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Digest of Japanese Science and Technology

Indicators 2024

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Center for S&T Foresight and Indicators
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Japanese Science and Technology Indicators 2024 (ABSTRACT)

"The Science and Technology Indicators" is a fundamental resource for systematically understanding Japan's science and technology activities based on objective and quantitative data. These activities are categorized into five areas: "Research and Development Expenditure," "Research and Development Personnel," "Higher Education and Science and Technology Personnel," "Research and Development Output," and "Science, Technology, and Innovation." Approximately 160 indicators represent the status of these activities in Japan. The report is published annually and offers the latest results of the analyses of scientific publications and patent applications conducted by the NISTEP.

This edition of "Science and Technology Indicators 2024" includes new indicators such as "Trends in Open Access (OA) papers," "Researchers' perceptions of open science: A comparison between Japan and Europe," "Changing the meaning of 'highly cited publications': Rise of China and global south," and "Alternative energy type patents and conventional patents related to the automotive industry."

Overviewing the latest situation of Japan from "Science and Technology Indicators 2024," the R&D expenditure and the number of researchers in Japan are the third-largest among major countries (Japan, U.S., Germany, France, U.K., China, and Korea). The rank of Japan in the number of scientific publications (fractional counting method) is 5th in the world. Japan ranks 13th and 12th in the top 10% and top 1% highly cited publications, respectively. For these indicators, Japan's ranking remains the same as last year.

After a long-term decline, the number of students enrolling in doctoral programs in Japan increased by 4.4% compared to the previous year in FY2023. The money received for "joint research" between Japanese universities and private business enterprises continued to increase, reaching 100 billion yen in FY2022.

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1. Japan's trends in key indicators

Trends in key indicators for Japan are as follows. Japan’s ranking is generally the same as that of the previous edition of the report. Japan has dropped in the rankings to fifth place in university R&D expenditures, but this is mainly due to a change in how the U.K. measures R&D expenditures in the universities and colleges sector. France also surpassed Japan, albeit slightly, in the number of researchers in public organizations. Japan's growth in R&D expenditures and the number of researchers is smaller than that in other selected countries. The OECD did not publish data for China in recent years, but it is now available through 2021.

[Summary Chart 1] Japan's trends in key indicators

Indicators	Changes in Japan's ranking	Japan’s figures	Note
R&D expenditure	No. 3→No. 3	19.1T yen	No. 1: U.S., No. 2: China
Business enterprises	No. 3→No. 3	15.1T yen	No. 1: U.S., No. 2: China
Universities and colleges	No. 4→No. 5	2.2T yen	No. 1: U.S., No. 2: China, No. 3: Germany, No. 4: U.K.
Public organizations	No. 4→No. 4	1.5T yen	No. 1: China, No. 2: U.S., No. 3: Germany
Number of Researchers	No. 3→No. 3	706K	No. 1: China, No. 2: U.S.
Business enterprises	No. 3→No. 3	531K	No. 1: China, No. 2: U.S.
Universities and colleges	No. 4→No. 4	138K	No. 1: China, No. 2: U.S., No. 3: U.K.
Public organizations	No. 4→No. 5	30K	No. 1: China, No. 2:U.S., No. 3: Germany, No. 4: France
Number of scientific papers (fractional counting)	No. 5→No. 5	72K	No. 1: China, No. 2: U.S., No. 3: India, No. 4: Germany
Number of adjusted top 10% scientific papers (fractional counting)	No. 13→No. 13	3.7K	No. 1: China, No. 2: U.S., No. 3: U.K., No. 4: India, No. 5: Germany, No. 6: Italy, No. 7: Australia, No. 8: Canada, No. 9: Korea, No. 10: France, No. 11: Spain, No 12: Iran
Number of adjusted top 1% scientific papers (fractional counting)	No. 12→No. 12	0.31K	No. 1: China, No. 2: U.S., No. 3: U.K., No. 4: Germany, No. 5: Italy, No. 6: India, No. 7: Australia, No. 8: Canada, No. 9: France, No. 10: Korea, No. 11: Spain
Number of patent families	No. 1→No. 1	67K	
The trade balance ratios for high R&D intensive industries	No. 6→No. 6	0.7	No. 1: Korea, No. 2: China, No. 3: Germany, No. 4: France, No. 5: U.K.
The trade balance ratios for medium-high R&D intensive industries	No. 1→No. 1	2.6	
Number of cross-border trademark applications (Number of classes)	No.6→No.6	120K	No. 1: U.S., No. 2: China, No. 3: Germany, No. 4: U.K., No. 5: France

