exports fell during 2009 (by 3.6% from the previous year). Because its technology imports are smaller than its technology exports, the U.S.'s technology trade balance shows an export surplus.

(1) Including rights related to the technologies of intellectual property rights, engineering drawings, blueprints and so-called know-how as provided for by the laws of patent rights, utility model rights, trademark rights, design rights and copy rights.

In Germany, both the amount of technology exports and imports greatly exceeds that of Japan. Looking at long-term changes over time, the amounts of both technology exports and imports had been showing consistent growth but have flattened out in recent years.

Of the countries in the Chart, France is one of the countries which have a small amount of both technology exports and technology imports. Looking at change over time, its amount of technology exports has tended to increase since the 1990s, while its amount of technology imports has remained flat. (Note that the most recent year for which French statistics were available is 2003.)

Regarding the U.K., caution is necessary when looking at change over time because the methods of gathering statistics changed in 1996 and again in 2009. Nevertheless, the amount of technology exports has tended to be flat in recent years.

Looking at the technology trade balance (the amount of technology exports/the amount of technology imports) (Chart 5-1-1(B)), the technology trade balance of Japan has increased since it was more than 1 for the first time in 1993, and the amount of the FY 2011 marked the high figure of 5.8.

The technology trade balance of the U.S. is tending to decrease in the long run. It has been below that of Japan since 2001, and had an export surplus of 1.5 in 2011.

The technology trade balance of Germany passed 1 in 2003, and has been gradually increasing since then.

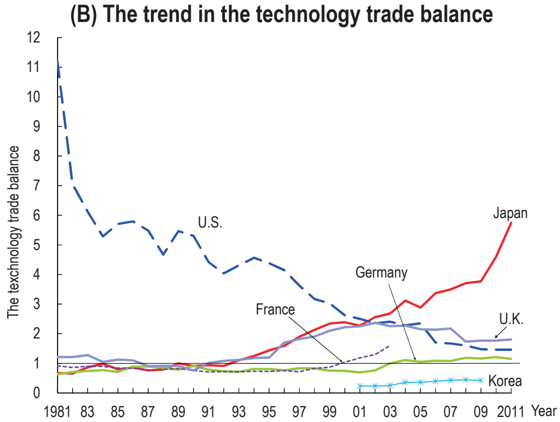
That of France was over 1 for the first time in 2000; an export surplus has existed since 2000. It marked 1.6 in 2003.

The technology trade balance of the U.K. had grown smoothly after entering the 1990s and consistently showed export surpluses since 1996. However, this growth slowed from around the mid-2000s and has been trending flat in recent years.

Chart 5-1-1: The technology trade of main countries

(A) The trend in the amount of technology trade

(B) The trend in the technology trade balance



Note :<Japan> Data are for fiscal years.
The sorts of technology trade are as follows (excluding trademark rights):
(1) Patent rights, utility model rights and copy rights
(2) Design rights
(3) Each kind of technological know-how provision and technical guidance (excluding free provision)
(4) Technological aid for developing countries (including government-commissioned works)

<U.S.> Through 2000, only royalties and licenses. For 2001–2005, research, development and testing services were added. Since 2006, intangible assets (excluding books, records, television, films, etc), computers, data processing services, etc., have been included. Figures for 2011 are provisional.

<Germany> West Germany until 1990. Until 1985 includes patents, licenses, know-how, trademarks, and design. From 1986, additionally included technical services, computer services and R&D in industrial fields. Figures for 2011 are provisional.

<U.K.> From1984, included oil companies. From 1996, includes patents, inventions, licenses, know-how, trademarks, design and services related to technology and R&D. Data continuity with the previous year is impaired for 2009. Figures for 2011 are provisional.

<Korea> Figures for 2009 are provisional.
Statistical reference E was used for purchasing power parity conversion.
Source :<Japan> Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development."
<U.S., Germany, France, U.K. and Korea>
OECD, "Main Science and Technology Indicators 2012/2."

When the data on technology trade is looked at, it can be seen that a significant ratio of technology trade among nations is accounted for technology transfers within corporate groups such as technology trade with affiliated companies overseas. Technology trade with affiliated companies is an indicator for international transfer of technical knowledge; however, it is not a strong indicator for the international competitiveness of technological strength. When technology trade is used as an indicator for seeing each country's technological strength, it is better to consider it by excluding technology transfers within corporate groups. Thus, regarding the amount of technology exports and imports of Japan and the U.S. whose data it is available, technology trade between affiliated companies and that between other companies are compared.

In Japan's survey(2), "Parent companies and subsidiaries" is defined as where the controlling share is over 50% in the capital ties between technology exporters and importers. With this definition, technology trade among parent companies and subsidiaries, and that among other companies are surveyed.

As shown in Chart 5-1-2(A), Japan's technology exports, excluding those between parent companies and subsidiaries, were 678.1 billion yen in FY2011, accounting for 28.4% of the whole. In FY 2001, they accounted for 43.3% of the total. Compared with FY 2011, technology exports exclusive of trade between parent companies and subsidiaries decreased by 14.9 percentage points. However, the amount of technology imports excluding that between parent companies and subsidiaries was 302.2 billion yen in FY 2011. It accounted for 72.9% for the total. That figure has declined by 9.8 percentage points since FY 2001. In the data for the U.S., technology trade of "associated companies" is defined as companies which own directly or indirectly 10% or more of voting rights or shares.

The amount of technology exports of companies excluding associated companies in 2011 was about 4,671.7 billion yen, accounting for 36.2% of the total.

Regarding the amount of technology imports, technology imports of companies excluding associated companies were about 1,111.1 billion yen in 2011, accounting for 28.4% of the total.

Also, looking at the technology trade balance of companies excluding parent companies, subsidiaries and affiliates (Chart 5-1-2 (B)), Japan had fluctuated around 1 but rose to 2.2 in 2011. This result can be interpreted as indicating that Japan's relative technical competitiveness has improved. However, declining technology imports are more of a factor here than increasing technology exports.

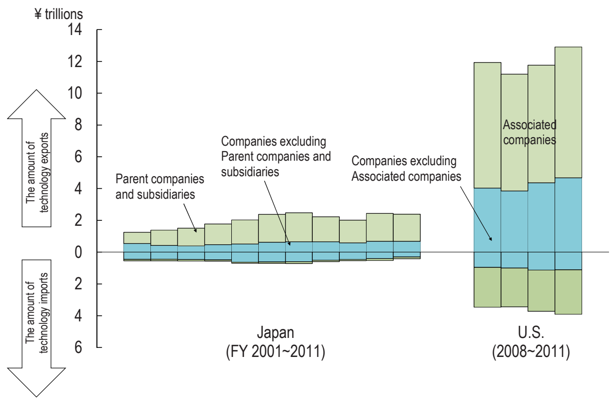
The U.S. has been fluctuating around 4 and stood at 4.2 in 2011.

Since definitions for parent companies and subsidiaries in Japan or associated companies in the U.S. are different, a simple comparison cannot be made. However, the data indicates that the technological strength of the U.S. surpasses that of Japan (See Chart 5-1-2(C) for definitions of parent companies and subsidiaries in Japan and the U.S.).

Chart 5-1-2: The change in the amount of technology trade in Japan and the U.S. (Technology trade among parent companies and subsidiaries, associated companies and others)

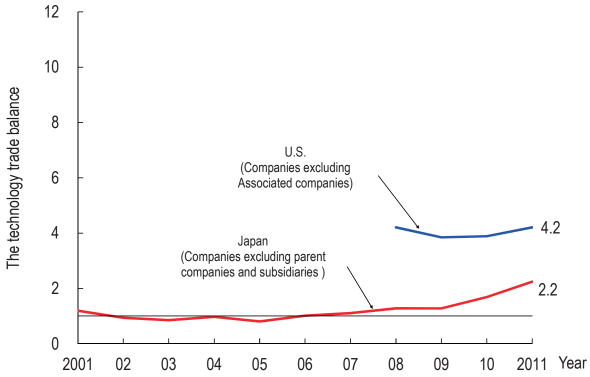
Attention to international comparison

(A) The amount of technology trade



(2)Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development" was a survey conducted on the Source of the technology trade of Japan by dividing it into the amount of the technology trade of parent companies and subsidiaries, and that for companies excluding parent companies and subsidiaries, since the survey for the FY 2002.

(B) Technology trade balance



(C) Definitions of parent companies and subsidiaries (associated companies) by capital ties, and the amount of technology trade

(Unit: ¥ trillions)

	Japan (FY2011)		U.S. (FY2011)		
	Technology Exports	Technology imports	Technology Exports	Technology imports	
Capital ties And/over 50% ↑	1.7	0.1	8.2	2.8	Capital ties ↑ And/over 10%
Under 50% ↓	0.7	0.3	4.7	1.1	↓ Under 10%

Note: Attention should be paid to when international comparisons are done, because definitions for parent companies and subsidiaries (affiliated companies) are different in Japan and in the U.S. Differences are as follows:
1) Japan's parent companies and subsidiaries are companies whose controlling share is over 50%.
2) U.S.'s associated companies are companies which own directly or indirectly 10% or more voting rights or shares.
<Japan> Types of technology are the same as in Chart 5-1-1.
<U.S.> Types of technology trade are royalties and licenses only.
Source: <Japan> Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development."
<U.S.> U.S. Department of Commerce, Bureau of Economic Analysis, U.S. International Services

Chart 5-1-3 is the ratio of the amount of the technology trade against the whole amount of trade. The level of the amount of the technology trade is shown by comparison with the entire trade amount of goods and services. Hereinafter, the ratio of the amount of technology exports which it occupies out of total exports is called the "Technology export ratio," and that for technology imports is called the "Technology import ratio." The U.K. had the highest technology export ratio, at 6.2% in 2011. Its 2001 figure of 5.5% was also high, and it increased by 1.2 percentage points. Second-highest was the U.S. at 5.4% in 2011. This was a 0.8 point increase from its 2001 figure of 4.6%.

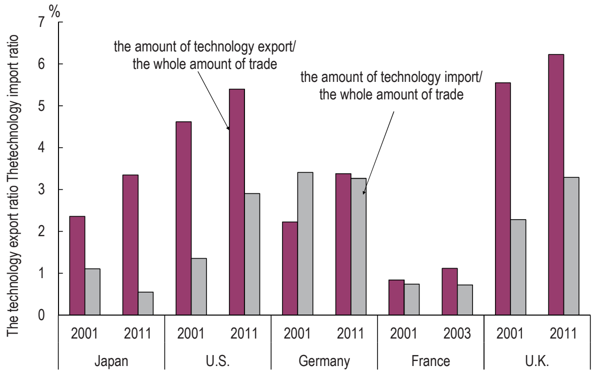
Japan's technology export ratio in 2011 was 3.3%, which was an increase of 0.9 points over the 2001 figure (2.4%).

Looking at technology import ratio," the U.K. (3.3%, 2011) and Germany (3.3%, 2011) rank high. Compared to 2001, the U.K.'s ratio has increased while Germany's has decreased.

The U.S.'s ratio stood at 2.9% in 2011, which was roughly double its ratio in 2001 (1.4%).

Japan's technology import ratio in 2001 was 1.1%; by 2011, it had decreased to 0.5%, or roughly half the 2001 figure.

Chart 5-1-3: The ratio of the amount of technology trade against the whole amount of trade



Note: The amount of technology imports and exports is the same as in Chart 5-1-1.
Source: <The amount of technology imports and exports>is the same as in Chart 5-1-1.
<The amount of the whole imports and exports>, OECD, "Aggregate National Accounts

5.1.2 The Technology Trade of Japan

Key Points

○Looking at Japan's amount of technology exports by industry classification, "Transportation equipment manufacturing" had the largest amount during FY 2011. At 1.2 trillion yen, it accounted for 50.8% of all industries. It was followed by "Drugs and medicines" with 0.3 trillion yen (12.1% of all industries). The industry with the largest amount of technology imports during FY 2011 was "Information and communication electronics equipment." With 0.2 trillion yen, it accounted for 40.7% of technology imports in all industries.

○ About 80% of trade in "Transportation equipment manufacturing" was among parent companies and subsidiaries. In the case of "Drugs and medicines," the percentage has remained around 50%. “Drugs and medicines” can be said to be an industry involving more international technology transfer for technology exports in Japan, many of which transactions are made among parent companies and subsidiaries.

○ Looking at partners for technology exports from Japan, the U.S. accounted for the largest amount in FY 2011, 0.8 trillion yen. China had the next highest amount with 0.3 trillion yen. Compared to 2006, the U.S.’s amount decreased as technology exports to Asia countries—notably China and Thailand—increased.

○Looking at partners for technology imports to Japan, the U.S. accounted for the largest amount at 0.3 trillion yen. Following were France and Germany at 0.02 trillion yen. Compared to 2006, technology imports from the U.S. have decreased considerably, and imports from the European nations have decreased as well.

(1) Technology trade by industry classification

Looking at the technology trade of Japan by industry classification (Chart 5-1-4(A)), the industry which had the largest amount of technology exports in the FY 2011 was “Transportation equipment manufacturing.” The amount was approx. 1,211.1 billion yen and accounted for 50.8% of the entire industries. It was followed by “Drugs and medicines” (approx. 289.0 billion yen, 12.1%) and “Information and communication electronics equipment” (approx. 271.2 billion yen, 11.4%).

Compared with FY 2006, technology exports in “Transportation equipment manufacturing” decreased; the industry’s share of the total also fell by 1.6 percentage points. Technology exports in “Drugs and medicines” increased, and its share grew by 3.3 percentage points. “Information and communication electronics equipment" had a 0.4 point decrease.

On the other hand, looking at in the FY 2011, the industry which had the large amount of technology imports was “Information and communication electronics equipment.” The amount was approx. 168.7 billion yen and accounted for 40.7% of the entire industries. It was followed by "Transportation equipment manufacturing" (53.6 billion yen, 12.9%) and "Drugs and medicines" (33.5 billion yen, 8.1%). Compared with FY 2006, technology imports in “Information and communication electronics equipment” decreased considerably, and its share of the total also fell by 4.4 percentage points. Technology imports in “Information and communication” increased, and its share increased by 5.6 percentage points.

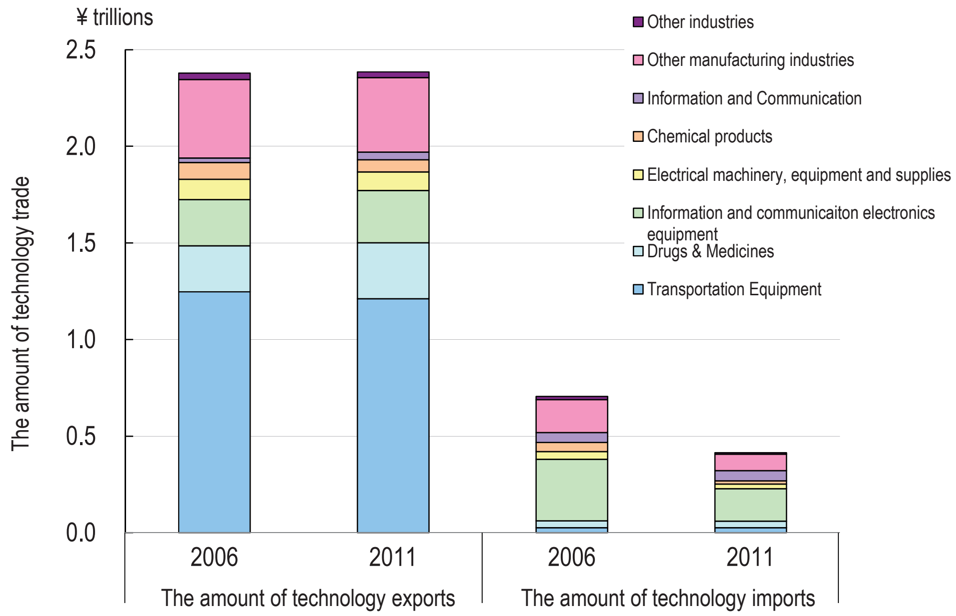
Looking by industry classification at the amount of technology trade of parent companies and subsidiaries and that of companies excluding parent companies and subsidiaries (Chart 5-1-4(B and, C)), it is thought that technology trade excluding parent companies and subsidiaries, in particular, is an indicator of international technical competitiveness.

In terms of technology exports, the percentage of trade among parent companies and subsidiaries is higher for almost all industries. However, the percentages of trade of companies excluding parent companies and subsidiaries are large for “Drugs and medicines” (63.3%) and “Information and communication electronics equipment” (66.6%). It should be noted that in the case of “Transportation equipment manufacturing," which accounts for a large amount of technology exports, 12.6% of trade in this industry is by companies excluding parent companies and subsidiaries.

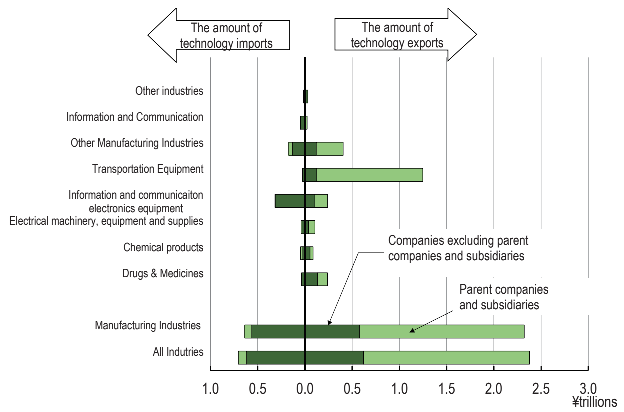
As for technology imports, the percentage of imports that were not among parent companies and subsidiaries was higher in almost every industry. Looking at the amount of technology imports, "Information and communication electronics equipment" was highest, followed by "Drugs and medicines." Almost all the trade in those industries was not among parent companies and subsidiaries.

