Highlights of
Science and Technology Indicators 2016

Research Unit for Science and Technology Analysis and Indicators

National Institute of Science and Technology Policy (NISTEP)

This material indicates the main points of the following reports released on August 4, 2016.

Science and Technology Indicators 2016, NISTEP Research Material-251

NATIONAL INSTITUTE OF SCIENCE AND TECHNOLOGY POLICY

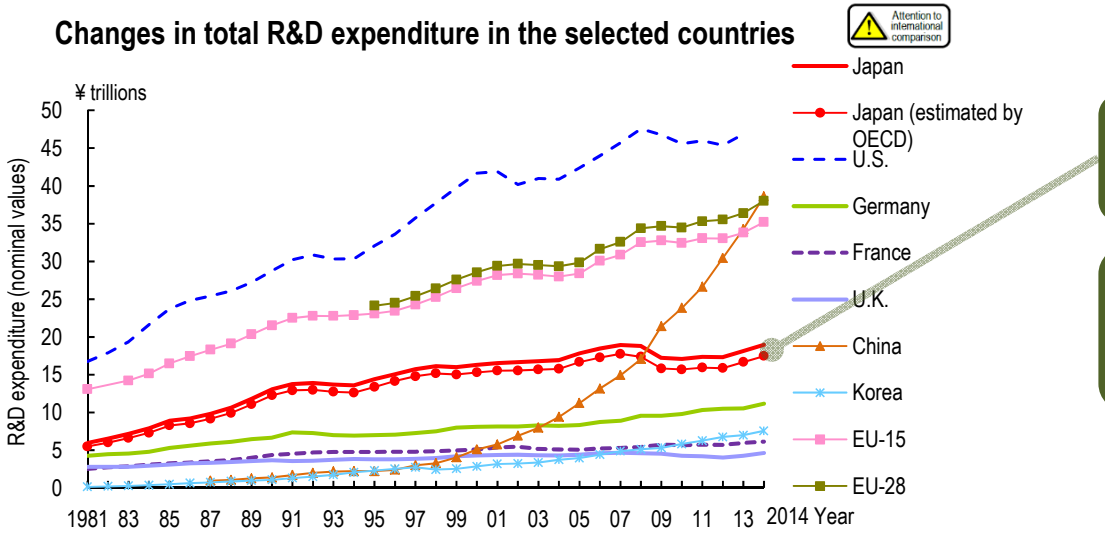
Science and Technology Indicators (from 1991, annually released since 2005)

- S&T activities are classified into five categories: “R&D expenditure,” “R&D personnel,” “higher education,” “output of R&D,” and “science, technology and innovation.”
- Approximately 150 indicators are used to understand the situation of Japan and those of the selected countries.
- Long-term (since the 1980s) S&T activities of Japan and the selected countries are shown if time-series data are available.

⇨ The main circumstances of S&T activities in Japan and the selected countries derived from “Science and Technology Indicators 2016” and “Benchmarking Scientific Research 2016” are as shown on the following slides.

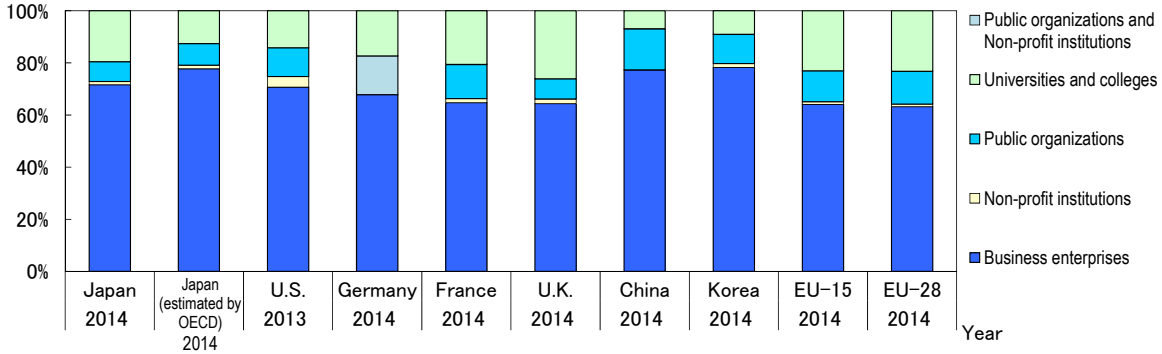
☐ Japan's total R&D expenditure was 19.0 trillion yen in 2014 (OECD-estimate Japan: 17.5 trillion yen), the world's third largest after the United States and China.

Changes in total R&D expenditure in the selected countries



- After remaining almost flat since 2009, Japan's total R&D expenditure increased 4.6% in 2014 from the previous year (OECD-estimated Japan: 4.8%).
- The United States' total R&D expenditure was 46.9 trillion yen in 2013, overwhelming all the other countries. After surpassing Japan in 2009, China's total R&D expenditure has constantly increased to 38.6 trillion yen in 2014.

Percentage of R&D expenditure by sector in the selected countries



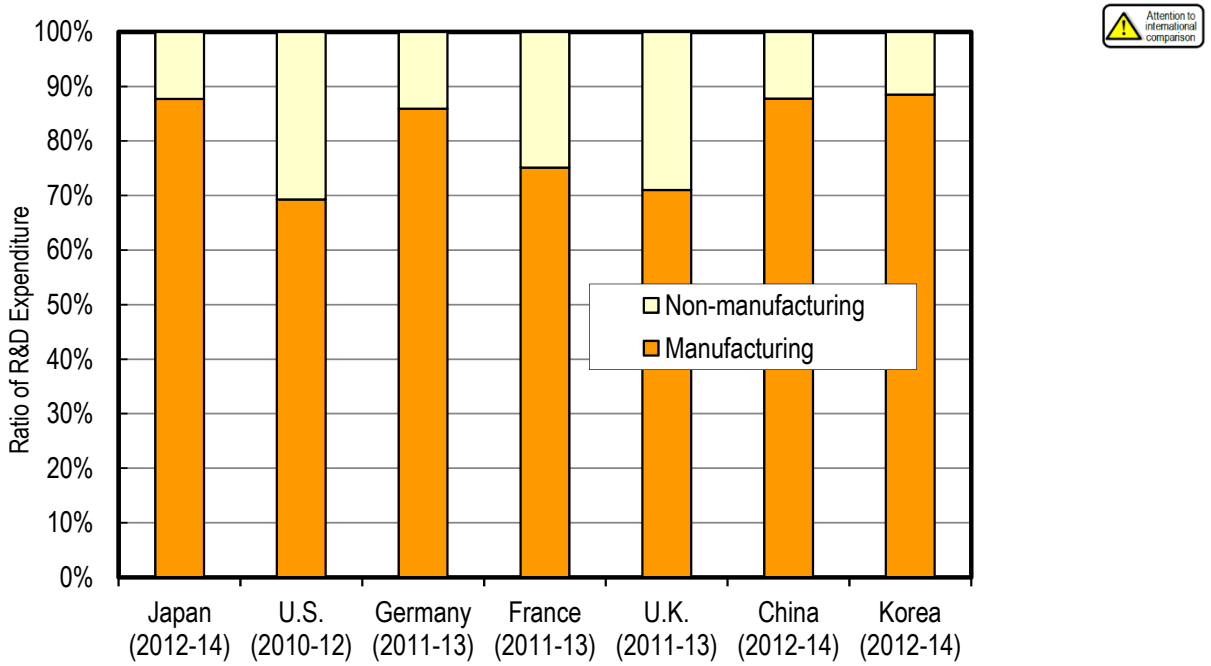
- The business enterprises sector accounts for the largest percentage of the total R&D expenditure. This tendency is particularly clear in Asian countries including Japan.