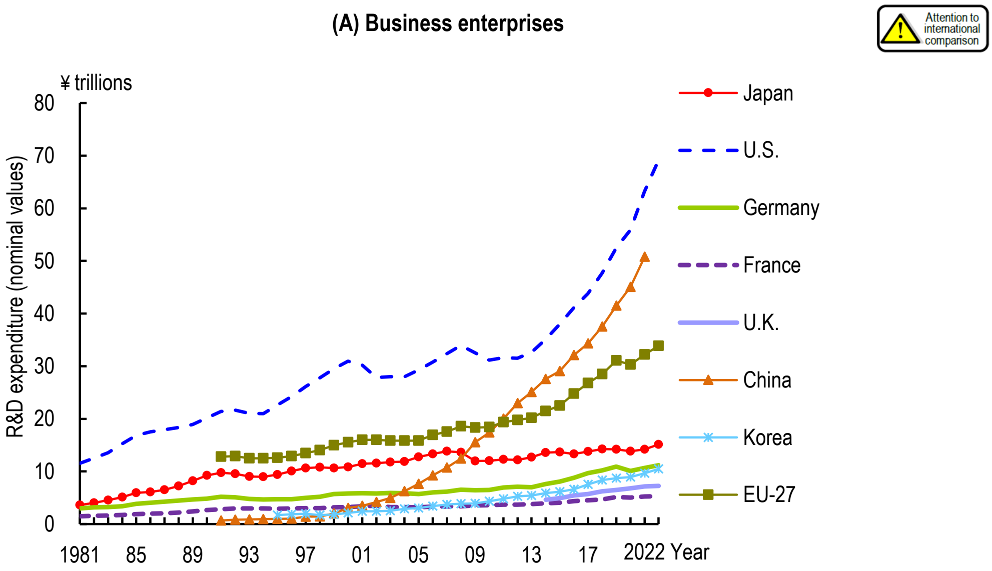
Notes:
*: R&D expenditure is the cost of performing research and development work at a given institution, and is different from the science and technology budget.
1) The “Changes in Japan's ranking” compares the latest year and the previous year. The “Japan’s figures” is for the latest year.
2) Except for the number of papers and adjusted top 10%/top 1% papers and the number of patent families, the rankings are within the following selected countries: Japan, the U.S., Germany, France, the U.K., China, and Korea.

(1) The growth of R&D expenditure in Japan's "business enterprises" and "universities and colleges" sectors is smaller compared to that in other selected countries.

The U.S. has the largest R&D expenditures in the sectors of "business enterprises" and "universities and colleges" among the selected countries. Both sectors have seen strong growth since the 2010s. China is also increasing its R&D expenditures. Growth in R&D expenditure in Japan's business enterprises sector has been slow, but in the most recent year it increased by 6.4% compared to the previous year. R&D expenditure contributed by the government sector increased by 44% over the same period. Although its weight in the overall business enterprises sector is small, the government sector also contributed to the increase in R&D expenditure. In the sector of "universities and colleges", Japan's R&D expenditure has remained almost flat since the 2000s, and has been surpassed by those of China and Germany, which have grown rapidly since the 2010s.

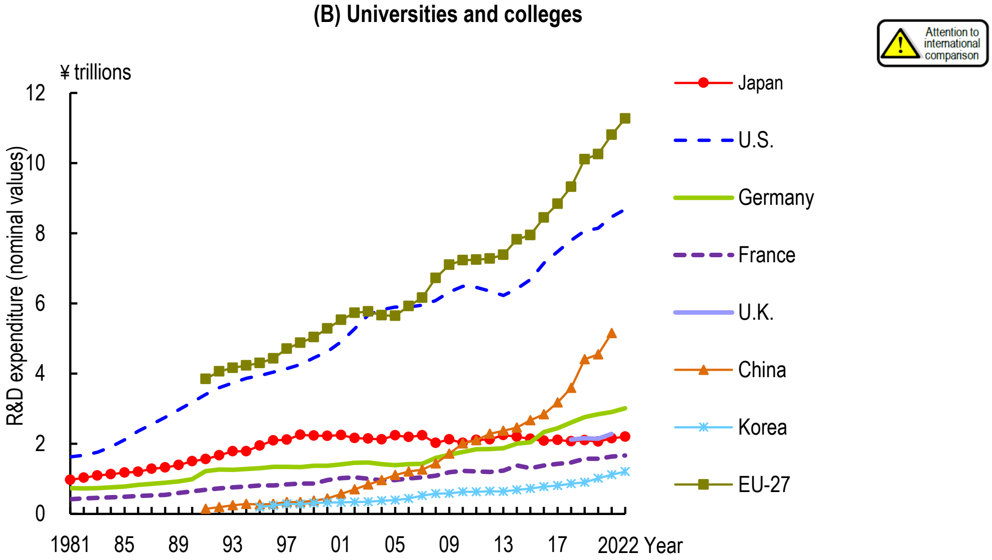
[Summary Chart 2] Nominal values of R&D expenditure by "business enterprises" and "universities and colleges" (based on OECD purchase power parities data)