Chart 5-1-4: The technology trade of Japan by industry classification

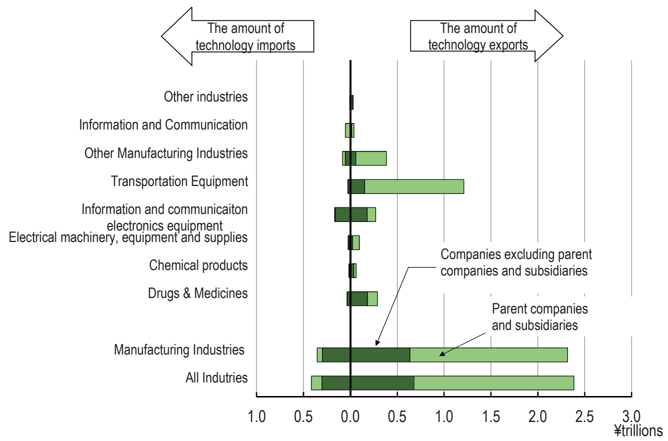
(A) The amount of technology trade



(B) The amount of technology trade of parent companies and subsidiaries, and that of companies excluding parent companies and subsidiaries (the FY 2006).



(C) The amount of technology trade of parent companies and subsidiaries, and that of companies excluding parent companies and subsidiaries (the FY 2011)



Note: 1) For the names of the components, the names of the components in the latest Survey of Research and Development are used.
2) For the industry classification for the FY 2006, the industry classification of the Survey of Research and Development based on Japan Standard Industry Classification revised edition 2002 (the 11th) is used.
3) For the industry classification for the FY 2011, used the industry classification of the Survey of Research and Development based on Japan Standard Industry Classification revised edition 2007 (the 12th) is used.
4) The targets for technology trade are patent, know-how and technical guidance.
5) Parent companies and subsidiaries are defined that their controlling share is over 50%.
Source: Ministry of Internal Affairs and Communications, "Report on the Survey of Research and Development"

(2) Technology trade by industry classification and partner

In this section, technology trade statistics are used to examine Japan in terms of its partners in order to elucidate technology relations between Japan and the other countries.

Chart 5-1-5 shows how much technology trade Japan engages in with selected countries and whether the trading enterprises are parent companies and subsidiaries.

Chart 5-1-5 (A) shows Japan’s technology exports and amounts received as payment by partner country. The U.S. accounts for an overwhelmingly large amount, while the Asian countries of China and Thailand have large amounts among the remaining countries. The Western countries of the U.K. and Canada also have a strong presence. Compared to 2006, the U.S.’s amount has decreased as technology exports to Asia countries—notably China and Thailand—have increased. In all of the countries, technology exports among parent companies and subsidiaries are large; however, in the case of China and the U.K., technology exports by companies excluding parent companies and subsidiaries are also large.

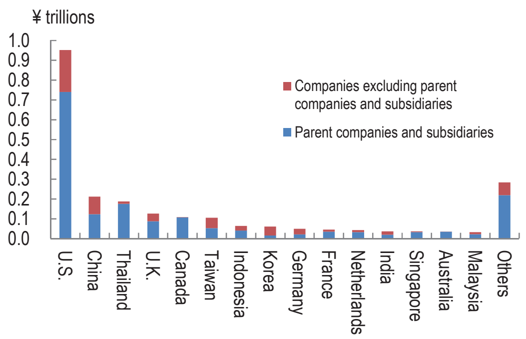
Chart 5-1-5 (B) shows Japan’s technology imports and amounts paid as payment by partner country. The U.S. also accounts for a large amount of technology imports; such imports are valued at 0.3 trillion yen. The European countries have large amounts among the other countries. Compared to 2006, technology imports from the U.S. have decreased considerably, and imports from the other European nations have decreased as well.

With regard to the U.S., while the technical imports of companies excluding parent companies and subsidiaries are decreasing significantly, technology imports among parent companies and subsidiaries are increasing.

Chart 5-1-5: The amount of technology trade of Japan by partner (FY 2006 and 2011)

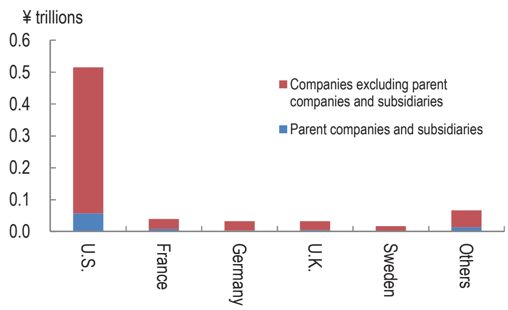
(A) The amount of technology exports by partner

(a) FY2006

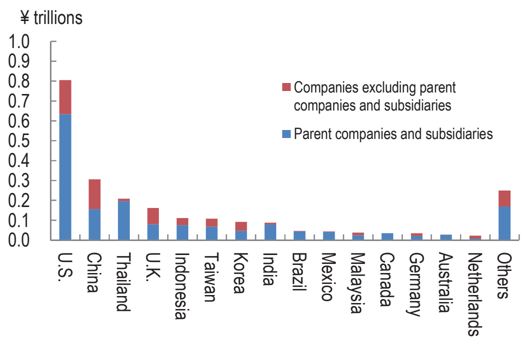


(B) The amount of technology imports by partner

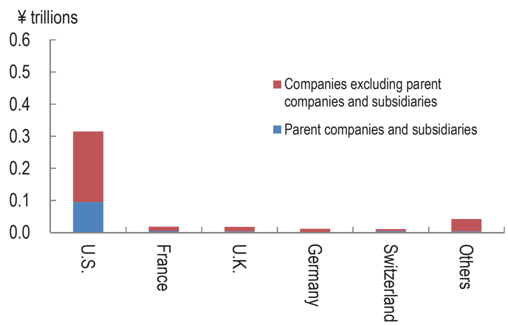
(a) FY2006



(b) FY2011



(b) FY2011



Note: Same as the Chart 5-1-4
Source: Ministry of Internal Affairs and Communications, “Report on the Survey of Research and Development.”

5.2 High-technology industry trade

Key Points

○Looking at high-technology industry trade of the selected countries, China is seeing rapid growth. Since the second half of the 2000s, China has surpassed the U.S., whose high-technology industrial exports had been increasing.

○Japan's high-technology industry trade continues to post export surpluses in "Radio, Television and Communication Equipment" and "Medical, Precision, and Optical Instruments" but is declining. China's exports of "Radio, Television and Communication Equipment" are growing remarkably; it achieved export surpluses here in 2008.

○ Japan's high-technology trade balance ratio has been on a long-term downward trend. Japan was passed by Korea in 2003 and by China in 2009. However, its high-technology trade balance ratio has never fallen below 1.

○The U.S., Germany, France, and U.K. had balanced high-technology industry trade balances when viewed over the long term; however, the U.S. and U.K. fell below 1 upon entering the 2000s and are currently showing declining trends.

○Germany has the highest export value in medium high-technology industry trade, followed by the U.S. Japan also has a presence, although China's exports exceeded those of Japan in the most recent available year. On the other hand, the U.S. has the highest import amount. Germany also has a large amount, but was surpassed by China in the most recent available year.

○Japan's medium high-technology trade balance ratio in 2011 was 3.18, which ranked number one among the selected countries. Looking at trends, Japan showed a rapid decline in the mid-1990s followed by a gradual decrease; however, its export surplus is still larger than the other countries.

○Germany's medium high-technology trade balance ratio in 2011 was 1.9. Its ratio has remained roughly unchanged and is producing sustained export surpluses.

(1) High-technology industry trade

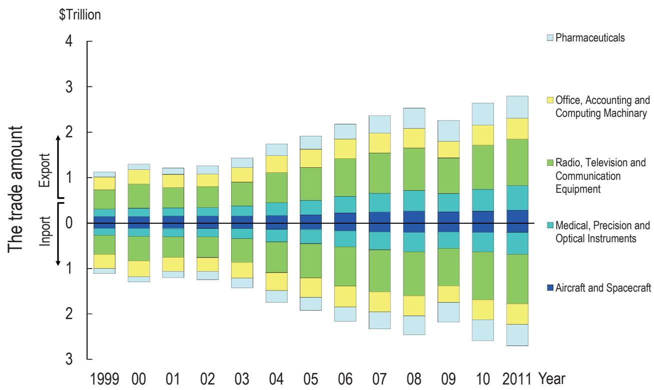
The trade amount of high-technology industries is not data regarding direct exchanges of science and technology knowledge in the sense that technology trade is. However, it is a direct indicator of science and technology knowledge that has been applied to the development of actual products. "High-technology industries" as used herein are based on definitions used by the OECD (they are sometimes called "R&D intensive industries"). They are "Pharmaceuticals," "Office, Accounting and Computing Machinery," "Radio, Television and Communication Equipment," "Medical, Precision and Optical Instruments" and "Aircraft and Spacecraft."

In Chart 5-2-1, regarding 34 OECD member-countries and 7 Non-OECD countries and regions[(3)], the change in the total amount of the trade amount[(4)] (export amount and import amount) of high-technology industry is shown. This is considered high-technology industry trade for the entire world. From this, it can be seen that the scale of high-technology industry trade shrank in 2009 but grew in 2010 and 2011. A breakdown of all industries shows that "Radio, Television and Communication Equipment" accounts for the largest share of trade at about 40%.

(3)Algeria, China, Russia, Singapore, Romania, South Africa and Taiwan

(4) Summed up the amount which each country trades with other countries.

Chart 5-2-1: The change of the trade amount of the high-technology industry of 34 OECD member-countries and 7 Non-OECD countries and regions



Note: The non-member countries and regions are Algeria, China, Russia, Singapore, Romania, South Africa and Taiwan.
Source : OECD, " Main Science and Technology Indicators 2012/2"

Chart 5-2-2 shows the change in the trade balance of the entire high-technology industry. Looking at this chart, it is obvious that China is seeing rapid growth. Since the second half of the 2000s, China has surpassed the U.S., whose high-technology industrial exports had been increasing.

Looking at the situation by country, Japan's high-technology industry trade was running large surpluses in the second half of the 1990s. However, its exports flattened out upon entering the 2000s, while its imports continue to grow.

In recent years, both "Radio, Television and Communication Equipment" and "Medical, Precision, and Optical Instruments" have had export surpluses but declining amounts. Both "Aircraft and Spacecraft" and "Pharmaceuticals" consistently show import surpluses.

The U.S. has seen growing exports and imports in its high-technology industry trade but its trade continued to be balanced. However, entering the 2000s, the U.S.'s imports came to greatly exceed its exports, and a trade deficit continues. The U.S. has large import surpluses in "Office, Accounting and Computing Machinery" and "Radio, Television and Communication Equipment." It had export surpluses in "Medical, Precision and Optical Instruments" and "Aircraft and Spacecraft."

Germany's high-technology industry trade amount is increasing; it surpassed that of Japan in the early 2000s. Germany has large export amounts for "Pharmaceuticals" and "Medical, Precision and Optical Instruments." It has export surpluses in these industries as well as in "Aircraft and Spacecraft."

France's high-technology industry trade has grown since entering the 2000s. It has continued to have export surpluses since the 1990s. France's highest export amount was in "Aircraft and Spacecraft," for which it also had a high trade balance ratio. The same was true of "Pharmaceuticals."

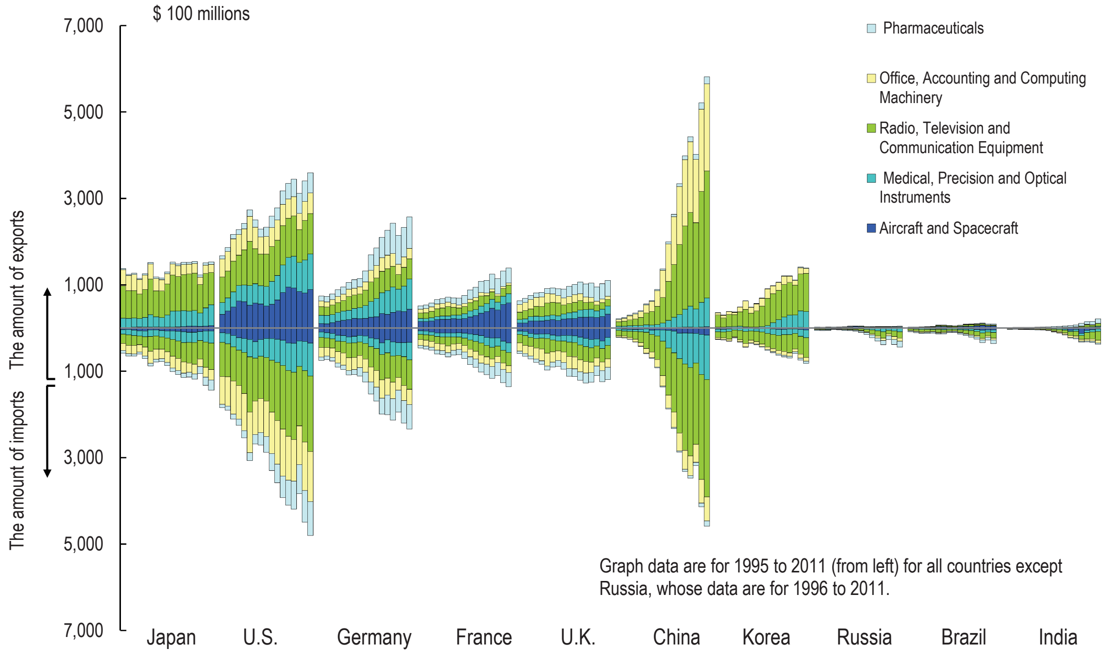
The U.K.'s high-technology industry trade was expanding from the second half of the 1990s; however, its exports flattened out upon entering the 2000s, and its imports flattened out in the second half of the 2000s. While the U.K. has an export surplus in "Pharmaceuticals," it has import surpluses in "Radio, Television and Communication Equipment" and "Office, Accounting and Computing Machinery" and thus its trade deficit is growing.

China's high-technology industry trade is growing remarkably in terms of both exports and imports. China's exports surpassed those of the U.S. in the second half of the 2000s and continue to grow. In particular, China's exports of "Radio, Television and Communication Equipment" are growing remarkably; it achieved export surpluses here in 2008. China achieved export surpluses in "Pharmaceuticals" and "Office, Accounting and Computing Machinery" from the 1990s. Growth of its export surplus in "Office, Accounting and Computing" is particularly noteworthy.

Korea's high-technology industry trade is growing in terms of both exports and imports. Its exports are growing particularly strongly, with conspicuously strong growth in "Radio, Television and Communication Equipment." Korea also enjoys an export surplus in "Office, Accounting and Computing Machinery" and, more recently, "Medical, Precision and Optical Instruments."

Looking at data for the BRICs countries, which have seen remarkable economic growth in recent years, Russia, Brazil, and India are all enjoying remarkable growth in their imports. Russia has an export surplus in "Aircraft and Spacecraft." Brazil's only export surplus is in "Aircraft and Spacecraft." India is showing remarkable growth in its exports in "Pharmaceuticals" and has a growing trade surplus.

Chart 5-2-2: The change in the trade amount of high technology industry in main countries

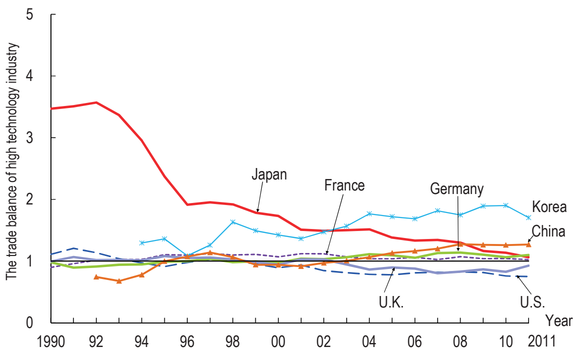


Sources: <Japan, U.S., Germany, France, U.K., China, Korea, Russia> OECD, "Main Science and Technology Indicators 2012/2"
<Brazil, India and Korea, 2010 values> OECD, "Bilateral Trade Database by Industry and End-use Category"

Chart 5-2-3 shows changes in the overall trade balance ratios for high-technology industries. Japan's balance ratio in 2011 was 1.06. Japan's ratio has been decreasing when viewed over the long term. It was surpassed by Korea in 2003 and China in 2009. However, it has never fallen below 1.

The U.S.'s balance ratio has been fluctuating around 1 but began declining around 2000. It stood at 0.75 in 2011. Germany, France and the U.K. had had balanced trade balance ratios when viewed over the long term; however, the U.K.'s ratio fell below 1 upon entering the 2000s and is continuing a downward trend.

Chart 5-2-3: Changes in the trade balance ratios for high-technology industries in selected countries



Source: Same as Chart 5-2-2.