- In major European countries, the percentages of sectors other than the business enterprises sector are higher compared with the other countries.

(Source) Science and Technology Indicators 2016, NISTEP Research Material-251, released on August 4, 2016

☐ The ratio of R&D expenditure in the manufacturing industry to that in the non-manufacturing industry varied depending on the country. The percentage of R&D expenditure in the manufacturing industry is relatively high in Japan among the selected countries.

The ratio of R&D expenditure in the manufacturing industry to that in the non-manufacturing industry in the business enterprises sector of the selected countries



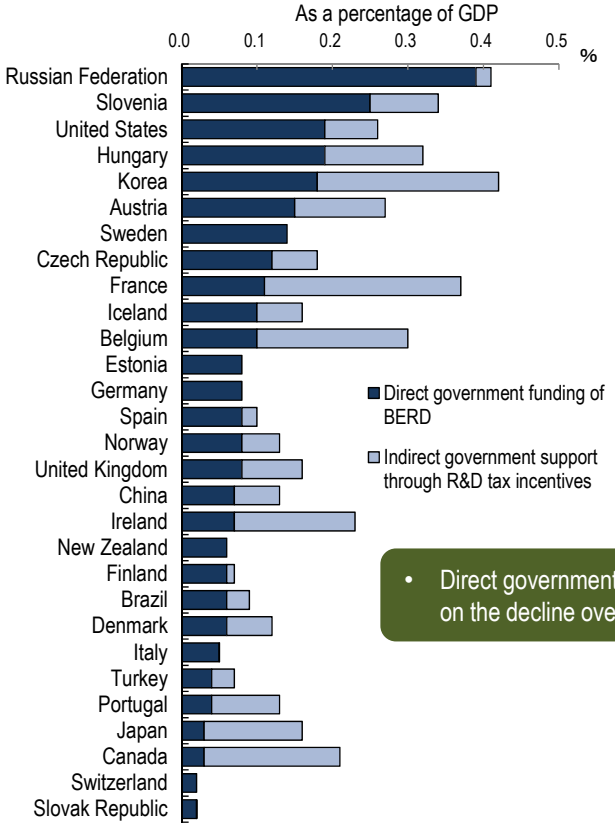
- The percentage of the manufacturing industry is a little less than 90% in Japan, Germany, China, and Korea.
- The percentage of the manufacturing industry is 70% in the United States and the U.K., and a little higher than 70% in France.

(Source) Science and Technology Indicators 2016, NISTEP Research Material-251, released on August 4, 2016

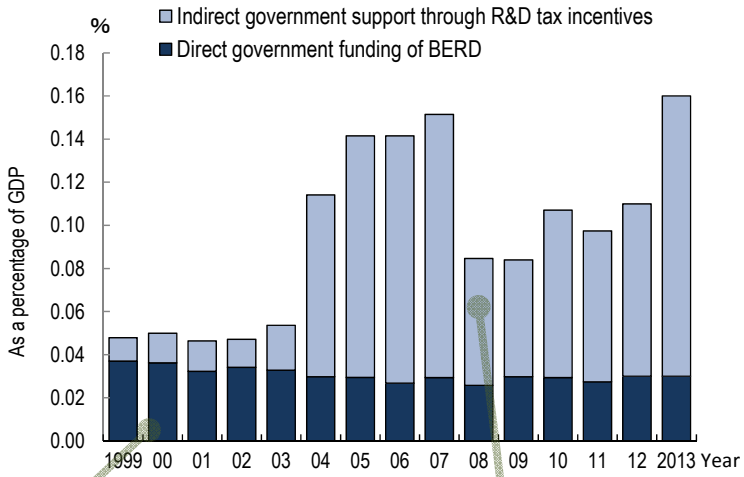
☐ Direct government funding to business enterprises has been on the decline over the long term. Indirect government support has been on the increase, though the amount of support changed significantly depending on the year.

government's direct and indirect support to help business enterprises with R&D

(A) Comparison of major countries (2011)



(B) Changes in Japan



- Direct government funding to business enterprises has been on the decline over the long term, but flat in recent years.

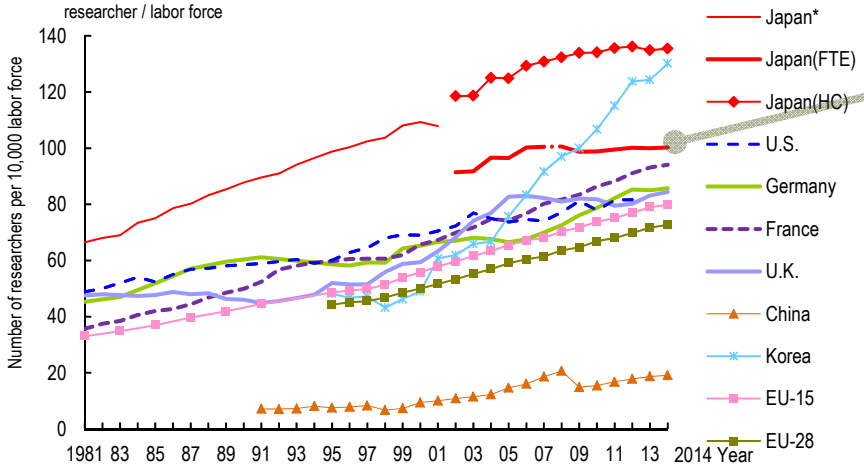
- Japan's indirect government support remarkably increased in 2004, but decreased in 2008 and increased again in 2013.
- The changes in the amount of R&D tax incentives are attributable to the changes in R&D tax incentives, market conditions (economy, depression), and other factors.

(Note)Direct government funding is the amount funded by the government to support business enterprises' R&D expenditure, which is expressed as a percentage of GDP. Indirect government support is the amount of deducted corporate tax through R&D tax incentives, which is expressed as a percentage of GDP.

(Source) Science and Technology Indicators 2016, NISTEP Research Material-251, released on August 4, 2016

☐ The number of researchers per 10,000 labor force in Japan has been relatively high among the selected countries. However, the growth of the number in the past 10 years has been slower compared with many of those countries.

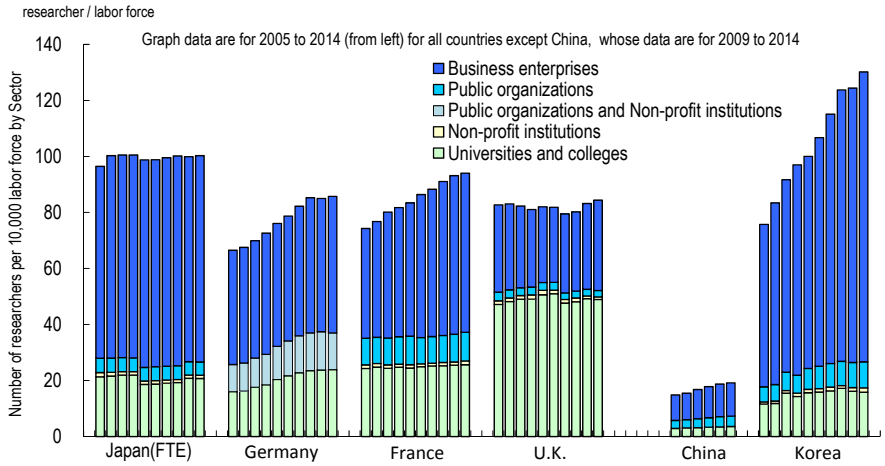
Changes in the number of researchers per 10,000 labor force



- In the first half of the 2000s, the number of researchers (FTE[1]) per 10,000 labor force in Japan was the largest of the selected countries. But Korea took over the top position from Japan in 2009.