(A) Business enterprises



Reference: Chart 1-3-3(A), Japanese Science and Technology Indicators 2024 (in Japanese)

(B) Universities and colleges

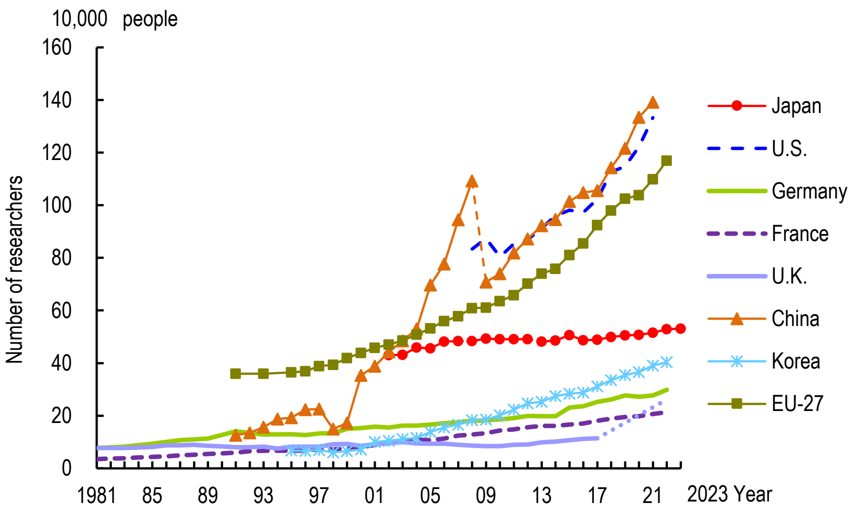


Reference: Chart 1-3-13(A), Japanese Science and Technology Indicators 2024 (in Japanese)

China has the largest number of researchers in the “business enterprises” and “universities and colleges” sectors among the selected countries. The U.S. and China are closely matched in the “business enterprises” sector, with both countries showing rapid growth. The number of researchers in Japan's “business enterprises” sector remained almost flat from the late 2000s, but has increased slightly since 2017. The number of Korean researchers in the “business enterprises” sector has also increased over time. Germany has seen an increase in the “universities and colleges” sector since the mid-2000s. Japan's growth has been moderate and has recently leveled off.

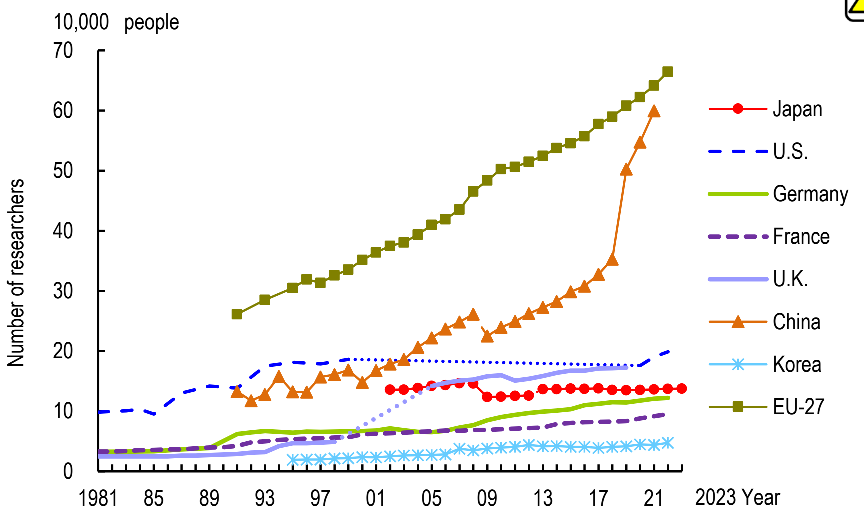
[Summary Chart 3] Trends in the number of researchers in “business enterprise” and “universities and colleges”

(A) Business enterprise



Reference: Chart 2-2-4, Japanese Science and Technology Indicators 2024 (in Japanese)

(B) Universities and colleges



Note : In the chart, periods for which no data is available are indicated by dotted lines.
Reference: Chart 2-2-11, Japanese Science and Technology Indicators 2024 (in Japanese)

2. Status of Higher Education and Science and Technology Personnel

(1) Enrollment growth was sluggish in Japanese graduate schools. Enrollment in master's programs increased after FY2020, while enrollment in doctoral programs increased by 4.4% in FY2023 compared to the previous year.