(2) Medium high-technology industry trade

Ascertaining the circumstances of medium high-technology industry trade is just as important as ascertaining those of high-technology industry trade.

"Medium high-technology industry" is one of the four manufacturing industry types developed by the OECD. Specifically, it is comprised of "Chemicals (excluding Pharmaceuticals)," "Machinery & Equipment," "Electrical Machinery and Apparatus (excluding Telecommunications Equipment)," "Motor Vehicles, Trailers and Semi-Trailers," and "Railroad Equipment and Transport Equipment."

Looking at Chart 5-2-4, Germany has the highest exports in medium high-technology industry trade, followed by the U.S. Japan also has a presence, although China's exports exceeded those of Japan in the most recent available year.

On the other hand, the U.S. has the highest import amount. Germany also has a large amount, but was surpassed by China in the most recent available year.

Looking at individual countries, Japan's exports have been growing rapidly since the mid-2000s, with large shares in "Motor Vehicles, Trailers and Semi-Trailers" and "Machinery & Equipment."

As for the U.S., "Motor Vehicles, Trailers and

Semi-Trailers" stands out in its amount of imports.

In the case of Germany, "Motor Vehicles, Trailers and Semi-Trailers" has the largest share of exports, although "Machinery & Equipment" has also been growing rapidly since the mid-2000s.

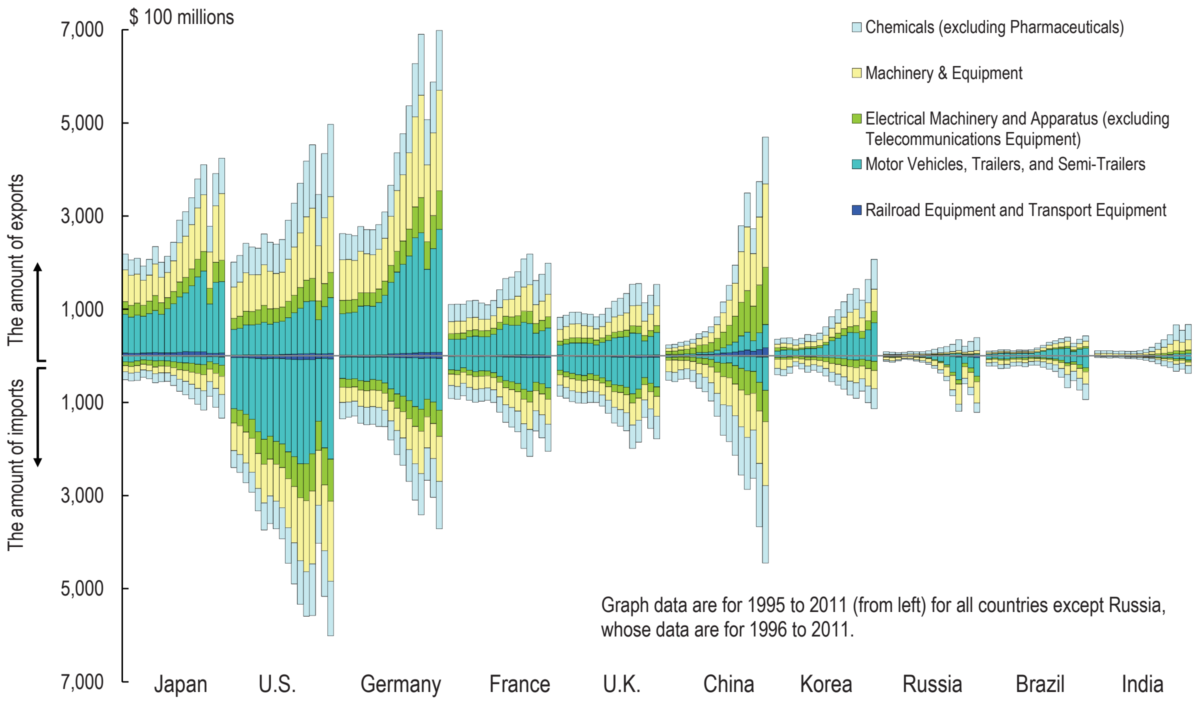
For France, "Motor Vehicles, Trailers and Semi-Trailers" had the largest share of exports; however "Chemicals (excluding Pharmaceuticals)" has surpassed it in recent years. The trend in the U.K. has been opposite of that in France.

As for China, "Machinery & Equipment" and "Electrical Machinery and Apparatus (excluding Telecommunications Equipment)" are increasing rapidly in exports, while "Chemicals (Excluding Pharmaceuticals)" is increasing rapidly in imports.

In Korea, "Motor Vehicles, Trailers and Semi-Trailers" and "Chemicals (excluding Pharmaceuticals)" are growing considerably in exports.

Looking at Russia, Brazil, and India, only India has an export surplus, of which half is comprised of "Chemicals (excluding Pharmaceuticals)." In Russia, which has an import surplus, import amounts are large for "Machinery & Equipment" and "Motor Vehicles, Trailers and Semi-Trailers." In Brazil, "Chemicals (excluding Pharmaceuticals)" and "Machinery & Equipment" have large import amounts.

Chart 5-2-4: Changes in medium high-technology industry trade amounts in the selected countries



Source: OECD, "Bilateral Trade Database by Industry and End-use category"

Chart 5-2-5 shows changes in the overall trade balance ratios for medium high-technology industries.

Japan's medium-high technology trade balance ratio in 2011 was 3.18, which ranked number one among the selected countries. Looking at trends, Japan showed a rapid decline in the mid-1990s followed by a gradual decrease; however, its export surplus is still larger than the other countries.

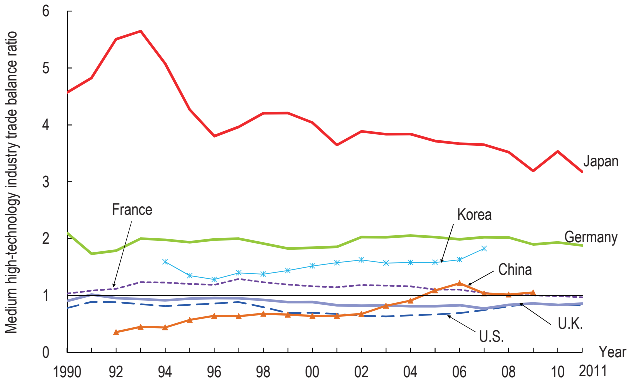
Following is Germany, which had a balance ratio of 1.9 in 2011. Its ratio has remained roughly unchanged and is producing sustained export surpluses.

In the cases of Korea and China, their balance ratios have been increasing when viewed over the long term. China achieved an export surplus in the second half of the 2000s. France's balance ratio was 1.0 in 2011. Its ratio has shown no significant movement even when viewed over time.

The U.K.'s balance ratio has shown an import surplus each year with the exception of 1991.

The U.S.'s balance ratio has yet to climb above 1.

Chart 5-2-5: Changes in medium high-technology industry trade balance ratios in the selected countries



Source: Same as for Chart 5-2-4.

5.3 Trademark applications and trilateral patent families

Key Points

○The number of trademark applications is related to innovation in the form of new products and services, and to associated marketing activities. It can thus be considered data that reflect the relationship between innovation and markets. By examining that number along with the number of patent applications, which indicates the technical aspects of innovation, the nature of innovation in each country can be grasped.

○Looking at the number of transnational trademark applications and trilateral patent families (patents with the same content submitted in Japan, the U.S. and Europe) per million population, in 2008-2010, Japan, Germany and Korea had relatively high numbers of trilateral patent families. The U.S. and the U.K., on the other hand, had more trademark applications than trilateral patent families.

Chart 5-3 shows the number of transnational trademark applications and the number of trilateral patent families in selected countries. Both values are standardized by population for each country.

When business enterprises bring new products or services to the market, they apply for trademarks in order to distinguish them from market competitors. Thus, the number of trademark applications is related to the realization of innovation in the form of new products and services, and to associated marketing activities. In that sense, it can be considered data that reflect the relationship between innovation and markets.

"Transnational applications" as used here are applications for trademarks in foreign countries. When applying for a trademark, there is a strong tendency to apply for it in the home country. In addition, because there are differences in the number of applications because of factors such as national size and systems, values were corrected using the number of applications from Japan, Germany, France, the U.K. and Korea to the U.S. Patent and Trademark Office and from the U.S. to Japan and Europe (See Chart 5-3, Note: 1.).

Patents are used as an indicator of countries' technological prowess. Bias is introduced because there are advantages to filing patent applications in one's own country and because of the influence of geography. The number of trilateral patent families was used because it is less susceptible to such effects.

In 2008–2010, Japan had a large number of trilateral patent families, but a relatively small number of trademark applications. Korea also had a relatively low number of trademark applications. Germany had a large number of trilateral patent families, but its number of trademark applications was not small. The U.S. and the U.K. both had more trademark applications than trilateral patent families.

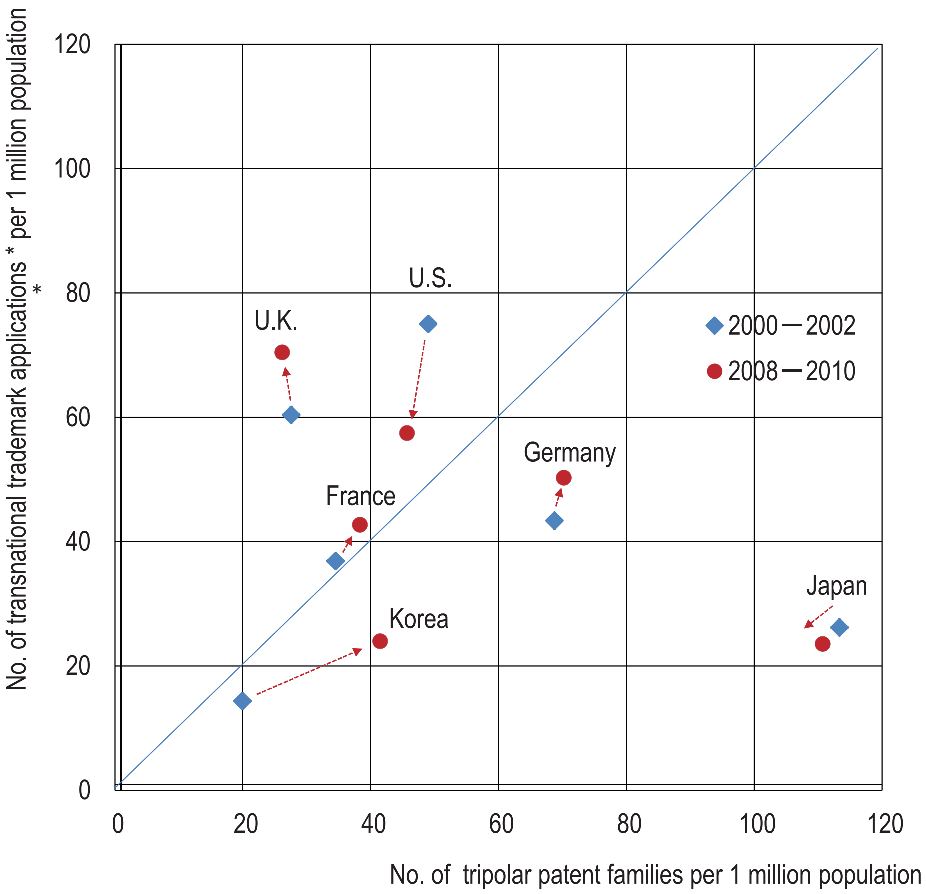
It is believed that countries with powerful manufacturing industries or those specializing in the information and communications industry tend to have more patent applications than trademark applications, while countries weighted towards service industries tend to have more trademark applications. Country characteristics may thus be appearing in the data. Data on international applications was used for both trademarks and patent families. In Japan's case, because international business development differs in manufacturing industries and service industries, this may affect the data.

Comparing 2000–2002 and 2008–2010, the number of trademark applications increased more than the number of trilateral patent families in Germany and the U.K.

The number of trilateral patent families increased more than the number of trademark applications in Korea. In France, the number of trademark applications and the number of trilateral patent families increased by about the same degree.

In Japan, on the other hand, the number of trademark applications and the number of trilateral patent families both decreased slightly. In the U.S., the number of trademark applications has been decreasing.

Chart 5-3: Transnational trademark applications and trilateral patent families per million population



Note: 1) *Transnational trademarks refer to the following.
For the number of trademarks in Japan, Germany, France, the U.K. and Korea, the number filed with the U.S. Patent and Trademark Office (USPTO).
The number of trademarks for the U.S. is the average of (i) and (ii).
(i) The corrected number of the U.S. applications, based on the ratio of Japanese and the U.S. applications to the Office for Harmonization in the Internal Market (OHIM) = (number of the U.S. applications to the OHIM / number of Japanese applications to the OHIM) × number of Japanese applications to the USTPO.
(ii) The corrected number of the U.S. applications, based on the ratio of European and the U.S. applications to the Japan Patent Office (JPO) = (number of the U.S. applications to the JPO / number of EU-15 applications to the JPO) × number of EU-15 applications to the USTPO.
2) Three-year averages.
Sources: WIPO, "WIPO statistics database. Last updated: November 2012"
OECD, "Main Science and Technology Indicators 2012/2"

5.4 The relationship between R&D and innovation: A Japan-the U.S. comparison

Key Points

○Looking at the achievement of innovation in business enterprises that carry out R&D activities, in both Japan and the U.S., enterprises with higher R&D expenditures achieve innovation at a higher rate.

○ In the case of Japanese business enterprises that carry out R&D activities, innovation related to new services is realized at a lower rate than innovation related to products and process innovation, regardless of the size of R&D expenditures.

○In the case of U.S. business enterprises that carry out R&D activities, innovation related to new services has a lower rate of innovation than innovation related to products and process innovation, regardless of the size of R&D expenditures. However, the difference is not as large as it is for Japan.

In 2009, the National Institute of Science and Technology Policy carried out the "Second Japanese National Innovation Survey." The survey collected data on the state of innovation in Japanese business enterprises[(5)]. The survey generally followed the "Oslo Manual," which sets forth international standards for surveys of innovation. Enterprises' innovation activities were defined as "Initiatives on design, R&D, market research and so on needed to develop novel products or services or processes that aim to improve work" in carrying out the survey of the state of innovation activities.

Product innovation in the "Second Japanese National Innovation Survey" is defined as "placement of new products or services on the market. New products and services include not only those that have novel functions, performance, design, materials, components or applications, but also those that combine existing technologies or that advance existing products or services to higher technological levels. However, it does not include mere design changes that leave the functions or purposes of products and services unchanged, nor simply selling or providing the products or services of another company." Process innovation is defined as "adoption of a new process or improvement of an existing process. Process innovation includes not only the adoption or improvement of methods for product or service manufacture and production or logistics and distribution, but also the adoption or improvement of maintenance or computer systems for manufacturing, production, logistics of distribution."

In the U.S., the "Business R&D Innovation Survey" carried out in 2008 surveyed the state of product innovation and process innovation in the U.S. business enterprises.

As shown in Chart 5-4-1, the populations for the Japanese and the U.S. innovation surveys differed (companies with 10 or more employees in Japan and 5 or more in the U.S.). There were also some differences in the form of questions asked. To the extent possible, however, this section will compare the state of innovation in Japanese and the U.S. business enterprises.

Chart 5-4-1: Number of companies in the Japanese and U.S. survey populations

(Unit: Companies)

	Japan	U.S.
All companies	331,037	1,545,100
Companies that performed R&D	51,445	46,800
Companies with R&D expenditure (internal + external) of less than $100 million	48,506	44,800
Companies with R&D expenditure (internal + external) of $100 million to less than $500 million	286	1,300
Companies with R&D expenditure (internal + external) of $500 million to less than $1 billion	64	300
Companies with R&D expenditure (internal + external) of $1 billion or more	91	400
Companies that did not perform R&D	279,592	1,498,300

Note: 1) Companies that had R&D expenditures, whether internal or external, during FY 2006–2008 are considered companies that engaged in R&D activities Classification of R&D expenditures is based on the amount during FY2008. The R&D expenditures of Japanese business enterprises were calculated in the U.S. dollars at 2008 purchasing power parity.
2) Because some companies in the Japanese survey did not enter an amount for FY2008, the number of companies that carried out R&D and the total number of companies classified by amount of expenditures do not match.
3) In the U.S. survey, the 327,300 companies that did not report on whether they carried out R&D activities are not included in the weighted totals.
4) Populations were companies with at least 10 employees for the Japanese survey and at least 5 employees for the U.S. survey.

Sources :<Japan> Tabulated by NISTEP based on data from the Second Japanese National Innovation Survey (performed in 2009).
<U.S.> NSF, "InfoBrief (NSF Releases New Statistics on Business Innovation)"

(5) National Institute of Science and Technology Policy, NR no. 144, "Report on Japanese National Innovation Survey 2009" (9/2010)

Chart 5-4-2 classifies Japanese and the U.S. companies that performed R&D according to the size of their R&D expenditures and shows the percentages that achieved innovation. "R&D expenditures" as used here are combined internal and external R&D expenses. Because activities that aim to achieve innovation are carried out both internally and externally, R&D expenditures were measured in the same way.

Innovation is classified as (i) product innovation related to goods, (ii) product innovation related to services and (iii) process innovation (Chart 5-4-2).