(Note) HC means the head count of researchers. FTE means the net number of researchers when the degree of involvement in research is taken into consideration.

Changes in the number of researchers per 10,000 labor force by sector



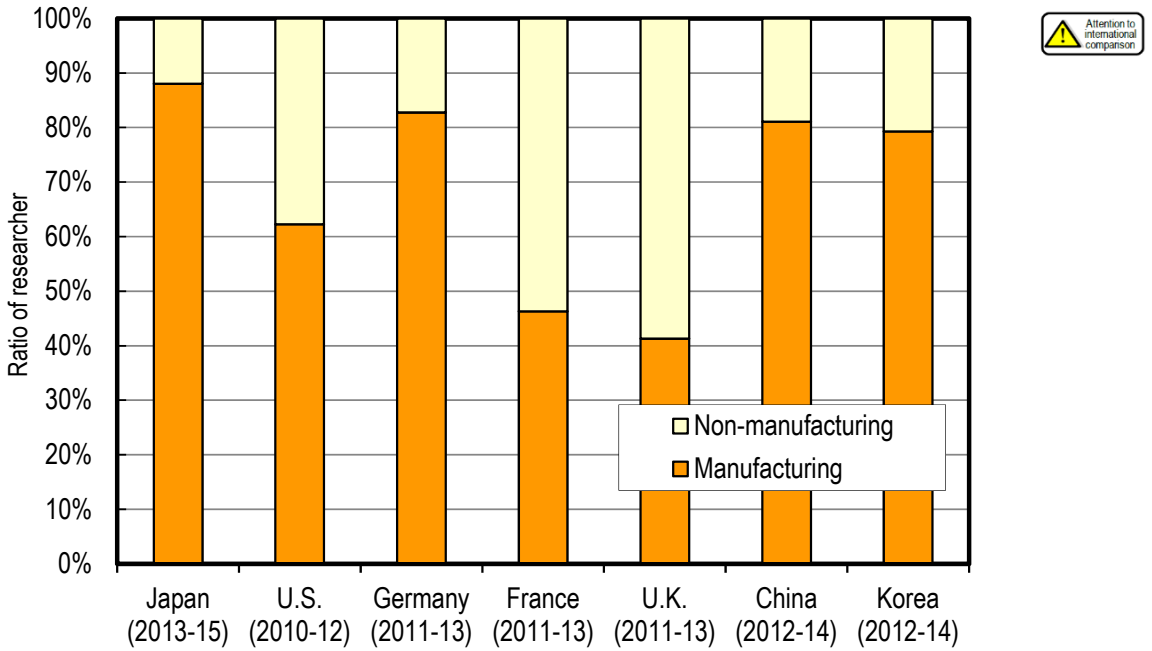
- The percentage of researchers in the business enterprises sector in Japan, China, and Korea was higher compared with European major countries.
- In the past ten years or so, Japan and the U.K. have shown no major changes in all sectors.
- The other countries have been increasing the number of researchers per 10,000 labor force at a constant pace, especially the number of researchers in the business enterprises shows remarkable growth in Korea.

(Note) (1) "Researchers" in Japanese companies refer to those who completed an undergraduate course at a college (excluding two-year colleges), or those who have equivalent or higher expertise. At the same time, they are involved in research for specific themes.
(2)There are no comments concerning the U.S. because the circumstances in the country except the business enterprises sector is unknown from the data in hand.

(Source) Science and Technology Indicators 2016, NISTEP Research Material-251, released on August 4, 2016

☐ The ratio of researchers in the manufacturing industry to those in the non-manufacturing industry varied depending on the country. Particularly in the U.K. and France, the percentage of researchers in the non-manufacturing industry was higher than 50%.

The ratio of researchers in the manufacturing industry to those in the non-manufacturing industry in the business enterprises sector of the selected countries



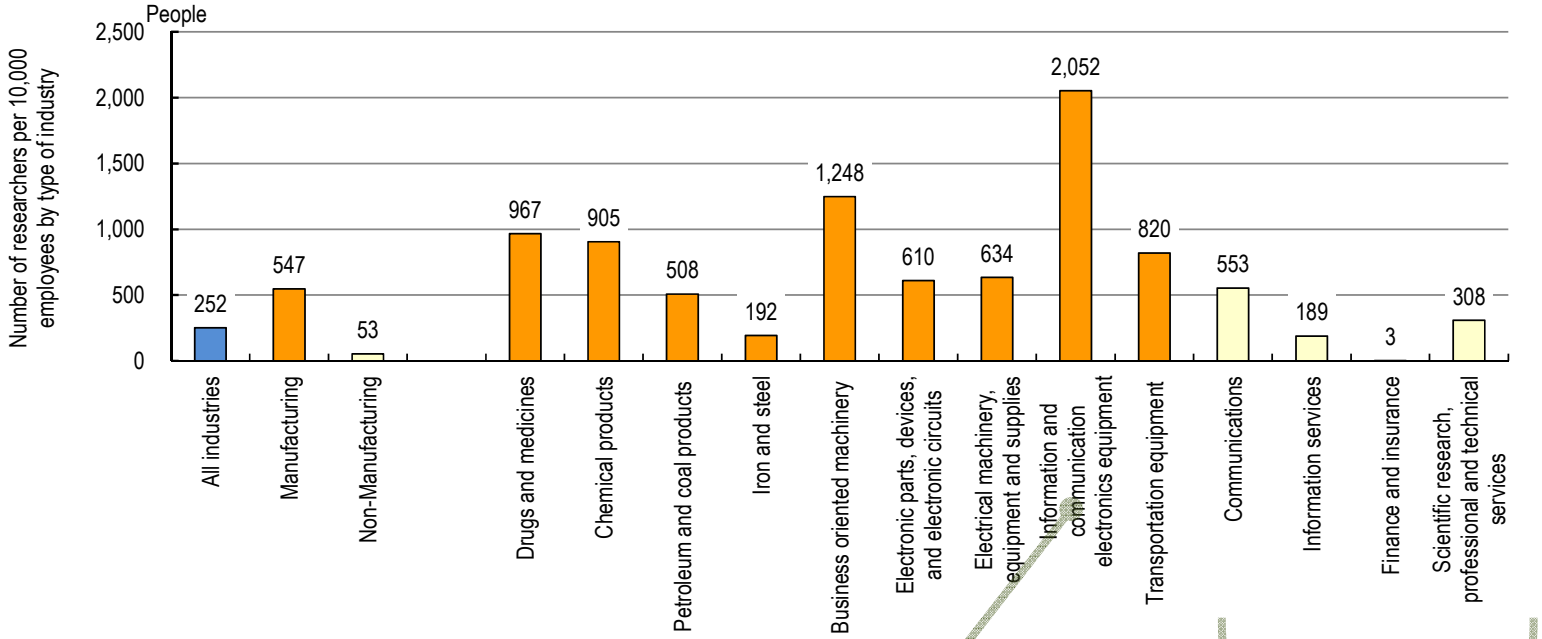
- The percentage of the manufacturing industry is about 90% in Japan and about 80% in Germany, China, and Korea.