Looking at the state of Japanese innovation, business enterprises with higher R&D expenditures tended to have higher rates of innovation, while those with low expenditures tended to have lower rates of innovation. However, the highest innovation rate for "product innovation related to goods" (88%) was the second tier of businesses, those utilizing 500 million dollars to less than 1 billion dollars, rather than the highest tier.

At every level of R&D expenditures, there was a lower rate of innovation for "product innovation related to services" than for "product innovation related to goods" or for "process innovation."

Regarding "product innovation related to goods" and "process innovation," over 50% of all businesses that carried out R&D activities achieved innovation, a 40 percentage point gap compared to the rate for businesses that did not carry out R&D activities.

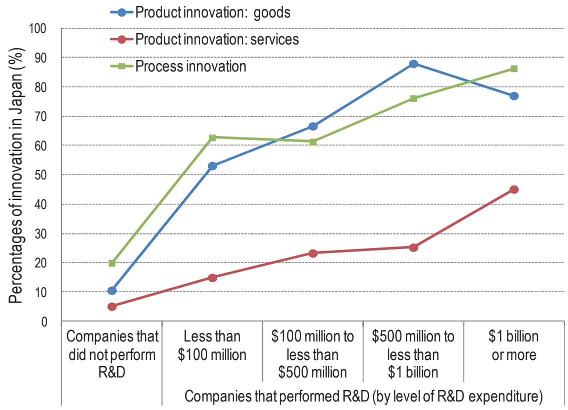
In the U.S. as in Japan, business enterprises with higher R&D expenditures tended to have higher rates of innovation.

At every level of R&D expenditures, there was a lower rate of innovation for "product innovation related to services" than for "product innovation related to goods" and "process innovation." However, the difference was not as large as it was in Japan.

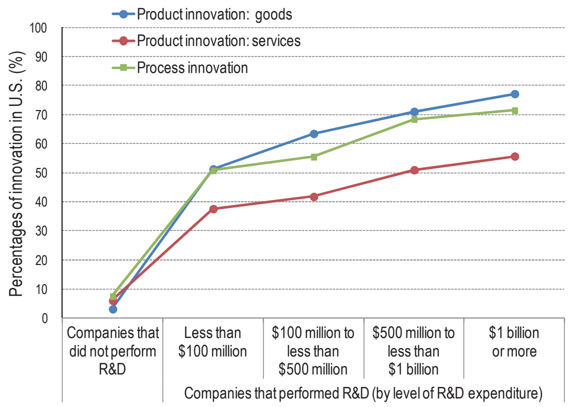
For all three types of innovation activities, businesses with at least 1 billion dollars in R&D expenditures had the highest rate of innovation. For "process innovation," however, the rate for businesses utilizing 500 million dollars to less than 1 billion dollars was 69%, while that for businesses with R&D expenditures of at least 1 billion dollars was 71%, so they were approximately the same.

Chart 5-4-2: The state of innovation by businesses in Japan and the U.S.: by level of R&D expenditures (2006–2008)

(A) Japan



(B) U.S.



Note: Same as Chart 5-4-1.
Sources: Same as Chart 5-4-1.

5.5 Total Factor Productivity (TFP)

Key points

○Total Factor Productivity (TFP) is used as an indicator that shows the contribution of technological progress to economic growth. Although Japan had the lowest TFP growth rate of any of the selected developed countries during the 1990s, since 2001 it has had a relatively high growth rate.

Total Factor Productivity (TFP) is an indicator showing that portion of economic growth that cannot be explained by the contributions of increased investment in capital and labor. TFP indicates the degree to which improved production efficiency contributes to economic growth (GDP increase). This is likely to include the effects not only of technological progress, but also of factors such as improvements in management and organizational efficiency, the development of divisions of labor, the achievement of economies of scale and the preservation of excess labor and capital due to recession. Thus, although TFP is not an indicator that directly measures technological progress, over the long term such progress has a relatively powerful effect on it. TFP is therefore widely used as an indicator of the contribution of technological progress on economic growth.

Chart 5-5 shows an example of TFP measurement of entire national economies on a macro basis. This is based on a methodology that has come into general use in recent years (the so-called KLEMS methodology), which aims to measure productivity improvement as accurately as possible by taking improvements in the quality of labor and capital service into account.

Japan had the lowest TFP growth rate of any of the selected developed countries during the 1990s, but has shown a relatively high rate since entering the 2000s.

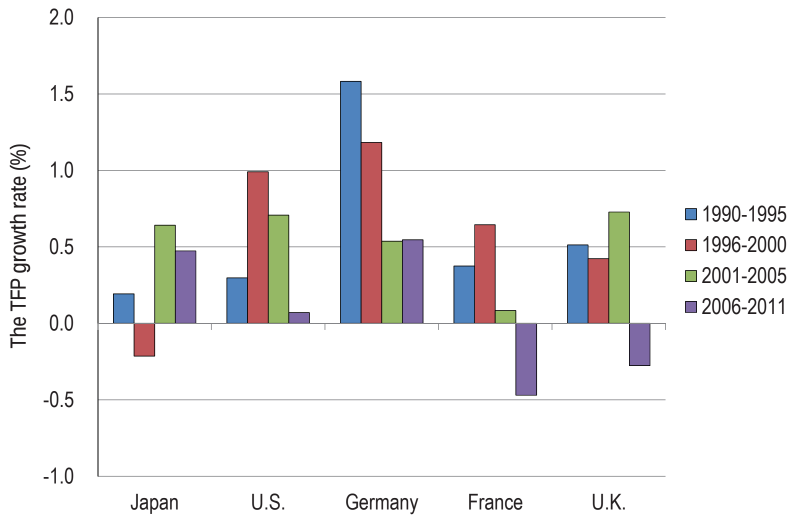
The U.S. had a high TFP growth rate from the late 1990s through the early 2000s, but this rate fell in the second half of the 2000s.

Germany's TFP growth rate was higher than the others in the 1990s but has not reached the same level since entering the 2000s.

France's TFP growth rate was high in the 1990s but declined in the first half of the 2000s and fell even lower in the second half of the 2000s.

The U.K. also had a high TFP growth rate up to the first half of the 2000s, but its rate fell in the second half.

Chart 5-5 Change in the TFP growth rates in major countries



Note: The TFP growth rate for each period is the average annual rate for that period. (For example, for 1990–1995 it is the average of the year-on-year growth rates for 1990, 1991, 1992, 1993, 1994 and 1995.)
Source: Created from the Conference Board Total Economy Database™, January 2012, http://www.conference-board.org/data/economydatabase/.

Reference materials

Reference Materials: Indicators for the regions

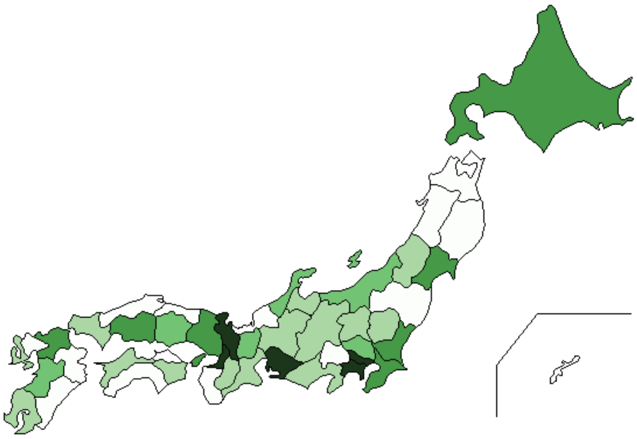
Here, regarding the following 7 items representing the situation of the output of scientific technology activities, the distributions or the changes in the values for the prefecture of Japan indicated are given.

1. The number of graduate students in national, public and private Universities and Colleges
2. The number of papers (all fields)
3. The number of papers (the field of Life sciences)
4. The number of papers (in fields other than Life sciences)
5. The balance of papers between the field of Life sciences and fields other than Life sciences
6. The number of patent applications
7. The number of inventors

In making these charts, the methods of grouping by the prefecture were standardized as far as possible.

1. The number of graduate students in national, public and private universities and colleges

Chart 1-1: The share of the number of graduate students in national, public and private universities and colleges
The average value for 2010–2012

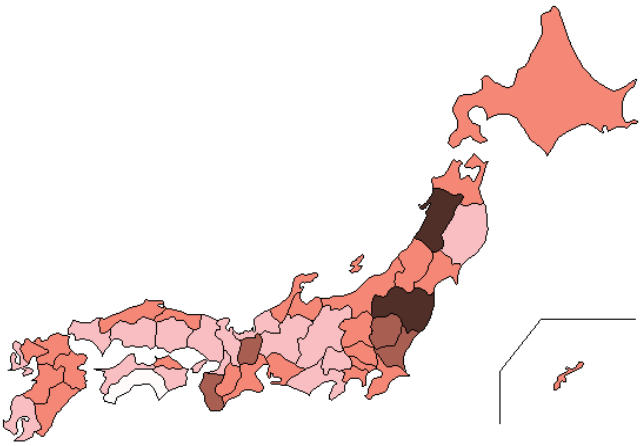


Legend	Classification			The number of prefectures
	5.00% or over	～		5
	2.00%	～	under 5.00%	7
	1.00%	～	2.00%	6
	0.50%	～	1.00%	14
		～	0.50%	15

Top 5	Share	Low rank 5	Share
Tokyo	26.95%	Miyazaki	0.29%
Osaka	6.73%	Shimane	0.30%
Kyoto	6.61%	Wakayama	0.31%
Aichi	5.75%	Akita	0.32%
Kanagawa	5.58%	Kagawa	0.35%

Source: MEXT, “School Basic Survey”

Chart 1-2: The share increase rate of the number of graduate students in national, public and private universities and colleges
Comparison of the average values between 2005–2007 and 2010–2012



Legend	Classification			The number of prefectures
	1.15 or over	～		2
	1.05	～	under 1.15	4
	0.95	～	1.05	24
	0.85	～	0.95	16
		～	0.85	1

Top 5	Share	Low rank 5	Share
Fukushima	1.23	Kochi	0.83
Akita	1.21	Nagano	0.87
Shiga	1.11	Iwate	0.91
Wakayama	1.07	Okayama	0.91
Ibaraki	1.07	Kagoshima	0.92

Source: MEXT, “School Basic Survey”

[Key Points]

- Prefectures with large cities have more graduate students. Tokyo Prefecture has far more than any other prefecture (Chart 1-1).
- Looking at the rate at which shares increased from 2005–2007 to 2010–2012, Fukushima Prefecture had the highest rate at 1.23, followed by Akita Prefecture at 1.21. On the other hand, there were 17 prefectures whose shares decreased with share increase rates below 0.95 (Chart 1-2).

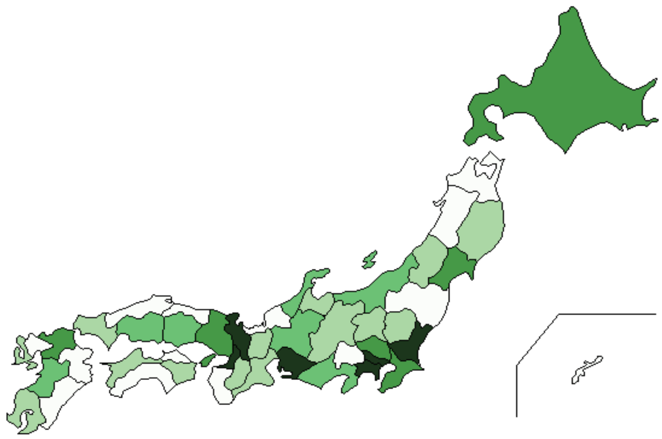
Table 1: The number of graduate students in national, public and private universities and colleges

Prefectures	3-year moving average				
	2005-2007 Unit: case	2010-2012 Unit: case	2005-2007 Share (A)	2010-2012 Share (B)	The growth rate of the share (B)/(A)
Hokkaido	9,107	9,407	3.60%	3.49%	0.971
Aomori	936	1,025	0.37%	0.38%	1.029
Iwate	1,358	1,317	0.54%	0.49%	0.912
Miyagi	7,853	7,960	3.10%	2.96%	0.953
Akita	696	897	0.28%	0.33%	1.210
Yamagata	1,471	1,501	0.58%	0.56%	0.959
Fukushima	816	1,072	0.32%	0.40%	1.234
Ibaraki	6,647	7,548	2.63%	2.80%	1.067
Tochigi	1,892	2,119	0.75%	0.79%	1.053
Gunma	1,906	1,969	0.75%	0.73%	0.971
Saitama	4,894	5,127	1.93%	1.90%	0.985
Chiba	9,166	9,945	3.62%	3.69%	1.020
Tokyo	68,467	72,579	27.04%	26.95%	0.996
Kanagawa	14,493	15,022	5.72%	5.58%	0.974
Niigata	4,595	4,834	1.81%	1.79%	0.989
Toyama	1,274	1,359	0.50%	0.50%	1.003
Ishikawa	4,105	4,187	1.62%	1.55%	0.959
Fukui	1,162	1,164	0.46%	0.43%	0.942
Yamanashi	1,196	1,202	0.47%	0.45%	0.945
Nagano	2,401	2,228	0.95%	0.83%	0.872
Gifu	2,155	2,149	0.85%	0.80%	0.938
Shizuoka	2,654	2,658	1.05%	0.99%	0.941
Aichi	14,855	15,485	5.87%	5.75%	0.980
Mie	1,332	1,394	0.53%	0.52%	0.984
Shiga	2,593	3,056	1.02%	1.13%	1.108
Kyoto	17,688	17,810	6.99%	6.61%	0.947
Osaka	18,339	18,117	7.24%	6.73%	0.929
Hyogo	9,861	9,878	3.89%	3.67%	0.942
Nara	2,340	2,400	0.92%	0.89%	0.964
Wakayama	771	876	0.30%	0.33%	1.068
Tottori	1,125	1,180	0.44%	0.44%	0.985
Shimane	758	790	0.30%	0.29%	0.980
Okayama	4,413	4,282	1.74%	1.59%	0.912
Hiroshima	5,989	5,955	2.37%	2.21%	0.935
Yamaguchi	1,944	1,953	0.77%	0.73%	0.945
Tokushima	2,424	2,414	0.96%	0.90%	0.936
Kagawa	878	940	0.35%	0.35%	1.006
Ehime	1,362	1,371	0.54%	0.51%	0.946
Kouchi	1,131	1,004	0.45%	0.37%	0.835
Fukuoka	11,925	12,369	4.71%	4.59%	0.975
Saga	966	1,032	0.38%	0.38%	1.004
Nagasaki	1,671	1,652	0.66%	0.61%	0.929
Kumamoto	2,636	2,760	1.04%	1.02%	0.984
Oita	1,011	1,106	0.40%	0.41%	1.029
Miyazaki	712	782	0.28%	0.29%	1.032
Kagoshima	2,044	1,990	0.81%	0.74%	0.915
Okinawa	1,200	1,237	0.47%	0.46%	0.968
Whole	253,184	269,336	100.00%	100.00%	-

Note: "The number of graduate students" is the total of national, public and private universities and colleges. Surveyed by the address with graduate courses in which students enroll.
Source: MEXT, "School Basic Survey"

2. The number of papers (all fields)

Chart 2-1: The share of the number of papers (all fields) The average value for 2010–2012

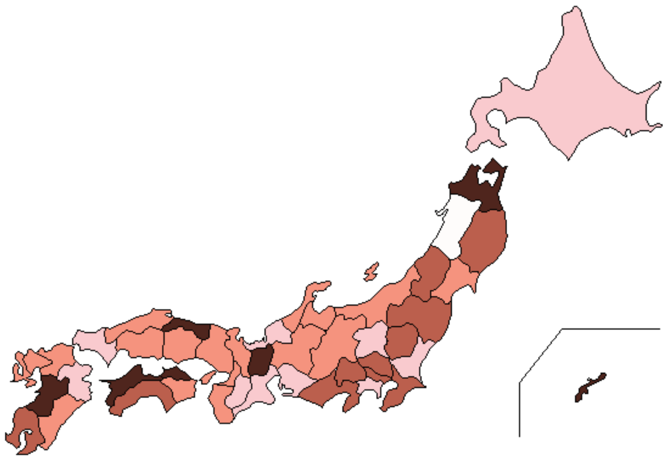


Legend	Classification			The number of prefectures
	5.00% or over	~		6
	2.00%	~	under 5.00%	6
	1.00%	~	2.00%	7
	0.50%	~	1.00%	14
		~	0.50%	14

Top 5	Share	Low rank 5	Share
Tokyo	19.95%	Wakayma	0.32%
Osaka	7.74%	Miyazaki	0.35%
Ibaraki	6.60%	Shimane	0.37%
Kanagawa	6.59%	Akita	0.37%
Kyoto	5.83%	Oita	0.37%

Source: Compiled by NISTEP based on Thomson Reuters, "Web of Science (SCIE, CPCI: Science)"

Chart 2-2: The share increase rate of the number of papers (all fields)
Comparisons of the average values between 2005–2007 and 2010–2012



Legend	Classification			The number of prefectures
	1.15 or over	~		7
	1.05	~	under 1.15	11
	0.95	~	1.05	18
	0.85	~	0.95	10
		~	0.85	1

Top 5	Share	Low rank 5	Share
Okinawa	1.22	Akita	0.85
Tottori	1.20	Nara	0.87
Kumamoto	1.20	Fukui	0.88
Kagawa	1.20	Gunma	0.88
Aomori	1.19	Yamaguchi	0.89

Source: Compiled by NISTEP based on Thomson Reuters, "Web of Science (SCIE, CPCI: Science)"

[Key Points]

- Looking at the distribution of shares of the number of papers, they were higher in prefectures with large metropolitan areas. The top five prefectures accounted for approximately 50% of the total (Chart 2-1).
- The five prefectures with the highest shares of the number of papers were not included among the top five prefectures in terms of share increase rate. On the other hand, there were 11 prefectures whose shares decreased because their share increase rate was less than 0.95 (Chart 2-2).