- The percentage of the manufacturing industry is about 60% in the U.S. and less than 50% in France and the U.K. In these countries, the percentage of researchers in the non-manufacturing industry has been remarkably higher than the other countries.

(Source) Science and Technology Indicators 2016, NISTEP Research Material-251, released on August 4, 2016

☐ In Japan, the number of researchers per 10,000 employees for each industry classification was larger in the manufacturing industry than in the non-manufacturing industry.

Number of researchers per 10,000 employees for each industry classification in Japan (2015)



- The number of researchers engaged in the "information and communication electronics equipment" in the manufacturing industry is the largest at 2,052, which is followed by the "business-oriented machinery" and "drugs and medicines".

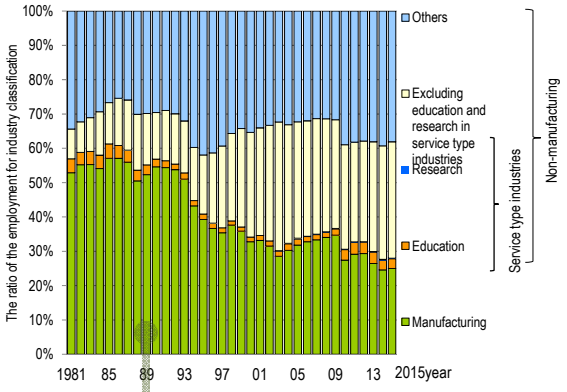
- In the non-manufacturing industry, the number of researchers engaged in the "communications" (553) and the "scientific research, professional and technical services" (308) are relatively large, though smaller compared with those in the manufacturing industry.

(Source) Science and Technology Indicators 2016, NISTEP Research Material-251, released on August 4, 2016

- **The percentage of the graduates in science and engineering who found employment in the non-manufacturing industry (except research and education) was 72.0% of the graduates of a bachelor's program and 42.2% of the graduates of a master's program. Those percentages have been on the increase over the long term. On the other hand, the percentage of graduates who found employment in the non-manufacturing industry (except R&D) of a doctor's program has slightly declined over the past 10 years to 22.2%.**

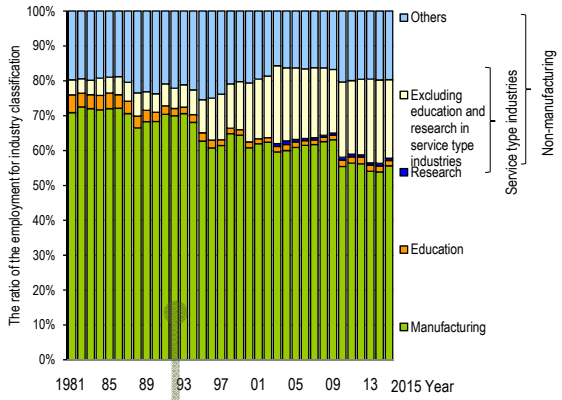
Employment status by industry classification of graduates in science and engineering

(A) Graduates of a bachelor's program in science and engineering



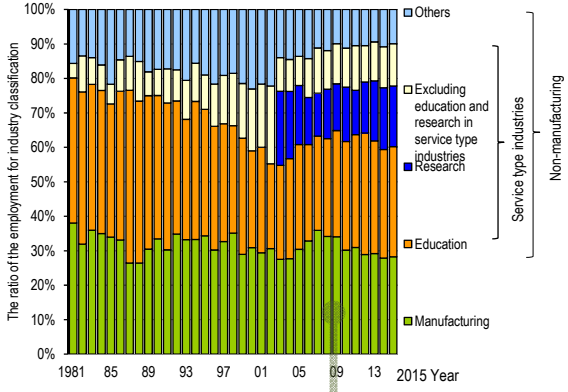
- The percentage of the "manufacturing industry" was 50-60% in the 1980s. The percentage in 2015 was 25.0%.

(B) Graduates of a master's program in science and engineering



- The percentage of the "manufacturing industry" was 70-80% in the 1980s. The percentage in 2015 was 55.6%.

(C) Graduates of a doctor's program in science and engineering



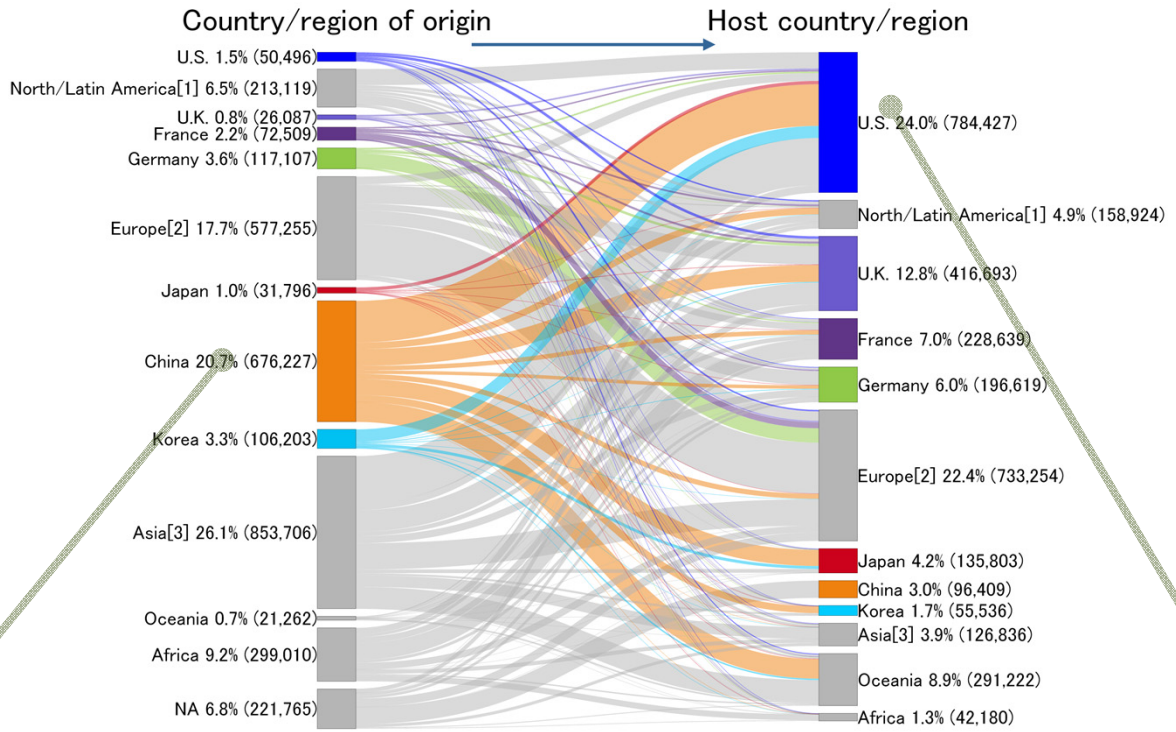
- The percentage of the "manufacturing industry" has hovered around 30%. The percentage in 2015 was 28.3%. The percentage of the "education" sector in 2015 was 31.9%. The percentage of the "research" sector in 2015 was 17.6%.

(Note) (1) The number of graduates who found employment includes work-study students.
(2) The following is the details of the service-related industries. Education: Those who found employment at schools. For example, those who became faculties of universities fall under this category. Research: Those who found employment at academic or R&D institutions (of which data have been collected since 2003). Others: Information and communication, medical welfare, etc.
(3) "Others" in the non-manufacturing industry include construction, wholesale and retail, finance, and insurance, public services, etc

(Source) Science and Technology Indicators 2016, NISTEP Research Material-251, released on August 4, 2016

◻ Among the selected countries, Japan sending a smaller number of students to other countries and also hosting a smaller number of students from other countries.

Country/region of origins and host country/region of foreign students with higher education (ISCED level 5–8) (2013)



- China is sending the largest number of students to other countries (20.7% of the world total).
- The U.K. is sending the smallest number of students abroad (0.8%). Japan and the U.S. are sending a small number of students overseas (1.0% and 1.5%, respectively).

- The U.S. is hosting the largest number of foreign students, accounting for 24.0% of the world total.

- While sending many students to foreign countries, China and Korea are hosting only a small number of foreign students. In contrast, while not sending many students overseas, the U.S. and the U.K. are hosting many foreign students.

(Notes)(1) Students with education level equivalent to ISCED 2011 level 5–8 (such as Japanese colleges including two-year colleges and technical colleges)
(2) Foreign students refer to students who do not hold nationality of a host country/region.
(3) China includes Hong Kong.

(Source) Science and Technology Indicators 2016, NISTEP Research Material-251, released on August 4, 2016

☐ The number of Japanese scientific publications remains at the same level as it was ten years ago. However the position of Japan in the global rank moved down due to a growth of other countries.

Top 10 countries/regions in terms of the number of papers, the number of adjusted top 10% papers, and the number of adjusted top 1% papers (based on the fractional counting method)

PY (published year) 2002–2004

All fields	2002 — 2004(PY) (Average)		
	The number of papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	213,319	26.5	1
Japan	67,475	8.4	2
Germany	51,205	6.3	3
U.K.	49,984	6.2	4
China	42,236	5.2	5
France	36,825	4.6	6
Italy	28,926	3.6	7
Canada	26,019	3.2	8
Spain	20,373	2.5	9
Russia	20,022	2.5	10

All fields	2002 — 2004(PY) (Average)		
	The number of adjusted top 10% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	32,239	40.1	1
U.K.	6,144	7.6	2
Germany	5,297	6.6	3
Japan	4,593	5.7	4
France	3,569	4.4	5
Canada	2,959	3.7	6
China	2,909	3.6	7
Italy	2,479	3.1	8
Netherlands	1,944	2.4	9
Australia	1,802	2.2	10

All fields	2002 — 2004(PY) (Average)		
	The number of adjusted top 1% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	3,897	48.5	1
U.K.	647	8.0	2
Germany	484	6.0	3
Japan	364	4.5	4
France	292	3.6	5
Canada	270	3.4	6
China	234	2.9	7
Netherlands	191	2.4	8
Italy	186	2.3	9
Switzerland	169	2.1	10

PY (published year) 2012–2014

All fields	2012 — 2014(PY) (Average)		
	The number of papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	269,016	20.5	1
China	191,043	14.5	2
Japan	64,730	4.9	3
Germany	64,072	4.9	4
U.K.	58,208	4.4	5
India	46,426	3.5	6
France	44,973	3.4	7
Korea	42,747	3.3	8
Italy	42,513	3.2	9
Canada	38,852	3.0	10

All fields	2012 — 2014(PY) (Average)		
	The number of adjusted top 10% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	38,964	29.7	1
China	18,052	13.8	2
U.K.	8,196	6.2	3
Germany	7,827	6.0	4
France	4,924	3.8	5
Italy	4,528	3.4	6
Japan	4,331	3.3	7
Canada	4,296	3.3	8
Australia	3,929	3.0	9
Spain	3,665	2.8	10

All fields	2012 — 2014(PY) (Average)		
	The number of adjusted top 1% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
U.S.	4,691	35.7	1
China	1,643	12.5	2
U.K.	932	7.1	3
Germany	759	5.8	4
France	459	3.5	5
Canada	408	3.1	6
Australia	405	3.1	7
Italy	353	2.7	8
Japan	340	2.6	9
Spain	303	2.3	10

[Methods of counting papers]
(Fractional counting method) In the case where one paper is co-authored by Japanese Organization A and US Organization B, this method counts Japan as 1/2 and the U.S. as 1/2. This indicates the degree of contribution to the production of papers.
(Whole counting method) In the case where one paper is co-authored by Japanese Organization A and US Organization B, this method counts Japan as 1 and the U.S. as 1. This indicates the degree of participation in the production of papers.
For counting, both the methods are based on the countries of the organizations with which the authors are affiliated.

(Source) Science and Technology Indicators 2016, NISTEP Research Material-251, released on August 4, 2016

☐ Japan has been ranked high in the number of patent families in the past ten years, and the majority of those patent applications were filed in the United States.

Patent families by selected country/region

(A) Number of patent families (top 10 countries/regions)

1999 - 2001(Average)(Whole counting)			
Country/Region	Patent Families	Share	World rank
Japan	42,731	27.8	1
U.S.	41,554	27.1	2
Germany	26,466	17.2	3
France	8,986	5.9	4
Yemen	8,338	5.4	5
Korea	5,978	3.9	6
Italy	4,361	2.8	7
Netherlands	3,990	2.6	8
Canada	3,857	2.5	9
Switzerland	3,362	2.2	10