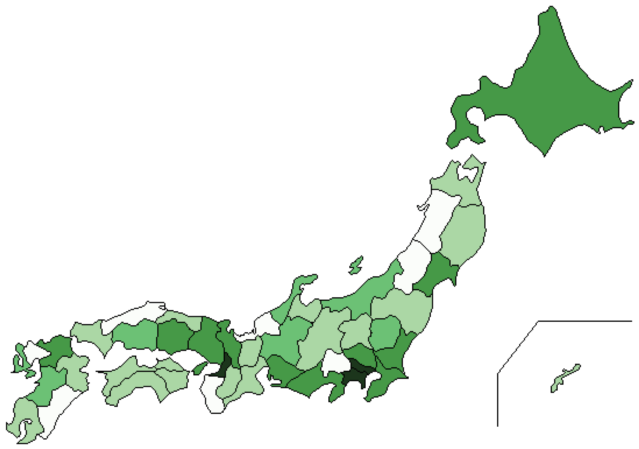
Table 2: The number of the papers (all fields)

Prefectures	3-year moving average				
	2005-2007 Unit: case	2010-2012 Unit: case	2005-2007 Share (A)	2010-2012 Share (B)	The growth rate of the share (B)/(A)
Hokkaido	2,751	2,466	4.04%	3.82%	0.945
Aomori	282	318	0.41%	0.49%	1.189
Iwate	351	350	0.52%	0.54%	1.053
Miyagi	2,811	2,537	4.13%	3.93%	0.952
Akita	298	239	0.44%	0.37%	0.846
Yamagata	321	324	0.47%	0.50%	1.062
Fukushima	251	255	0.37%	0.40%	1.073
Ibaraki	4,907	4,262	7.20%	6.60%	0.916
Tochigi	505	515	0.74%	0.80%	1.077
Gunma	586	491	0.86%	0.76%	0.884
Saitama	1,910	1,910	2.80%	2.96%	1.054
Chiba	2,479	2,497	3.64%	3.87%	1.062
Tokyo	12,805	12,882	18.80%	19.95%	1.061
Kanagawa	4,797	4,259	7.04%	6.59%	0.936
Niigata	812	772	1.19%	1.20%	1.003
Toyama	478	438	0.70%	0.68%	0.965
Ishikawa	906	837	1.33%	1.30%	0.974
Fukui	320	267	0.47%	0.41%	0.881
Yamanashi	253	263	0.37%	0.41%	1.094
Nagano	558	552	0.82%	0.85%	1.044
Gifu	710	686	1.04%	1.06%	1.020
Shizuoka	1,012	1,076	1.49%	1.67%	1.121
Aichi	3,888	3,468	5.71%	5.37%	0.941
Mie	437	390	0.64%	0.60%	0.941
Shiga	463	521	0.68%	0.81%	1.187
Kyoto	4,129	3,764	6.06%	5.83%	0.961
Osaka	5,506	4,998	8.08%	7.74%	0.957
Hyogo	1,972	1,962	2.90%	3.04%	1.049
Nara	591	488	0.87%	0.76%	0.870
Wakayama	225	206	0.33%	0.32%	0.968
Tottori	271	310	0.40%	0.48%	1.204
Shimane	240	237	0.35%	0.37%	1.044
Okayama	1,115	1,019	1.64%	1.58%	0.963
Hiroshima	1,274	1,148	1.87%	1.78%	0.951
Yamaguchi	455	383	0.67%	0.59%	0.888
Tokushima	525	485	0.77%	0.75%	0.976
Kagawa	267	302	0.39%	0.47%	1.196
Ehime	372	418	0.55%	0.65%	1.184
Kouchi	289	294	0.42%	0.45%	1.071
Fukuoka	2,922	2,859	4.29%	4.43%	1.032
Saga	292	263	0.43%	0.41%	0.952
Nagasaki	525	513	0.77%	0.79%	1.031
Kumamoto	577	655	0.85%	1.01%	1.197
Oita	268	240	0.39%	0.37%	0.942
Miyazaki	235	225	0.35%	0.35%	1.010
Kagoshima	373	400	0.55%	0.62%	1.131
Okinawa	269	312	0.40%	0.48%	1.221
Unknown	524	523	0.77%	0.81%	1.054
Whole	68,108	64,579	100.00%	100.00%	-

Note: 1) The papers of the prefectures were analyzed by fractional counts based on the prefectures of those institutions (faculties, research courses, etc.) to which the authors belong. For example, if a paper was written collectively by authors affiliated with the University of Tokyo (Komaba, Tokyo), University of Tokyo (Kashiwa, Chiba Prefecture), Keio University (Tokyo), Chiba University (Chiba Prefecture), and Stanford University (the U.S.), the result of the count becomes two-fifths for Tokyo and two-fifths for Chiba Prefecture.
2) Since there are some magazines that can not be classified, the total of Chart 3 and Chart 4 is not added up to the entire figures (Chart 2).
Source: Compiled by NISTEP based on Thomson Reuters, "Web of Science (SCIE, CPCI: Science)"

3. The number of papers (the field of Life sciences)

Chart 3-1: The share of the number of papers (the field of Life sciences)
The average value for 2010–2012

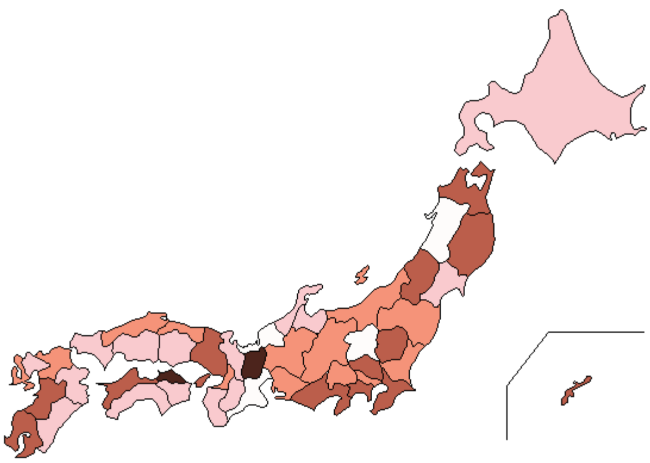


Legend	Classification			The number of prefectures
	5.00% or over	~		3
	2.00%	~	under 5.00%	11
	1.00%	~	2.00%	7
	0.50%	~	1.00%	18
		~	0.50%	8

Top 5	Share	Low rank 5	Share
Tokyo	20.58%	Saga	0.36%
Osaka	7.62%	Fukui	0.40%
Kanagawa	5.32%	Yamanashi	0.42%
Aichi	4.94%	Akita	0.43%
Kyoto	4.84%	Simane	0.45%

Source: Compiled by NISTEP based on Thomson Reuters, "Web of Science (SCIE, CPCI: Science)"

Chart 3-2: Share increase rate for number of papers (Life sciences)
Comparison of average values between 2005–2007 and 2010–2012



Legend	Classification			The number of prefectures
	1.15 or over	~		2
	1.05	~	under 1.15	13
	0.95	~	1.05	13
	0.85	~	0.95	15
		~	0.85	4

Top 5	Share	Low rank 5	Share
Siga	1.20	Akita	0.74
Kagawa	1.17	Fukui	0.81
Sizuoka	1.15	Mie	0.81
Kumamoto	1.14	Gunma	0.83
Hyogo	1.13	Kouchi	0.86

Source: Compiled by NISTEP based on Thomson Reuters, "Web of Science (SCIE, CPCI: Science)"

[Key Points]

- Data for Life sciences are shown here after papers were divided into the fields of Life sciences and the fields other than Life Sciences. The fields of Life sciences are Clinical medicine, Psychiatric Psychology, Agricultural science, Biology･Biochemistry, Immunology, Microbiology, Molecular biology and Genetics, Neural science and Behavioral science, Pharmacology･Toxicology, and Botany･Zoology[1].
- As for the distribution of shares of the number of papers in Life sciences only (Chart 3-1), many of these prefectures (18) had shares of 0.5%-1.0%. Only three, however, had shares of 5% or more.
- Two prefectures had a share increase rate for the number of papers of at least 1.15%. On the other hand, there were 19 prefectures whose shares decreased because their share increase rate was less than 0.95 (Chart 3-2).

Table 3: The number of papers (the field of Life sciences)

Prefectures	3-year moving average				
	2005-2007 Unit: case	2010-2012 Unit: case	2005-2007 Share (A)	2010-2012 Share (B)	The growth rate of the share (B)/(A)
Hokkaido	1,598	1,445	4.89%	4.30%	0.878
Aomori	208	230	0.64%	0.68%	1.077
Iwate	223	249	0.68%	0.74%	1.086
Miyagi	875	830	2.68%	2.47%	0.920
Akita	188	144	0.58%	0.43%	0.742
Yamagata	139	159	0.43%	0.47%	1.109
Fukushima	156	169	0.48%	0.50%	1.048
Ibaraki	1,369	1,349	4.19%	4.01%	0.957
Tochigi	379	416	1.16%	1.24%	1.064
Gunma	351	298	1.08%	0.89%	0.825
Saitama	878	988	2.69%	2.94%	1.092
Chiba	1,144	1,248	3.50%	3.71%	1.059
Tokyo	6,405	6,923	19.62%	20.58%	1.049
Kanagawa	1,618	1,790	4.96%	5.32%	1.074
Niigata	444	441	1.36%	1.31%	0.965
Toyama	276	253	0.85%	0.75%	0.889
Ishikawa	516	482	1.58%	1.43%	0.907
Fukui	162	135	0.50%	0.40%	0.808
Yamanashi	139	141	0.43%	0.42%	0.981
Nagano	297	308	0.91%	0.92%	1.009
Gifu	365	392	1.12%	1.17%	1.044
Shizuoka	600	708	1.84%	2.11%	1.146
Aichi	1,641	1,661	5.02%	4.94%	0.983
Mie	312	262	0.96%	0.78%	0.815
Shiga	214	263	0.65%	0.78%	1.195
Kyoto	1,719	1,629	5.26%	4.84%	0.920
Osaka	2,552	2,562	7.82%	7.62%	0.975
Hyogo	938	1,091	2.87%	3.24%	1.129
Nara	337	310	1.03%	0.92%	0.892
Wakayama	172	167	0.53%	0.50%	0.946
Tottori	185	198	0.57%	0.59%	1.039
Shimane	144	150	0.44%	0.45%	1.011
Okayama	714	694	2.19%	2.06%	0.943
Hiroshima	647	616	1.98%	1.83%	0.924
Yamaguchi	262	235	0.80%	0.70%	0.871
Tokushima	327	317	1.00%	0.94%	0.941
Kagawa	184	222	0.56%	0.66%	1.171
Ehime	218	246	0.67%	0.73%	1.096
Kouchi	195	172	0.60%	0.51%	0.858
Fukuoka	1,539	1,583	4.71%	4.71%	0.999
Saga	134	122	0.41%	0.36%	0.884
Nagasaki	397	417	1.22%	1.24%	1.020
Kumamoto	361	425	1.11%	1.26%	1.144
Oita	199	184	0.61%	0.55%	0.900
Miyazaki	173	168	0.53%	0.50%	0.939
Kagoshima	278	314	0.85%	0.93%	1.095
Okinawa	195	224	0.60%	0.67%	1.114
Unknown	284	302	0.87%	0.90%	1.030
Whole	32,654	33,631	100.00%	100.00%	-

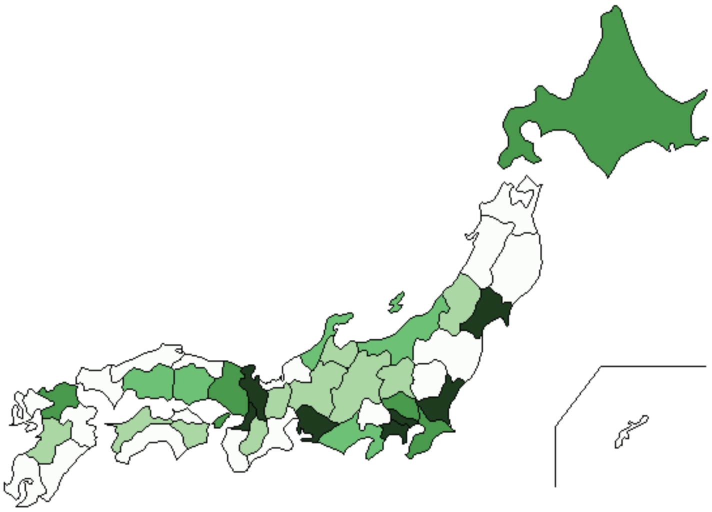
Note: The method of counting the papers is in accordance with the note for Table 2.
Source: Compiled by NISTEP based on Thomson Reuters, "Web of Science (SCIE, CPCI: Science)"

(1)Refer to Chart 4-1-4 (B) in Chapter 4 of the main text.

4. The number of papers (fields other than Life sciences)

Chart 4-1: The share of the number of papers (fields other than Life sciences)

The average value for 2010–2012



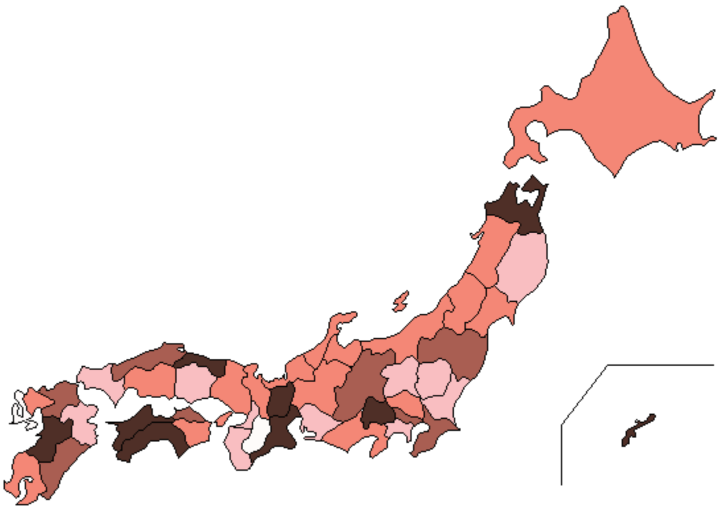
Legend	Classification			The number of prefectures
	5.00% or over	~		7
	2.00%	~	under 5.00%	5
	1.00%	~	2.00%	5
	0.50%	~	1.00%	10
		~	0.50%	20

Top 5	Share	Low rank 5	Share
Tokyo	19.08%	Wakayama	0.13%
Ibaraki	9.49%	Oita	0.18%
Kanagawa	8.01%	Miyazaki	0.19%
Osaka	7.90%	Kagawa	0.26%
Kyoto	6.90%	Okinawa	0.27%

Source: Compiled by NISTEP based on Thomson Reuters, "Web of Science (SCIE, CPCI: Science)"

Chart 4-2: The share increase rate of the number of papers (fields other than Life sciences)

Comparison of the average values between 2005–2007 and 2010–2012



Legend	Classification			The number of prefectures
	1.15 or over	~		9
	1.05	~	under 1.15	8
	0.95	~	1.05	17
	0.85	~	0.95	11
		~	0.85	2

Top 5	Share	Low rank 5	Share
Tottori	1.49	Nara	0.81
Kouchi	1.47	Nagasaki	0.83
Okinawa	1.35	Yamaguchi	0.86
Aomori	1.33	Wakayama	0.86
Ehime	1.28	Tochigi	0.89

Source: Compiled by NISTEP based on Thomson Reuters, "Web of Science (SCIE, CPCI: Science)"

[Key points]

- The fields other than Life sciences are Chemistry, Material science, Physics, Space science, Computer science, Mathematics, Engineering, Environment/Ecology and Geoscience.(2)
- Regarding shares of the number of papers in fields other than Life sciences, seven prefectures had shares of at least 5%. However, many prefectures (20) had shares of 0.5% or less (Chart 4-1).
- Looking at the share increase rate, a relatively large number of prefectures (9) had a rate of at least 1.15. On the other hand, there were 13 prefectures whose shares decreased because their share increase rate was less than 0.95% (Chart 4-2).

Table 4: The number of papers (fields other than Life sciences)

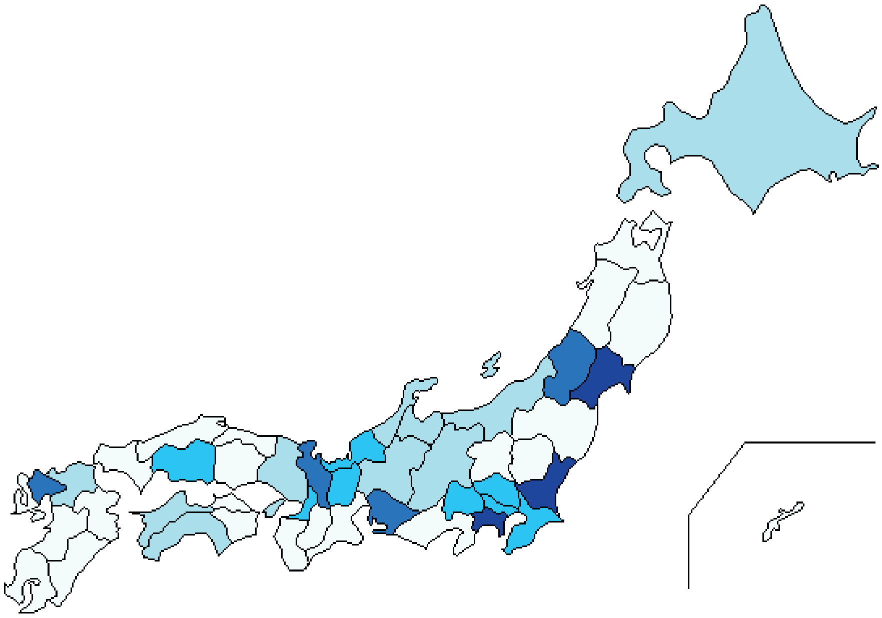
Prefectures	3-year moving average				
	2005-2007 Unit case	2010-2012 Unit case	2005-2007 Share (A)	2010-2012 Share (B)	The growth rate of the share (B)/(A)
Hokkaido	1,140	1,011	3.25%	3.31%	1.016
Aomori	75	87	0.21%	0.28%	1.332
Iwate	127	100	0.36%	0.33%	0.901
Miyagi	1,923	1,699	5.48%	5.55%	1.013
Akita	109	94	0.31%	0.31%	0.989
Yamagata	182	164	0.52%	0.54%	1.032
Fukushima	93	86	0.27%	0.28%	1.052
Ibaraki	3,519	2,902	10.04%	9.49%	0.945
Tochigi	123	95	0.35%	0.31%	0.887
Gunma	232	190	0.66%	0.62%	0.940
Saitama	1,022	916	2.92%	2.99%	1.027
Chiba	1,327	1,238	3.78%	4.05%	1.070
Tokyo	6,280	5,835	17.91%	19.08%	1.065
Kanagawa	3,149	2,452	8.98%	8.01%	0.892
Niigata	364	328	1.04%	1.07%	1.034
Toyama	202	183	0.58%	0.60%	1.039
Ishikawa	385	350	1.10%	1.14%	1.042
Fukui	157	132	0.45%	0.43%	0.960
Yamanashi	113	121	0.32%	0.40%	1.228
Nagano	259	241	0.74%	0.79%	1.067
Gifu	342	293	0.98%	0.96%	0.980
Shizuoka	410	364	1.17%	1.19%	1.020
Aichi	2,221	1,789	6.33%	5.85%	0.923
Mie	124	128	0.35%	0.42%	1.178
Shiga	245	255	0.70%	0.83%	1.191
Kyoto	2,372	2,110	6.77%	6.90%	1.019
Osaka	2,936	2,418	8.38%	7.90%	0.944
Hyogo	1,025	859	2.92%	2.81%	0.960
Nara	249	176	0.71%	0.58%	0.812
Wakayama	51	38	0.15%	0.13%	0.864
Tottori	84	109	0.24%	0.36%	1.488
Shimane	94	87	0.27%	0.28%	1.062
Okayama	399	321	1.14%	1.05%	0.923
Hiroshima	620	523	1.77%	1.71%	0.965
Yamaguchi	192	143	0.55%	0.47%	0.858
Tokushima	193	166	0.55%	0.54%	0.985
Kagawa	82	80	0.23%	0.26%	1.121
Ehime	154	171	0.44%	0.56%	1.278
Kouchi	94	120	0.27%	0.39%	1.469
Fukuoka	1,366	1,262	3.90%	4.13%	1.059
Saga	157	140	0.45%	0.46%	1.022
Nagasaki	126	91	0.36%	0.30%	0.828
Kumamoto	216	228	0.62%	0.74%	1.209
Oita	68	54	0.19%	0.18%	0.921
Miyazaki	61	57	0.17%	0.19%	1.070
Kagoshima	94	85	0.27%	0.28%	1.035
Okinawa	72	84	0.20%	0.27%	1.346
Unknown	238	218	0.68%	0.71%	1.051
Whole	35,062	30,592	100.00%	100.00%	-

Note: The ways of the count of the papers is followed by Note of Table 2.
Source: Compiled by NISTEP based on Thomson Reuters, "Web of Science (SCIE, CPCI: Science)"

(2) Refer to Chart 4-1-4 (B) in Chapter 4 of the main text.

5. The balance of papers between Life sciences fields and fields other than Life sciences

Chart 5: The balance of papers between Life sciences fields and fields other than Life sciences
(non–Life sciences/Life sciences)



Legend	Classification			The number of prefectures	
	1.5 or over	～		3	The number of non-Life sciences is very large (Approximately over twice)
	1.1	～	under 1.5	4	The number of non-Life sciences is slightly large
	0.9	～	1.1	8	The number of non-Life sciences and Life sciences are fifty-fifty split
	0.75	～	0.9	10	The number of Life sciences is slighly large
		～	0.75	22	The number of Life sciences is very large

(The number of non-Life sciences is under half of that of Life sciences)

Source: Compiled by NISTEP based on Thomson Reuters, "Web of Science (SCIE, CPCI: Science)"

[Key Points]

- The balance of share of papers between fields other than Life sciences and Life sciences fields is shown for each prefecture. To calculate the balance, the share of papers in fields other than Life sciences during 2010–2012 was divided by the share of papers in the field of Life sciences.
- Overall, there were many prefectures whose shares of papers in Life sciences fields were larger than those for fields other than Life sciences. Three prefectures had very large shares (1.5 or more) of the number of non-Life science papers, and 22 prefectures had very large shares (0.75 or less) of the number of Life science papers (Chart 5).

Table 5: Shares of and balance between papers in Life science fields and fields other than Life sciences

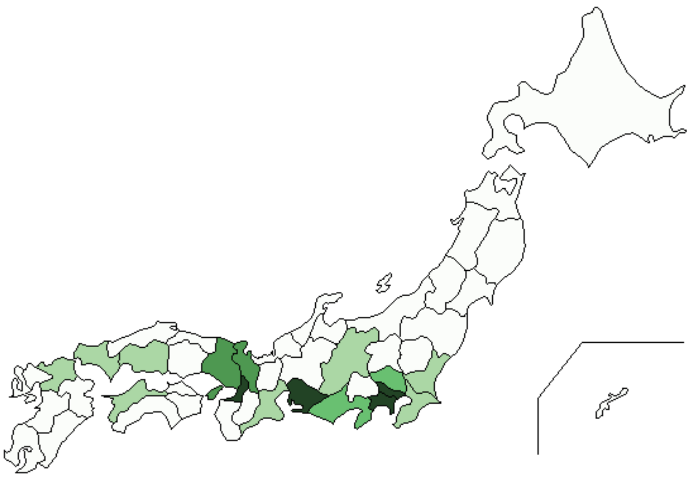
Prefectures	Non-Life sciences 3-year moving average			Life sciences 3-year moving average			Balance
	2005-2007 Share (A)	2010-2012 Share (B)	The growth rate of the share (B)/(A)	2005-2007 Share (C)	2010-2012 Share (D)	The growth rate of the share (D)/(C)	non-Life sciences (B)/ Life sciences (D)
Hokkaido	3.25%	3.31%	1.02	4.89%	4.30%	0.878	0.769
Aomori	0.21%	0.28%	1.33	0.64%	0.68%	1.077	0.414
Iwate	0.36%	0.33%	0.90	0.68%	0.74%	1.086	0.442
Miyagi	5.48%	5.55%	1.01	2.68%	2.47%	0.920	2.251
Akita	0.31%	0.31%	0.99	0.58%	0.43%	0.742	0.718
Yamagata	0.52%	0.54%	1.03	0.43%	0.47%	1.109	1.133
Fukushima	0.27%	0.28%	1.05	0.48%	0.50%	1.048	0.558
Ibaraki	10.04%	9.49%	0.95	4.19%	4.01%	0.957	2.365
Tochigi	0.35%	0.31%	0.89	1.16%	1.24%	1.064	0.251
Gunma	0.66%	0.62%	0.94	1.08%	0.89%	0.825	0.700
Saitama	2.92%	2.99%	1.03	2.69%	2.94%	1.092	1.020
Chiba	3.78%	4.05%	1.07	3.50%	3.71%	1.059	1.091
Tokyo	17.91%	19.08%	1.06	19.62%	20.58%	1.049	0.927
Kanagawa	8.98%	8.01%	0.89	4.96%	5.32%	1.074	1.505
Niigata	1.04%	1.07%	1.03	1.36%	1.31%	0.965	0.818
Toyama	0.58%	0.60%	1.04	0.85%	0.75%	0.889	0.795
Ishikawa	1.10%	1.14%	1.04	1.58%	1.43%	0.907	0.798
Fukui	0.45%	0.43%	0.96	0.50%	0.40%	0.808	1.070
Yamanashi	0.32%	0.40%	1.23	0.43%	0.42%	0.981	0.950
Nagano	0.74%	0.79%	1.07	0.91%	0.92%	1.009	0.858
Gifu	0.98%	0.96%	0.98	1.12%	1.17%	1.044	0.821
Shizuoka	1.17%	1.19%	1.02	1.84%	2.11%	1.146	0.566
Aichi	6.33%	5.85%	0.92	5.02%	4.94%	0.983	1.184
Mie	0.35%	0.42%	1.18	0.96%	0.78%	0.815	0.537
Shiga	0.70%	0.83%	1.19	0.65%	0.78%	1.195	1.067
Kyoto	6.77%	6.90%	1.02	5.26%	4.84%	0.920	1.424
Osaka	8.38%	7.90%	0.94	7.82%	7.62%	0.975	1.037
Hyogo	2.92%	2.81%	0.96	2.87%	3.24%	1.129	0.865
Nara	0.71%	0.58%	0.81	1.03%	0.92%	0.892	0.626
Wakayama	0.15%	0.13%	0.86	0.53%	0.50%	0.946	0.252
Tottori	0.24%	0.36%	1.49	0.57%	0.59%	1.039	0.606
Shimane	0.27%	0.28%	1.06	0.44%	0.45%	1.011	0.634
Okayama	1.14%	1.05%	0.92	2.19%	2.06%	0.943	0.509
Hiroshima	1.77%	1.71%	0.97	1.98%	1.83%	0.924	0.933
Yamaguchi	0.55%	0.47%	0.86	0.80%	0.70%	0.871	0.672
Tokushima	0.55%	0.54%	0.98	1.00%	0.94%	0.941	0.575
Kagawa	0.23%	0.26%	1.12	0.56%	0.66%	1.171	0.395
Ehime	0.44%	0.56%	1.28	0.67%	0.73%	1.096	0.765
Kouchi	0.27%	0.39%	1.47	0.60%	0.51%	0.858	0.768
Fukuoka	3.90%	4.13%	1.06	4.71%	4.71%	0.999	0.876
Saga	0.45%	0.46%	1.02	0.41%	0.36%	0.884	1.264
Nagasaki	0.36%	0.30%	0.83	1.22%	1.24%	1.020	0.239
Kumamoto	0.62%	0.74%	1.21	1.11%	1.26%	1.144	0.588
Oita	0.19%	0.18%	0.92	0.61%	0.55%	0.900	0.324
Miyazaki	0.17%	0.19%	1.07	0.53%	0.50%	0.939	0.373
Kagoshima	0.27%	0.28%	1.04	0.85%	0.93%	1.095	0.297
Okinawa	0.20%	0.27%	1.35	0.60%	0.67%	1.114	0.413
Unknown	0.68%	0.71%	1.05	0.87%	0.90%	1.030	0.794
Whole	100.00%	100.00%	-	100.00%	100.00%	-	1.00

Note: The method of counting the papers was in accordance with the note to Table 2. The values of the 3-year moving averages for fields other than Life sciences and for Life sciences fields were the same as in Table 3 and Table 4.
Source: Compiled by NISTEP based on Thomson Reuters, "Web of Science (SCIE, CPCI: Science)"

6. The number of patent applications

Chart 6-1: The share of the number of the patent applications

The average value for 2009–2011



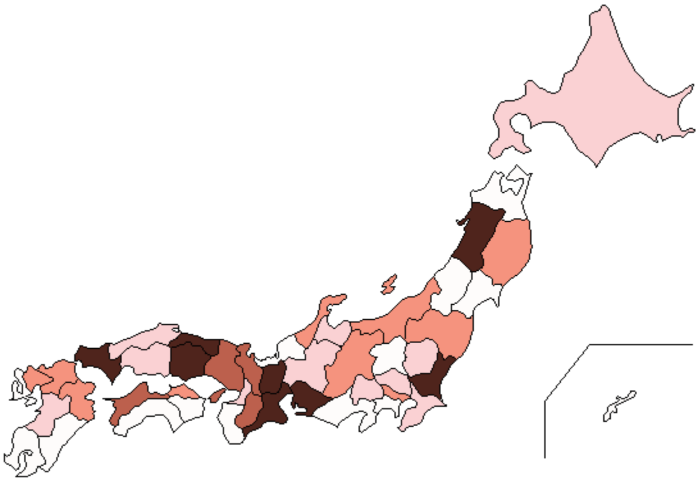
Legend	Classification			The number of prefectures
	5.00% or over	～		4
	2.00%	～	under 5.00%	2
	1.00%	～	2.00%	2
	0.50%	～	1.00%	8
		～	0.50%	31

Top 5	Share	Low rank 5	Share
Tokyo	51.40%	Aomori	0.04%
Osaka	15.48%	Okinawa	0.05%
Aichi	9.03%	Tottori	0.05%
Kanagawa	5.93%	Nagasaki	0.05%
Kyoto	3.06%	Kouchi	0.06%

Source: Japan patent Office, "Japan Patent Office Annual Report"

Chart 6-2: The share increase rate of the number of the patent applications

Comparison of the average values between 2004–2006 and 2009–2011



Legend	Classification			The number of prefectures
	1.15 or over	～		8
	1.05	～	under 1.15	4
	0.95	～	1.05	10
	0.85	～	0.95	11
		～	0.85	14

Top 5	Share	Low rank 5	Share
Akita	1.60	Wakayama	0.53
Tottori	1.39	Gunma	0.63
Mie	1.31	Yamagata	0.63
Ibaraki	1.29	Miyagi	0.65
Shiga	1.27	Aomori	0.70

Source: Japan Patent Office, "Japan Patent Office Annual Report"

[Key Points]

- Looking at the distributions of the share of the number of patent applications, Tokyo accounted for 51.4% of the total, followed by Osaka with 15.5%. Moreover, the top 4 prefectures alone account for about over 80% (Chart 6-1). This is because the headquarters of many business enterprises are concentrated in Tokyo and there are many cases that the addresses of the headquarters are written down when patents are applied for.
- Looking at the share increase rate from 2004–2006 to 2009–2011 the growing prefectures included Akita and Tottori Prefectures. However, looking at the whole, there were 25 prefectures whose share increase rate was less than 0.95% and which represents over half of all prefectures (Chart 6-2).