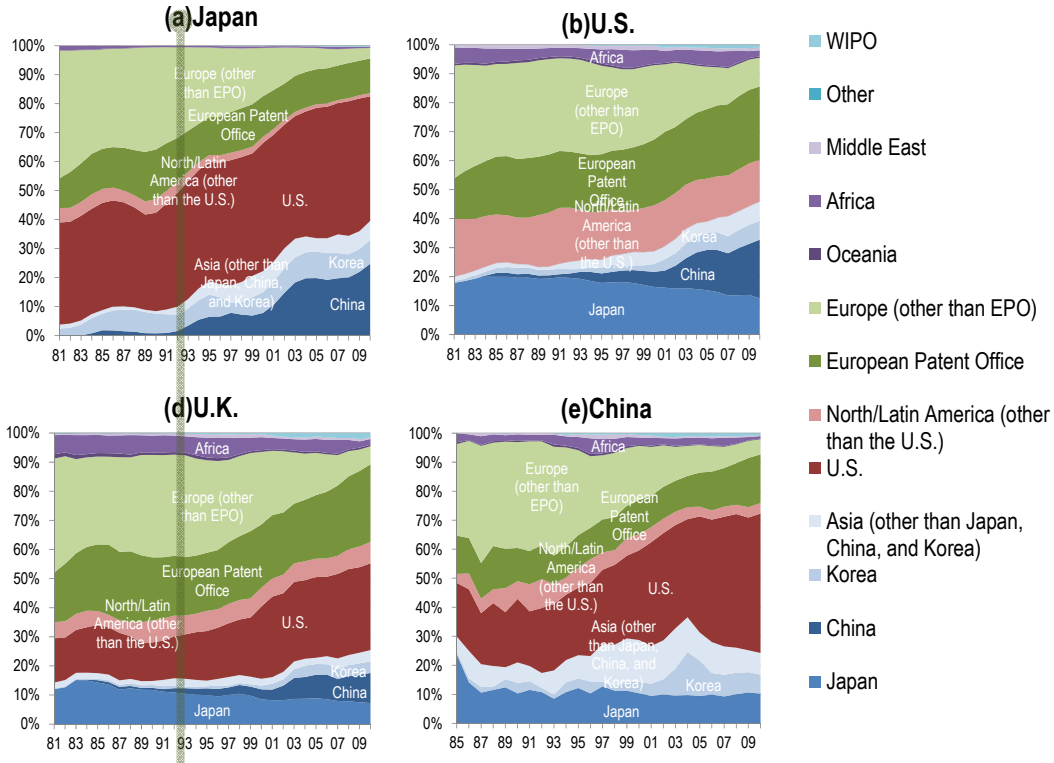
2009 - 2011(Average)(Whole counting)			
Country/Region	Patent Families	Share	World rank
Japan	61,229	28.3	1
U.S.	46,417	21.5	2
Germany	29,929	13.9	3
Korea	18,501	8.6	4
China	13,715	6.3	5
France	11,141	5.2	6
Taiwan	10,892	5.0	7
Yemen	8,453	3.9	8
Canada	5,807	2.7	9
Italy	5,460	2.5	10

99–01

Japan remains in first place

09–11

(B) Selected countries/regions in which patent families were filed



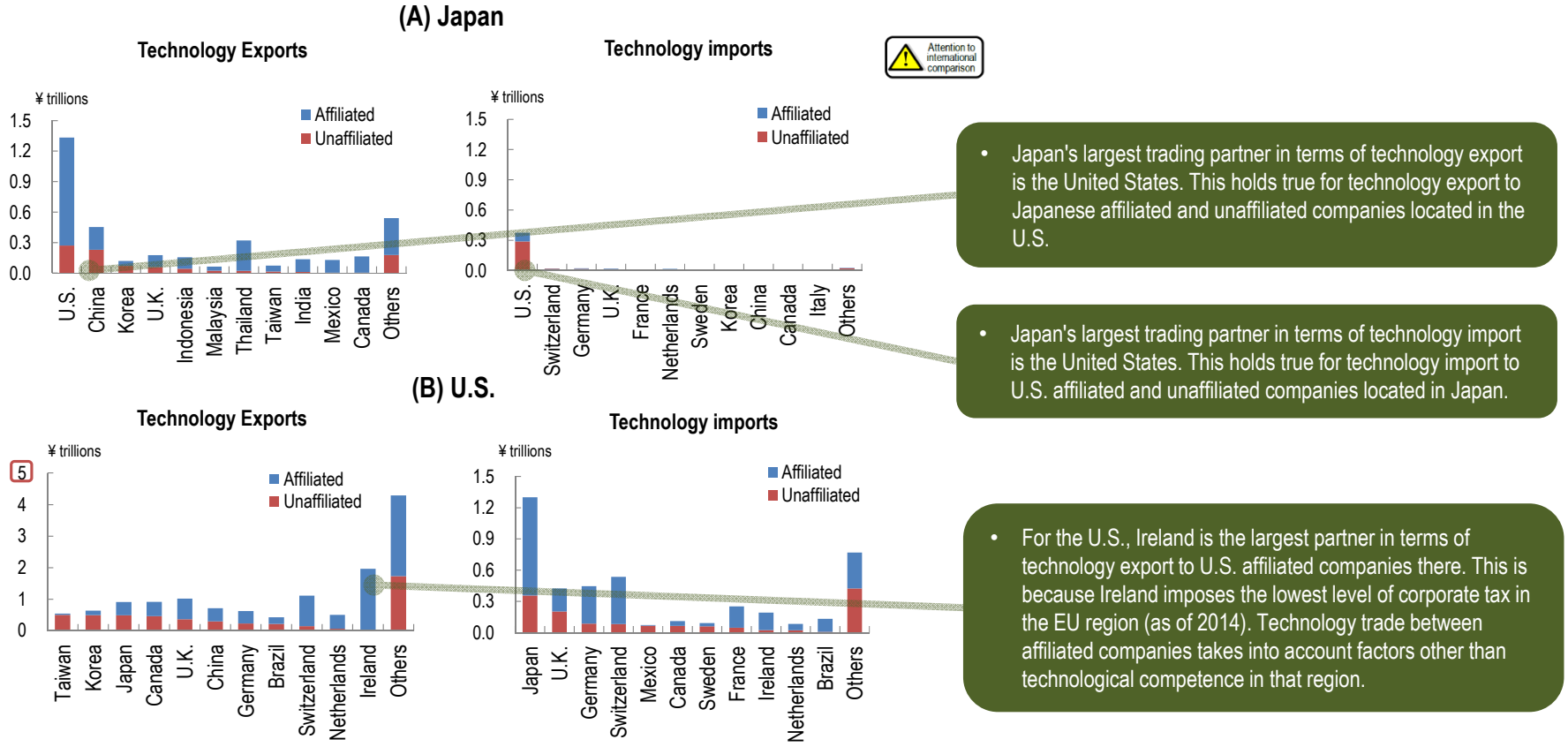
- Japan has filed 43.0% of its patent applications in the U.S. In the past 10 years. Japan has been increasing the percentage of its patent applications in China, but the percentage of its patent applications in Europe has been decreasing.

(Notes)(1) Patent applications filed in home countries/regions are excluded.
(2) A patent family is a group of patents filed in two or more countries, directly or indirectly related to each other by priority rights. In many cases, the same patents filed in multiple countries belong to the same patent family.

(Source) Science and Technology Indicators 2016, NISTEP Research Material-251, released on August 4, 2016

☐ Japan and the United States are dependent on each other in the technology trade, but Japan's dependence on the United States is more remarkable.

Technology exports and imports by partner country/region: Japan vs. the United States (2014)