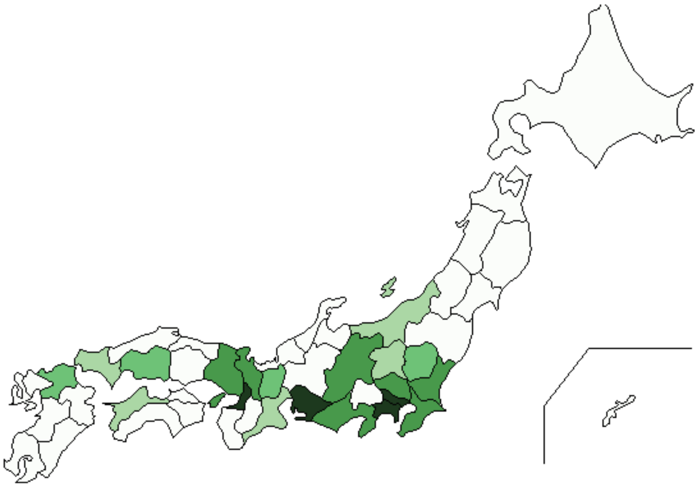
Table 6: The number of patent applications

Prefectures	3-year moving average				
	2004-2006 Unit: case	2009-2011 Unit: case	2004-2006 Share (A)	2009-2011 Share (B)	The growth rate of the share (B)/(A)
Hokkaido	1,133	780	0.31%	0.27%	0.85
Aomori	211	120	0.06%	0.04%	0.70
Iwate	294	234	0.08%	0.08%	0.99
Miyagi	1,390	730	0.38%	0.25%	0.65
Akita	203	262	0.06%	0.09%	1.60
Yamagata	400	204	0.11%	0.07%	0.63
Fukushima	314	261	0.09%	0.09%	1.03
Ibaraki	1,961	2,037	0.54%	0.70%	1.29
Tochigi	653	453	0.18%	0.16%	0.86
Gunma	2,515	1,272	0.70%	0.44%	0.63
Saitama	5,100	3,805	1.41%	1.31%	0.93
Chiba	3,126	2,326	0.87%	0.80%	0.92
Tokyo	179,217	149,571	49.62%	51.40%	1.04
Kanagawa	26,355	17,250	7.30%	5.93%	0.81
Niigata	1,236	990	0.34%	0.34%	0.99
Toyama	919	694	0.25%	0.24%	0.94
Ishikawa	804	623	0.22%	0.21%	0.96
Fukui	872	572	0.24%	0.20%	0.81
Yamanashi	822	589	0.23%	0.20%	0.89
Nagano	2,498	2,026	0.69%	0.70%	1.01
Gifu	1,293	916	0.36%	0.31%	0.88
Shizuoka	5,559	3,800	1.54%	1.31%	0.85
Aichi	28,142	26,288	7.79%	9.03%	1.16
Mie	1,400	1,473	0.39%	0.51%	1.31
Shiga	876	899	0.24%	0.31%	1.27
Kyoto	9,973	8,912	2.76%	3.06%	1.11
Osaka	60,020	45,034	16.62%	15.48%	0.93
Hyogo	7,032	6,030	1.95%	2.07%	1.06
Nara	505	460	0.14%	0.16%	1.13
Wakayama	962	408	0.27%	0.14%	0.53
Tottori	136	152	0.04%	0.05%	1.39
Shimane	393	299	0.11%	0.10%	0.95
Okayama	1,258	1,281	0.35%	0.44%	1.26
Hiroshima	3,534	2,546	0.98%	0.87%	0.89
Yamaguchi	1,532	1,520	0.42%	0.52%	1.23
Tokushima	586	351	0.16%	0.12%	0.74
Kagawa	546	448	0.15%	0.15%	1.02
Ehime	1,802	1,657	0.50%	0.57%	1.14
Kouchi	247	163	0.07%	0.06%	0.82
Fukuoka	2,876	2,253	0.80%	0.77%	0.97
Saga	233	191	0.06%	0.07%	1.02
Nagasaki	252	158	0.07%	0.05%	0.78
Kumamoto	349	239	0.10%	0.08%	0.85
Oita	201	168	0.06%	0.06%	1.03
Miyazaki	278	182	0.08%	0.06%	0.81
Kagoshima	286	191	0.08%	0.07%	0.83
Okinawa	221	141	0.06%	0.05%	0.79
Unknown	629	33	0.17%	0.01%	0.07
Whole	361,145	290,992	100.00%	100.00%	1.000

Note: 1) By Japanese people.
2) The column for others indicates that the prefecture cannot be determined.
3) The address of the first listed applicant is counted
Source: Japan Patent Office, "Japan Patent Office Annual Report"

7. The number of inventors

Chart 7-1: The share of the number of inventors in 2011

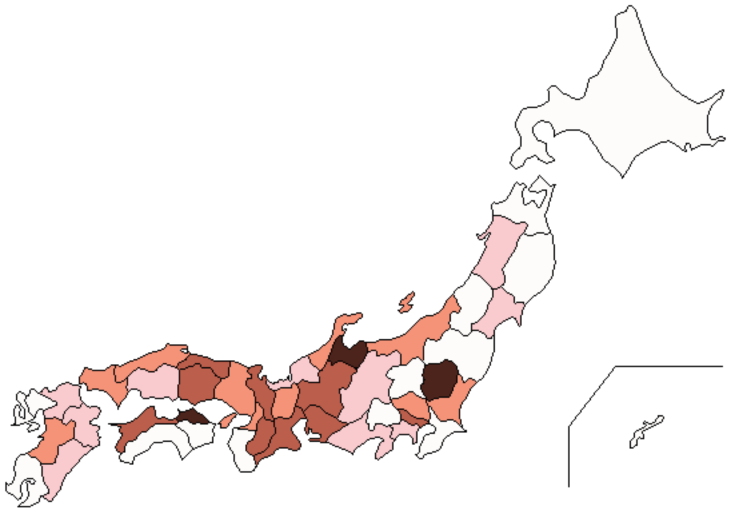


Legend	Classification			The number of prefectures
	5.00% or over	～		4
	2.00%	～	under 5.00%	7
	1.00%	～	2.00%	4
	0.50%	～	1.00%	5
		～	0.50%	27

Top 5	Share	Low rank 5	Share
Tokyo	34.08%	Okinawa	0.03%
Osaka	13.54%	Aomori	0.05%
Kanagawa	10.37%	Kouchi	0.06%
Aichi	9.33%	Saga	0.07%
Saitama	3.38%	Iwate	0.07%

Source: Japan Patent Office, "Japan Patent Office Annual Report"

Chart 7-2: The share increase rate of the number of inventors
Comparison of the values between 2006 and those for 2011



Legend	Classification			The number of prefectures
	1.15 or over	～		3
	1.05	～	under 1.15	9
	0.95	～	1.05	10
	0.85	～	0.95	10
		～	0.85	15

Top 5	Share	Low rank 5	Share
Kagawa	1.52	Nagasaki	0.49
Tochigi	1.24	Wakayama	0.59
Toyama	1.20	Okinawa	0.65
Ehime	1.15	Tokushima	0.68
Nara	1.14	Aomori	0.69

Source: Japan Patent Office, "Japan Patent Office Annual Report"

[Key Points]

- Regarding addresses when patents are applied for, there are many cases where applicant companies write down the addresses of the headquarters as the address of applicants. However, it is generally considered that the addresses of the inventors themselves are written down as the address of inventors. Comparison of the status of patent applications, which are a result of intellectual production activities, with the distribution of shares of the number of applications (Chart 6-1) and the distribution of shares of actual inventors (Chart 7-1), found that many prefectures with large shares of inventors are among the prefectures with the largest shares of patent applications and they are also widely distributed in neighboring prefectures.
- Three prefectures had a high share increase rate for the number of inventors of at least 1.15. On the other hand, there were 25 prefectures whose shares decreased because their share increase rate was less than 0.95 (Chart 7-2).

Table 7: The number of inventors

Prefectures	The number of inventors (Unit: people)		Share		
	2006	2011	2006 (A)	2011 (B)	The growth rate of the share (B)/(A)
Hokkaido	3,037	2,000	0.41%	0.31%	0.770
Aomori	493	289	0.07%	0.05%	0.685
Iwate	772	469	0.10%	0.07%	0.710
Miyagi	4,030	2,941	0.54%	0.46%	0.853
Akita	787	590	0.11%	0.09%	0.877
Yamagata	1,170	806	0.16%	0.13%	0.806
Fukushima	1,695	1,188	0.23%	0.19%	0.820
Ibaraki	25,309	21,396	3.40%	3.36%	0.989
Tochigi	6,854	7,283	0.92%	1.14%	1.242
Gunma	8,951	5,451	1.20%	0.86%	0.712
Saitama	24,493	21,543	3.29%	3.38%	1.028
Chiba	18,874	13,180	2.53%	2.07%	0.817
Tokyo	234,463	217,211	31.46%	34.08%	1.083
Kanagawa	87,189	66,065	11.70%	10.37%	0.886
Niigata	4,005	3,457	0.54%	0.54%	1.009
Toyama	2,548	2,608	0.34%	0.41%	1.197
Ishikawa	1,877	1,592	0.25%	0.25%	0.992
Fukui	1,861	1,383	0.25%	0.22%	0.869
Yamanashi	2,202	1,564	0.30%	0.25%	0.830
Nagano	18,027	13,472	2.42%	2.11%	0.874
Gifu	2,714	2,472	0.36%	0.39%	1.065
Shizuoka	22,411	16,829	3.01%	2.64%	0.878
Aichi	65,123	59,461	8.74%	9.33%	1.068
Mie	5,642	5,429	0.76%	0.85%	1.125
Shiga	11,192	9,246	1.50%	1.45%	0.966
Kyoto	15,484	14,859	2.08%	2.33%	1.122
Osaka	102,214	86,314	13.72%	13.54%	0.987
Hyogo	20,412	17,464	2.74%	2.74%	1.000
Nara	1,738	1,689	0.23%	0.27%	1.136
Wakayama	3,107	1,568	0.42%	0.25%	0.590
Tottori	996	939	0.13%	0.15%	1.102
Shimane	840	715	0.11%	0.11%	0.995
Okayama	3,053	2,806	0.41%	0.44%	1.075
Hiroshima	11,034	8,025	1.48%	1.26%	0.850
Yamaguchi	4,207	3,554	0.56%	0.56%	0.988
Tokushima	1,606	939	0.22%	0.15%	0.684
Kagawa	1,520	1,975	0.20%	0.31%	1.519
Ehime	6,151	6,034	0.83%	0.95%	1.147
Kouchi	667	411	0.09%	0.06%	0.721
Fukuoka	9,749	7,563	1.31%	1.19%	0.907
Saga	668	449	0.09%	0.07%	0.786
Nagasaki	1,133	473	0.15%	0.07%	0.488
Kumamoto	935	788	0.13%	0.12%	0.985
Oita	904	670	0.12%	0.11%	0.867
Miyazaki	849	619	0.11%	0.10%	0.853
Kagoshima	1,865	1,345	0.25%	0.21%	0.843
Okinawa	370	207	0.05%	0.03%	0.654
Whole	745,221	637,331	100.00%	100.00%	1.000

Note: 1) The number of people is the total numbers of people who are abstracted from “Applicants” who were written on one application.
2) Excluding international applications (PCT applications)
Source: Japan Patent Office, “Patent Administration Annual Report”

Statistical Reference A Population of the main countries

(Unit: 1,000 people)

Year	Japan	U.S.	Germany	France	U.K.	China	Korea	EU-15	EU-27
1981	117,902	229,966	61,682	55,407	56,358	1,000,720	38,723	341,060	-
1982	118,728	232,188	61,638	55,739	56,291	1,016,540	39,326	341,774	-
1983	119,536	234,307	61,423	56,036	56,316	1,030,080	39,910	342,279	-
1984	120,305	236,348	61,175	56,305	56,409	1,043,570	40,406	342,757	-
1985	121,049	238,466	61,024	56,582	56,554	1,058,510	40,806	343,365	-
1986	121,660	240,651	61,066	56,866	56,684	1,075,070	41,214	344,105	-
1987	122,239	242,804	61,077	57,169	56,804	1,093,000	41,622	344,819	-
1988	122,745	245,021	61,450	57,492	56,916	1,110,260	42,031	345,935	-
1989	123,205	247,342	62,063	57,828	57,077	1,127,040	42,449	347,397	-
1990	123,611	250,132	63,254	58,138	57,238	1,143,330	42,869	349,480	-
1991	124,101	253,493	79,984 [a]	58,426	57,439	1,158,230	43,296	367,230 [a]	-
1992	124,567	256,894	80,594	58,712	57,585	1,171,710	43,748	368,831	-
1993	124,938	260,255	81,179	58,961	57,714	1,185,170	44,195	370,309	-
1994	125,265	263,436	81,422	59,175	57,862	1,198,500	44,642	371,332	-
1995	125,570	266,557	81,661	59,384	58,025	1,211,210	45,093	372,278	477,910
1996	125,859	269,667	81,896	59,589	58,164	1,223,890	45,525	373,249	478,647
1997	126,157	272,912	82,052	59,795	58,314	1,236,260	45,954	374,190	479,358
1998	126,472	276,115	82,029	60,011	58,475	1,247,610	46,287	375,013	479,938
1999	126,667	279,295	82,087	60,315	58,684	1,257,860	46,617	376,107	480,787
2000	126,926	282,162	82,188	60,725	58,886	1,267,430	47,008	377,955	482,424
2001	127,291	284,969	82,340	61,163	59,113	1,276,270	47,357	379,671	483,870
2002	127,435	287,625	82,482	61,605	59,319	1,284,530	47,622	381,672	485,822
2003	127,689	290,108	82,520	62,038	59,552	1,292,270	47,859	383,908	487,843
2004	127,790	292,805	82,501	62,491	59,842	1,299,880	48,039	386,278	490,044
2005	127,768	295,517	82,464	62,958	60,235	1,307,560	48,138	388,653	492,287
2006	127,901	298,380	82,366	63,393	60,584	1,314,480	48,372	390,756	494,263
2007	128,033	301,231	82,263	63,781	60,986	1,321,290	48,598	393,124	496,553
2008	128,084	304,094	82,120	64,133	61,398	1,328,020	48,949	395,378	498,798
2009	128,032	306,772	81,875	64,476	61,792	1,334,500	49,182	396,985	500,418
2010	128,057	309,350	81,757	64,824	62,262	1,340,910	49,410	398,498	502,212
2011	127,799	311,592	81,779	65,176	62,735	1,347,350	49,779	400,023	503,041

Note: a: Break in series with previous year for which data is available.
<Germany> Until 1990, data is for the former West Germany. After 1991, data is for the unified Germany.
Source: <Japan> Ministry of Internal Affairs and Communications, Statistics Bureau "Population Estimates" Annual Report (Web site).
<U.S.> The Executive Office of the President, "Economic Report of the President 2012" (Web site).
<Germany, France, U.K., China, Korea, EU> OECD, "Economic Indicators for MSTI "".

Statistical Reference B Labor force population of the main countries

(Unit: 1,000 people)

Year	Japan	U.S.	Germany	France	U.K.	China	Korea	EU-15	EU-27
1981	57,070	108,670	28,305	23,994	26,740	-	14,683	148,011	-
1982	57,740	110,204	28,558	24,043	26,678	-	15,032	148,839	-
1983	58,890	111,551	28,605	24,118	26,610	-	15,118	149,855	-
1984	59,270	113,544	28,298	24,290	27,235	-	14,997	150,787	-
1985	59,630	115,462	28,434	24,381	27,486	-	15,592	151,508	-
1986	60,200	117,834	28,768	24,638	27,491	-	16,116	152,872	-
1987	60,840	119,865	29,036	24,643	27,943	-	16,873	154,395	-
1988	61,660	121,669	29,220	24,698	28,345	-	17,305	155,972	-
1989	62,700	123,870	29,624	24,876	28,764	-	18,023	157,296	-
1990	63,840	125,840	30,771	24,852	28,909	653,230	18,539	159,428	-
1991	65,050	126,346	39,577 [a]	24,872	28,545	660,910	19,109	168,104 [a]	-
1992	65,780	128,105	39,490	25,085	28,306	667,820	19,499	167,987	-
1993	66,150	129,199	39,557	25,119	28,103	674,680	19,806	167,686	-
1994	66,450	131,056	39,492	25,254	28,052	681,350	20,353	167,998	-
1995	66,660	132,304	39,376	25,392	28,024	688,550	20,845	168,499	218,296
1996	67,110	133,944	39,550	25,674	28,134	697,650	21,288	169,713	218,865
1997	67,870	136,297	39,804	25,627	28,252	708,000	21,782	170,638	219,621
1998	67,930	137,673	40,131	25,781	28,223	720,870	21,428	172,230	221,016
1999	67,790	139,368	39,614	25,983	28,508	727,910	21,666	173,137	221,928
2000	67,660	142,583	39,533	26,260	28,740	739,920	22,134	174,967	223,799
2001	67,520	143,734	39,686	26,432	28,774	738,840	22,471	175,795	224,601
2002	66,890	144,863	39,641	26,740	29,030	744,920	22,921	177,553	225,332
2003	66,660	146,510	39,507	26,970	29,235	749,110	22,957	178,947	225,907
2004	66,420	147,401	39,948	27,188	29,756	752,900	23,417	181,186	228,377
2005	66,510	149,321	40,928	27,378	30,057	761,200	23,743	183,912	231,237
2006	66,640	151,428	41,429	27,549	30,572	763,150	23,978	186,445	233,975
2007	66,840	153,125	41,590	27,784	30,718	765,310	24,216	188,265	235,823
2008	66,740	154,286	41,677	27,952	31,090	770,460	24,347	190,283	238,112
2009	66,500	154,142	41,699	28,217	31,215	775,100	24,394	190,817	238,822
2010	66,320	153,889	41,684	28,333	31,353	783,880	24,748	191,107	239,466
2011	65,910	153,616	42,240	28,387	31,632	-	25,099	192,073	240,441
2012	-	154,975	-	-	-	-	-	-	-

Note: a: Break in series with previous year for which data is available.
Source: <Japan> Ministry of Internal Affairs and Communications, average labor force population from Labor Force Survey (Web site)
<U.S.> Bureau of Labor Statistics, U.S. Department of Labor, Current Population Survey (Web site)
<Germany, France, U.K., China, EU, Korea> OECD, "Economic Indicators for MSTI "