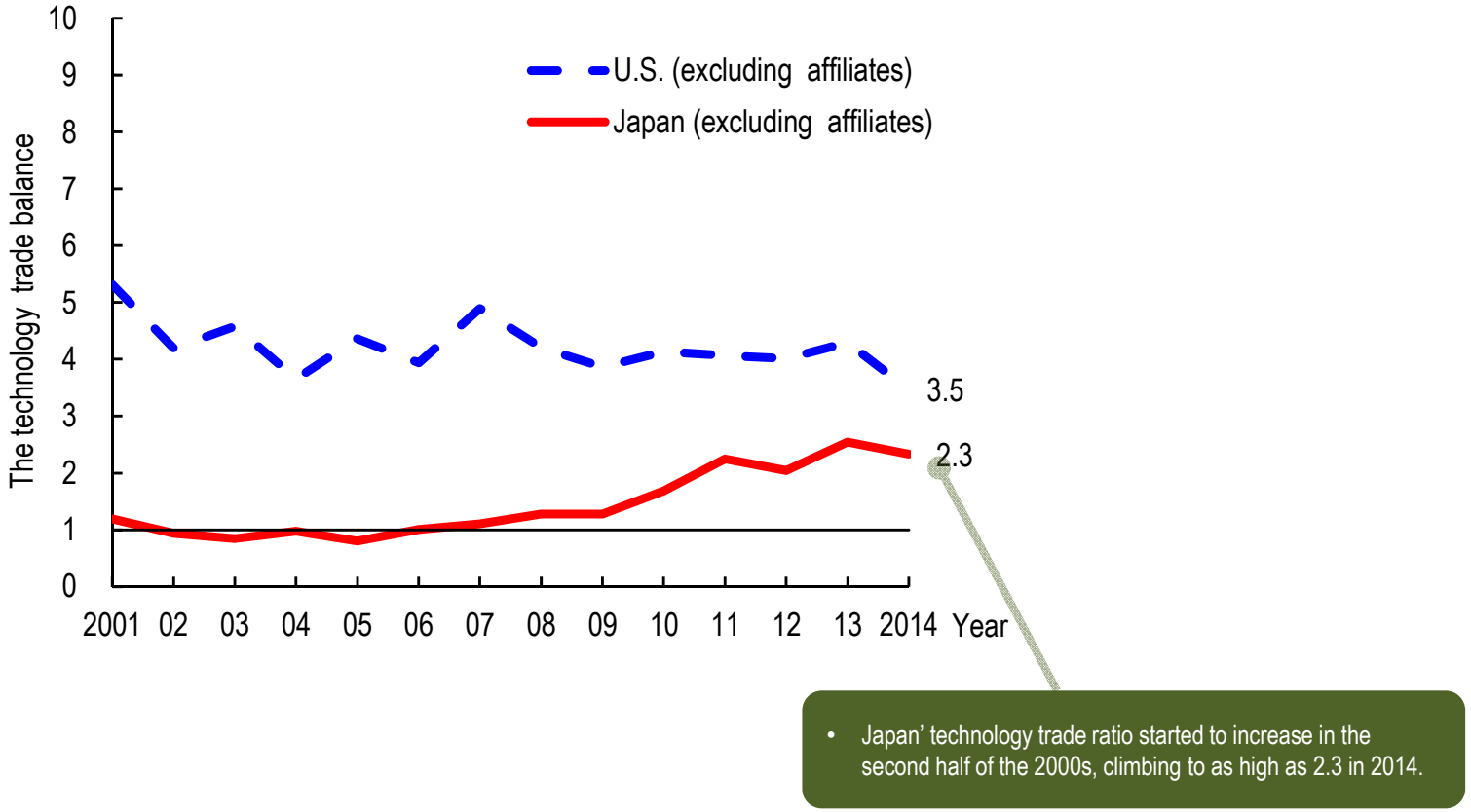
- Japan's largest trading partner in terms of technology export is the United States. This holds true for technology export to Japanese affiliated and unaffiliated companies located in the U.S.
- Japan's largest trading partner in terms of technology import is the United States. This holds true for technology import to U.S. affiliated and unaffiliated companies located in Japan.
- For the U.S., Ireland is the largest partner in terms of technology export to U.S. affiliated companies there. This is because Ireland imposes the lowest level of corporate tax in the EU region (as of 2014). Technology trade between affiliated companies takes into account factors other than technological competence in that region.

(Note)(1) The amounts for Japan are financial-year-based.
(2) The definition of affiliated companies is different between Japan and the United States, which requires attention in international comparison. The following are major differences in the definition of affiliated companies between the two countries:
[Japan] A parent company owns more than 50% of the stake of its subsidiary company. The types of Japanese technology trade include 1) patent right, utility model right, and copyright, 2) design right, 3) technical know-how service and technical guidance (except ones provided free of charge), and 4) technical assistance to developing countries (including government-commissioned assistance).
[U.S.] If a company directly or indirectly owns 10% or more of equity or a voting right of another company, the subsidiary company is called an affiliated company. The types of U.S. technology trade include 1) industrial processes, 2) computer software, 3) trademarks, 4) franchise fees, 5) audio-visual and related products, and 6) other intellectual properties

(Source) Science and Technology Indicators 2016, NISTEP Research Material-251, released on August 4, 2016

☐ The increase in Japan's technology trade balance (exports/imports), excluding its affiliated companies, indicates that Japan is increasing its technical competitiveness.

Technology trade ratios of Japan and the United States excluding their affiliated companies

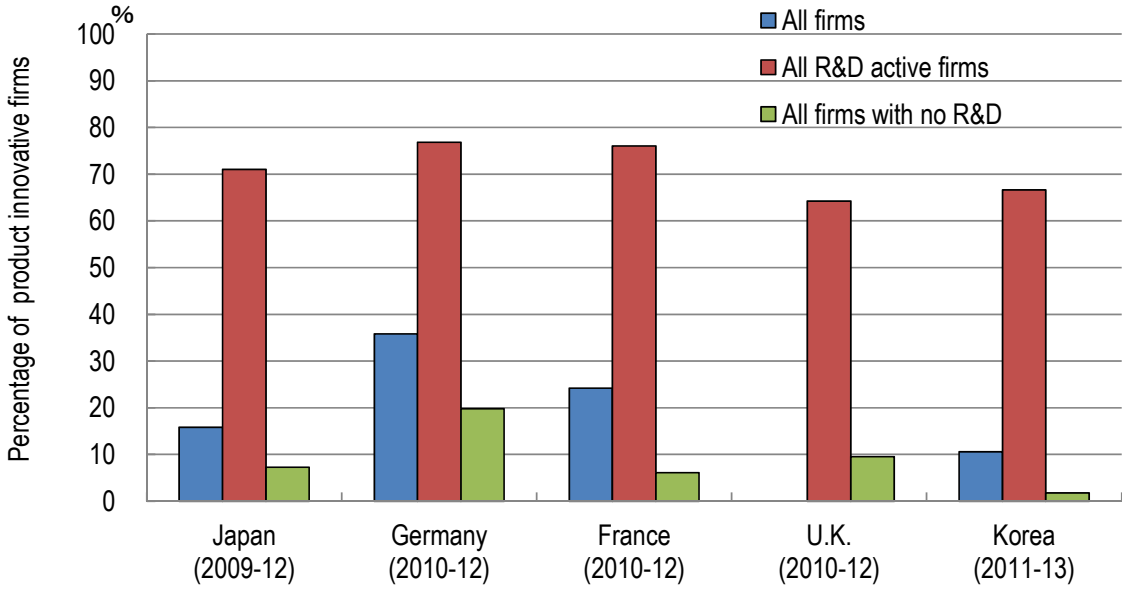


(Source) Science and Technology Indicators 2016, NISTEP Research Material-251, released on August 4, 2016

☐ Percentage of product innovative firms in Japan is smaller than that in Germany and France in all firms. The percentage, however, is comparable among selected countries in R&D active firms.

Percentage of firms that achieved product innovation in the selected countries (by involvement in R&D activities)

Attention to international comparison



- The percentage of firms involved in R&D activities in the business enterprises section of each country is estimated to be 13.5% in Japan, 28.1% in Germany, and 25.9% in France.
- One of the reasons why the percentage of firms that achieved product innovation is high in Germany and France is that the percentage of all firms implementing R&D activities is high.