Statistical Reference C　Gross Domestic Product (GDP) of the main countries

(A) National Currencies

Year	Japan (Billion yen)	U.S. (Billion dollar)	Germany (Billion euro)	France (Billion euro)	U.K. (Billion pound)	China (Billion yuan)	Korea (Billion won)	EU-15 (Billion dollar)	EU-27 (Billion dollar)
1981	264,641.7	3,126.8	825.8	501.4	256.3	489.2	49,305.7	3,435.3	-
1982	276,162.8	3,253.2	860.2	575.7	281.0	532.3	56,676.8	3,679.9	-
1983	288,772.7	3,534.6	898.3	639.4	307.2	596.3	66,685.1	3,891.5	-
1984	308,238.4	3,930.9	942.0	695.0	329.9	720.8	76,523.5	4,137.1	-
1985	330,396.8	4,217.5	984.4	744.5	361.8	901.6	85,699.1	4,371.3	-
1986	342,266.4	4,460.1	1,037.1	800.9	389.1	1,027.5	100,254.1	4,592.6	-
1987	362,296.7	4,736.4	1,065.1	841.1	428.7	1,205.9	117,938.2	4,861.3	-
1988	387,685.6	5,100.4	1,123.3	909.2	478.5	1,504.3	140,524.8	5,245.4	-
1989	415,885.2	5,482.1	1,200.7	979.4	525.3	1,699.2	158,620.1	5,644.2	-
1990	451,683.0	5,800.5	1,306.7	1,032.8	570.3	1,866.8	191,382.8	6,034.9	-
1991	473,607.6	5,992.1	1,534.6 a	1,071.2	598.7	2,178.1	231,428.2	6,490.7 a	-
1992	483,255.6	6,342.3	1,648.4	1,108.0	622.1	2,692.3	263,993.2	6,719.8	-
1993	482,607.6	6,667.4	1,696.9	1,119.8	654.2	3,533.4	298,761.6	6,844.3	-
1994	495,612.2	7,085.2	1,782.2	1,157.9	693.0	4,819.8	349,972.6	7,181.6	-
1995	504,594.3	7,414.7	1,848.5	1,196.2	733.3	6,079.4	409,653.6	7,518.5	8,336.8
1996	515,943.9	7,838.5	1,875.0	1,226.6	781.7	7,117.7	460,952.6	7,823.7	8,686.5
1997	521,295.4	8,332.4	1,912.6	1,264.8	835.6	7,897.3	506,313.6	8,199.0	9,100.6
1998	510,919.2	8,793.5	1,959.7	1,321.1	882.7	8,440.2	501,027.2	8,578.3	9,519.4
1999	506,599.2	9,353.5	2,000.2	1,367.0	929.5	8,967.7	549,005.0	8,926.4	9,901.7
2000	510,834.7	9,951.5	2,047.5	1,439.6	975.3	9,921.5	603,236.0	9,541.1	10,575.7
2001	501,710.6	10,286.2	2,101.9	1,495.6	1,019.8	10,965.5	651,415.3	10,046.5	11,156.8
2002	498,008.8	10,642.3	2,132.2	1,542.9	1,068.6	12,033.3	720,539.0	10,437.6	11,629.1
2003	501,889.1	11,142.2	2,147.5	1,587.9	1,136.6	13,582.3	767,113.7	10,700.8	11,959.1
2004	502,760.8	11,853.3	2,195.7	1,655.6	1,199.9	15,987.8	826,892.7	11,224.7	12,589.5
2005	505,349.4	12,623.0	2,224.4	1,718.0	1,262.7	18,493.7	865,240.9	11,769.8	13,225.8
2006	509,106.3	13,377.2	2,313.9	1,798.1	1,333.2	21,631.4	908,743.8	12,738.3	14,355.0
2007	513,023.3	14,028.7	2,428.5	1,886.8	1,412.1	26,581.0	975,013.0	13,487.2	15,278.2
2008	489,520.1	14,291.5	2,473.8	1,933.2	1,440.9	31,404.5	1,026,451.8	14,007.5	15,954.0
2009	473,933.9	13,973.7	2,374.5	1,885.8	1,401.9	34,090.3	1,065,036.8	13,588.9	15,530.0
2010	480,098.0	14,498.9	2,496.2	1,937.3	1,466.6	40,151.3	1,173,274.9	13,942.9	15,944.3
2011	473,282.6	15,075.7	2,592.6	1,996.6	1,516.2	47,156.4	1,237,128.2	14,349.0	16,449.9
2012	-	-	2,652.4 b	2,030.7 b	1,546.2 b	51,478.8 b	1,280,984.0 b	14,559.3	16,724.0

(B) OECD Purchasing Power Parity Equivalent

Year	Japan (Billion yen)	U.S. (Billion yen)	Germany (Billion yen)	France (Billion yen)	U.K. (Billion yen)	China (Billion yen)	Korea (Billion yen)	EU-15 (Billion yen)	EU-27 (Billion yen)
1981	264,641.7	730,370.3	182,778.4	134,853.7	118,779.9	-	25,074.3	802,424.6	-
1982	276,162.8	727,410.4	184,892.1	140,264.7	123,154.6	73,748.0	27,576.1	822,830.1	-
1983	288,772.7	767,209.6	189,516.4	143,290.8	128,785.0	82,540.5	31,218.3	844,671.5	-
1984	308,238.4	836,682.2	198,263.8	147,968.1	134,530.1	96,734.9	34,894.1	880,570.9	-
1985	330,396.8	879,838.3	204,918.7	151,862.2	140,773.3	110,836.2	37,878.0	911,921.5	-
1986	342,266.4	926,269.1	213,330.1	158,047.2	149,023.2	122,710.7	43,269.6	953,795.7	-
1987	362,296.7	954,613.0	216,090.9	161,649.8	155,656.0	136,769.4	48,525.2	979,784.3	-
1988	387,685.6	996,942.5	224,846.7	169,757.4	164,031.9	152,744.1	54,363.6	1,025,286.0	-
1989	415,885.2	1,055,439.4	238,809.5	180,804.5	171,509.9	162,515.7	59,326.5	1,086,642.9	-
1990	451,683.0	1,099,514.1	257,051.2	189,743.7	176,760.6	172,529.5	66,310.7	1,143,952.0	-
1991	473,607.6	1,125,537.6	300,484.1 a	196,711.5	178,841.1	193,262.6	74,647.1	1,219,185.4 a	-
1992	483,255.6	1,182,163.6	311,092.4	202,789.0	181,947.9	224,334.5	80,204.5	1,252,525.5	-
1993	482,607.6	1,221,385.2	309,322.1	202,316.9	186,804.7	256,752.8	85,654.0	1,253,790.0	-
1994	495,612.2	1,272,789.6	317,332.4	207,101.7	195,024.4	290,741.8	93,274.6	1,290,103.7	-
1995	504,594.3	1,295,441.0	320,313.8	209,808.8	199,500.9	320,211.8	100,867.7	1,313,569.3	1,456,540.3
1996	515,943.9	1,336,318.6	321,576.4	211,304.6	207,546.5	350,296.9	107,513.8	1,333,794.0	1,480,891.0
1997	521,295.4	1,404,069.3	325,169.5	218,579.0	221,568.2	385,055.7	114,390.5	1,381,589.5	1,533,510.9
1998	510,919.2	1,464,406.1	330,187.7	227,413.6	227,791.6	414,991.1	107,795.7	1,428,571.4	1,585,298.7
1999	506,599.2	1,515,601.3	332,448.7	230,763.7	230,764.6	440,998.1	117,842.4	1,446,390.3	1,604,437.0
2000	510,834.7	1,543,602.1	328,450.6	237,788.6	237,866.7	467,621.3	125,393.5	1,479,946.6	1,640,422.9
2001	501,710.6	1,541,459.7	329,666.1	243,997.2	243,871.0	500,383.7	128,814.3	1,505,538.8	1,671,923.2
2002	498,008.8	1,530,088.2	325,474.1	245,127.7	244,790.1	532,166.6	134,578.7	1,500,656.1	1,671,959.3
2003	501,889.1	1,557,948.8	327,279.1	236,752.7	247,991.4	581,307.1	135,041.5	1,496,228.3	1,672,166.9
2004	502,760.8	1,590,253.3	328,556.0	236,295.3	254,503.2	630,310.7	139,368.3	1,505,924.0	1,689,016.2
2005	505,349.4	1,635,334.3	332,430.0	241,057.3	257,141.6	694,866.5	142,084.9	1,524,802.0	1,713,426.3
2006	509,106.3	1,670,325.6	344,608.5	248,427.3	265,314.8	779,054.0	146,446.5	1,590,546.2	1,792,421.5
2007	513,023.3	1,686,477.9	351,464.7	253,998.3	263,034.9	881,266.4	152,491.2	1,621,383.5	1,836,692.7
2008	489,520.1	1,669,901.9	356,130.0	256,036.9	258,690.3	959,845.5	152,645.9	1,636,713.4	1,864,156.1
2009	473,933.9	1,610,445.8	336,322.4	251,045.2	244,953.2	1,042,964.8	152,367.5	1,566,098.3	1,789,812.3
2010	480,098.0	1,614,529.4	342,866.5	248,279.8	244,734.3	1,127,915.7	158,619.1	1,552,615.9	1,775,481.3
2011	473,282.6	1,609,558.3	344,578.3	246,237.8	238,469.1	1,206,483.0	160,960.5	1,531,972.8	1,756,279.2
2012	-	-	344,759.6 b	244,485.4 b	236,033.9 b	1,269,257.9 b	163,119.1 b	1,512,709.8	1,737,624.5

Note: a: Continuity of these data with the previous fiscal year is impaired.
b: Calculated estimates of OECD Secretariat based on the materials of each country.
<Japan> Data is for the fiscal year in each case. FY 2000 is used as the base value through FY 1993, and FY 2005 from FY 1994 on.
<Germany> Until 1990, data is for the former West Germany. After 1991, data is for the unified Germany.

Source :<Japan> Economic and Social Research Institute, Cabinet Office, "System of National Accounts (93SNA)" (website).
<U.S.> Bureau of Economic Analysis, “National Economic Accounts” (Web site).
<Germany, France, U.K., Korea,, China, EU> OECD, “Economic Indicators for MSTI”.

Statistical Reference D　Gross Domestic Product (GDP) deflator of the main countries

Year	Japan	U.K.	Germany	France	U.K.	China	Korea
1981	94.3	52.2	62.9	48.1	39.9	26.1	31.5
1982	95.7	55.4	65.8	53.9	42.9	26.0	33.4
1983	96.6	57.6	67.6	59.2	45.2	26.3	35.0
1984	98.3	59.8	69.0	63.4	47.3	27.6	36.6
1985	99.3	61.6	70.4	66.8	50.1	30.4	38.1
1986	101.0	63.0	72.5	70.3	51.8	31.8	39.7
1987	100.9	64.8	73.5	72.1	54.6	33.5	41.6
1988	101.3	67.0	74.7	74.4	58.0	37.5	44.4
1989	103.5	69.6	76.9	77.0	62.3	40.7	47.0
1990	105.9	72.3	79.5	79.1	67.1	43.1	51.9
1991	108.6	74.8	81.9 [a]	81.2	71.4	46.3	57.2
1992	110.4	76.6	86.3	82.8	74.1	50.1	61.7
1993	110.8	78.3	89.8	84.2	76.2	57.8	65.6
1994	111.0	79.9	92.0	85.2	77.4	69.7	70.7
1995	110.2	81.6	93.9	86.2	79.5	79.2	75.9
1996	109.5	83.1	94.5	87.5	82.4	84.3	79.7
1997	110.2	84.6	94.7	88.3	85.2	85.6	82.8
1998	110.1	85.6	95.3	89.2	87.0	84.8	86.9
1999	108.7	86.8	95.5	89.3	88.8	83.7	86.0
2000	107.4	88.7	94.8	90.7	89.4	85.4	86.8
2001	106.1	90.7	95.9	92.6	90.8	87.2	90.2
2002	104.4	92.2	97.3	94.6	92.9	87.7	93.1
2003	102.7	94.1	98.3	96.5	95.2	90.0	96.4
2004	101.3	96.8	99.4	98.1	97.7	96.2	99.3
2005	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2006	98.9	103.2	100.3	102.1	102.9	103.8	99.9
2007	98.0	106.2	101.9	104.8	105.2	111.7	101.9
2008	96.7	108.6	102.7	107.4	108.4	120.4	104.9
2009	96.2	109.5	103.9	108.2	109.8	119.7	108.5
2010	94.2	111.0	104.9	109.4	112.8	127.6	112.4
2011	92.3	113.3	105.8	110.8	115.8	137.5 [b]	114.4
2012	91.5 [b]	115.4 [b]	107.2 [b]	112.5 [b]	118.2 [b]	139.6 [b]	115.8 [b]

Note: a: This data has impaired continuity with the data for the previous fiscal year.
b: Calculated estimates of OECD Secretariat based on the materials of each country.
<Germany> Until 1990, data is for the former West Germany.　After 1991, data is for the unified Germany.
Source: OECD, "Economic Indicators for MSTI"

Statistical Reference E　Purchasing Power Parity of the main countries

Year	Japan [yen/yen]	U.S. [yen/dollar]	Germany [yen/euro]	France [yen/euro]	U.K. [yen/pound]	China [yen/yuan]	Korea [yen/wan]
1981	1.0000	233.5840	221.3377	268.9407	463.4788	-	0.5085
1982	1.0000	223.5984	214.9383	243.6478	438.2352	138.5368	0.4866
1983	1.0000	217.0570	210.9793	224.0864	419.2123	138.4292	0.4681
1984	1.0000	212.8475	210.4712	212.8908	407.7744	134.2040	0.4560
1985	1.0000	208.6161	208.1640	203.9882	389.1368	122.9323	0.4420
1986	1.0000	207.6790	205.6927	197.3320	382.9463	119.4244	0.4316
1987	1.0000	201.5482	202.8775	192.1959	363.1180	113.4205	0.4114
1988	1.0000	195.4636	200.1680	186.7205	342.7973	101.5395	0.3869
1989	1.0000	192.5246	198.8985	184.6043	326.5150	95.6407	0.3740
1990	1.0000	189.5551	196.7209	183.7214	309.9525	92.4208	0.3465
1991	1.0000	187.8369	195.8061	183.6412	298.7338	88.7279	0.3225
1992	1.0000	186.3935	188.7239	183.0251	292.4830	83.3230	0.3038
1993	1.0000	183.1876	182.2866	180.6670	285.5486	72.6647	0.2867
1994	1.0000	179.6406	178.0565	178.8626	281.4258	60.3226	0.2665
1995	1.0000	174.7125	173.2831	175.3989	272.0717	52.6719	0.2462
1996	1.0000	170.4814	171.5074	172.2676	265.4977	49.2152	0.2332
1997	1.0000	168.5072	170.0144	172.8111	265.1495	48.7579	0.2259
1998	1.0000	166.5328	168.4889	172.1391	258.0570	49.1682	0.2151
1999	1.0000	162.0357	166.2077	168.8097	248.2757	49.1762	0.2146
2000	1.0000	155.1125	160.4154	165.1765	243.8923	47.1323	0.2079
2001	1.0000	149.8571	156.8419	163.1484	239.1272	45.6325	0.1977
2002	1.0000	143.7742	152.6471	158.8717	229.0757	44.2246	0.1868
2003	1.0000	139.8242	152.4000	149.0977	218.1878	42.7989	0.1760
2004	1.0000	134.1612	149.6361	142.7273	212.1070	39.4244	0.1685
2005	1.0000	129.5520	149.4470	140.3089	203.6426	37.5731	0.1642
2006	1.0000	124.8636	148.9297	138.1598	199.0124	36.0149	0.1612
2007	1.0000	120.2163	144.7250	134.6191	186.2696	33.1540	0.1564
2008	1.0000	116.8458	143.9607	132.4424	179.5300	30.5639	0.1487
2009	1.0000	115.2483	141.6392	133.1266	174.7341	30.5942	0.1431
2010	1.0000	111.3553	137.3554	128.1602	166.8754	28.0917	0.1352
2011	1.0000	106.7651	132.9084	123.3296	157.2857	25.5847	0.1301
2012	1.0000	103.9001	129.9782	120.3917	152.6521	24.6559	0.1273
2013	1.0000	101.5527 [b]	127.2515 [b]	118.4112 [b]	149.2191 [b]	23.9533 [b]	0.1246 [b]

Note: b: Calculated estimates of OECD Secretariat based on the materials of each country.
Source: OECD, "Economic Indicators for MSTI"

A List of Science and Technology Indicators

1991	First edition	The Japanese Science and Technology Indicator System: Analysis of Science and Technology Activities	NISTEP REPORT No. 19
1995	Second edition	Science and Technology Indicators: 1994 *- A Systematic Analysis of Science and Technology Activities in Japan -*	NISTEP REPORT No. 37
1997	Third edition	Science and Technology Indicators: 1997 *- A Systematic Analysis of Science and Technology Activities in Japan -*	NISTEP REPORT No. 50
2000	Forth edition	Science and Technology Indicators: 2000 *- A Systematic Analysis of Science and Technology Activities in Japan -*	NISTEP REPORT No. 66
2001		Science and Technology Indicators: 2000 *Data Update (2001)*	NISTEP REPORT No. 66-2
2002		Science and Technology Indicators 2000 *Data Updated in 2002*	Research Material - 88
2004	Fifth edition	Science and Technology Indicators 2004 *A Systematic Analysis for Science and Technology Activities in Japan*	NISTEP REPORT No. 73
2005		Science and Technology Indicators 2004 *- Data Updated in 2005 -*	Research Materials - 117
2006		Science and Technology Indicators *- Data Updated in 2006 for 5th edition -*	Research Materials - 126
2007		Science and Technology Indicators *- Data Updated in 2007 for 5th edition -*	Research Materials - 140
2008		Science and Technology Indicators *- Data Updated in 2008 for 5th edition –*	Research Materials - 155
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