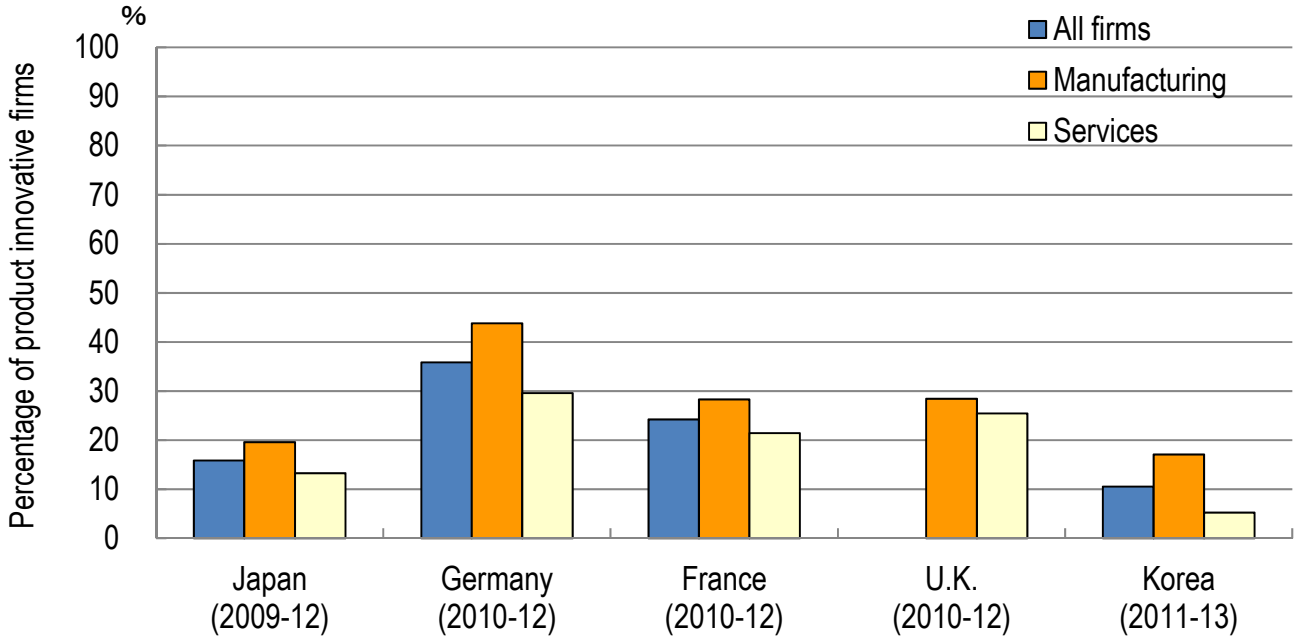
(Note)The value for "all firms" in the U.K. is not shown.

(Source) Science and Technology Indicators 2016, NISTEP Research Material-251, released on August 4, 2016

☐ The percentage of firms that achieved product innovation was higher in the manufacturing industry than in the service industry. The percentages of Japanese firms that achieved product innovation in the manufacturing industry and the service industry were lower than European countries.

Percentage of firms that achieved product innovation in the selected countries (manufacturing industry vs. service industry)

Attention to international comparison



- Between the manufacturing industry and the service industry, the difference in the percentage of firms that achieved product innovation is the largest in Korea and the smallest in the U.K.

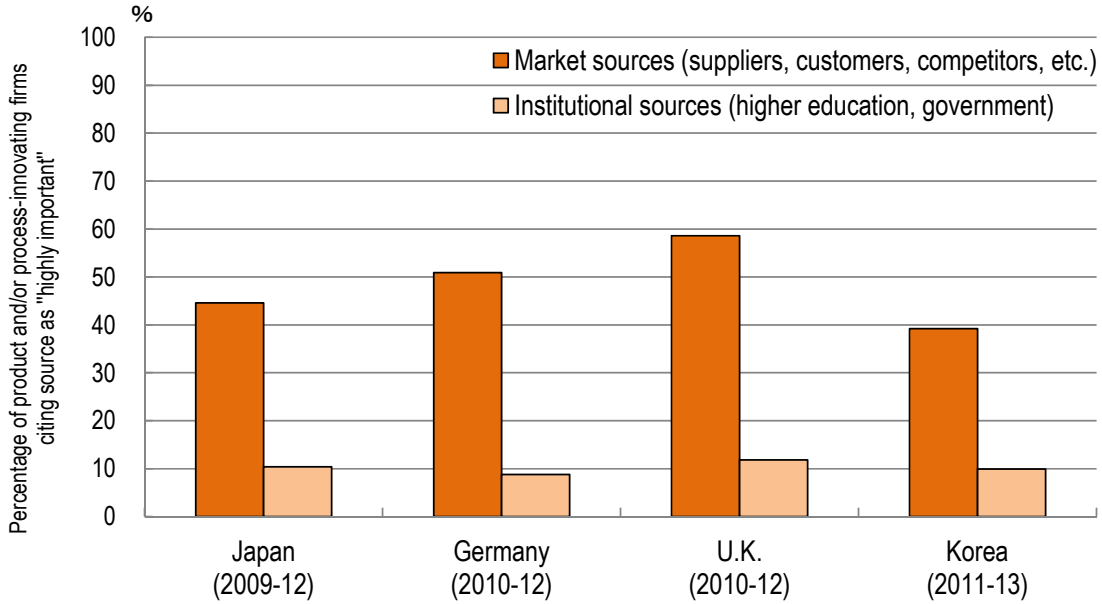
(Note)The value for "all firms" in the U.K. is not shown.

(Source) Science and Technology Indicators 2016, NISTEP Research Material-251, released on August 4, 2016

☐ In all countries, firms that were involved in product/process innovation activities attached importance to market related information as external sources of information.

External sources of information for firms involved in product/process innovation activities in the selected countries

Attention to international comparison



- In all countries, 40-60% of the firms believe that the importance of "market related" information is greater, and such information is very important.
- In all countries, about 10% of firms believe that "institution related" information is very important.

(Note)This survey targeted firms involved in product/process innovation activities (including ongoing and suspended activities).
(Source) Science and Technology Indicators 2016, NISTEP Research Material-251, released on August 4, 2016

Summary

- After remaining almost flat since 2009, Japan's total R&D expenditure increased 4.6% (OECD-estimated Japan: 4.8%) to 19 trillion yen in 2014 (OECD-estimated: 17.5 trillion yen) from the previous year. The percentage of R&D expenditure in the business enterprises sector was larger than in the other sectors.
- The number of researchers per 10,000 in the labor force in Japan was relatively large among the selected countries, but the growth in the number of researchers has been relatively slow among the selected countries in the past 10 years.
- The ratio of R&D expenditure in the manufacturing industry to that in the non-manufacturing industry varied depending on the country. The percentage of R&D expenditure in the manufacturing industry was relatively high in Japan among the selected countries.
- Among the selected countries, not only is Japan sending a smaller number of Japanese students to other countries, but it is also hosting a smaller number of students from other countries.
- The number of Japanese scientific publications remains at the same level as it was ten years ago. However the position of Japan in the global rank moved down due to a growth of other countries.
- Japan has been ranked high in the number of patents (patent families) in the past ten years, and the majority of those patent applications were filed in the United States.
- The percentage of firms that achieved product innovation was higher with the firms that were involved in R&D activities than with firms that were not. The percentage of achievement in product innovation was higher in the manufacturing industry than in the service industry. This tendency is commonly seen in all the selected countries.

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