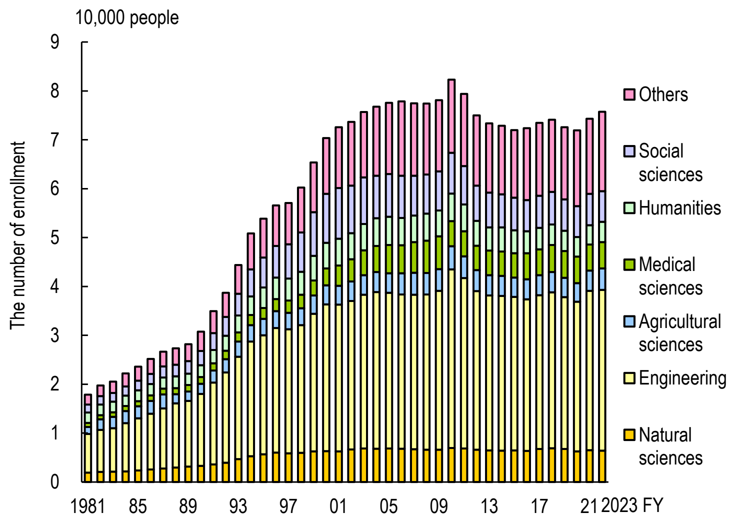
The number of enrollments in Japan's graduate school master's programs peaked in FY2010 and began to decline. However, enrollment increased after FY2020, reaching 77,000 in FY2023, an increase of 1.4% from the previous year. The percentage of recurrent students in the total is 9.3%.

The number of enrollments in the graduate doctoral programs peaked in FY2003 and has been on a long-term downward trend, but in FY2023, the number of enrollments increased to about 15,000, a 4.4% increase over the previous year. About 6,000 are recurrent students, a 3.9% increase from the previous year[1]. Looking at the number by major, there was an increase in all fields shown here from FY2022 to FY2023. "Engineering" increased by 8.8%, "Social sciences" increased by 6.1%, "Others" increased by 5.0%, "Medical sciences" increased by 3.1%, and "Agricultural sciences" increased by 3.0%.

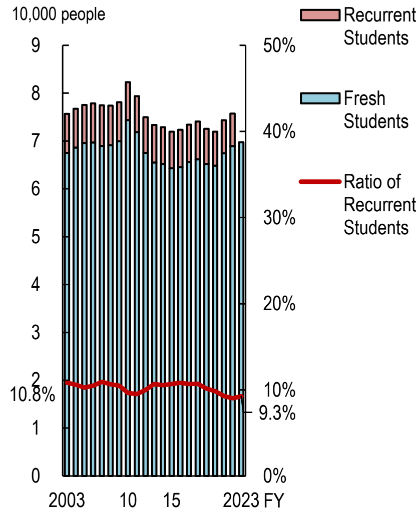
[1] In FY2023, the number of international students enrolled in doctoral programs was 3,000. Compared to the previous year, this represents an increase of 10.8%.

[Summary Chart 4] The number of enrollments in graduate schools (master's programs)

(A) Changes in the number of enrollments in graduate schools by major subject (master's programs)



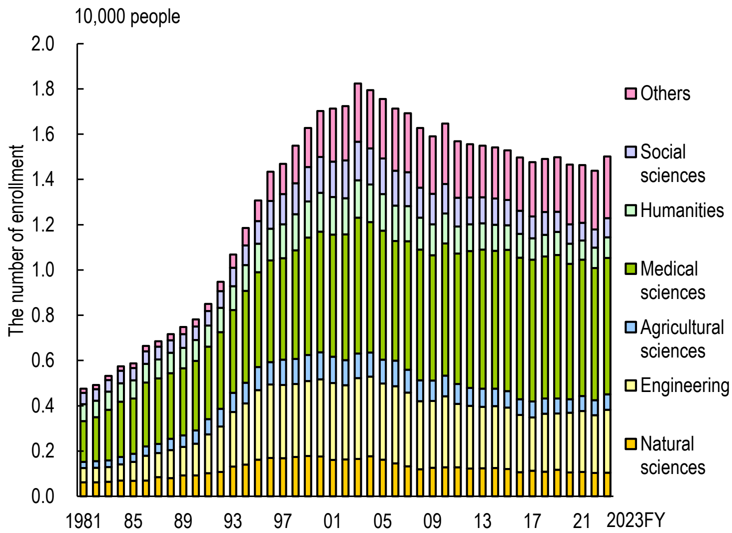
(B) Changes in the number of recurrent students newly enrolled in graduate schools (master's programs)



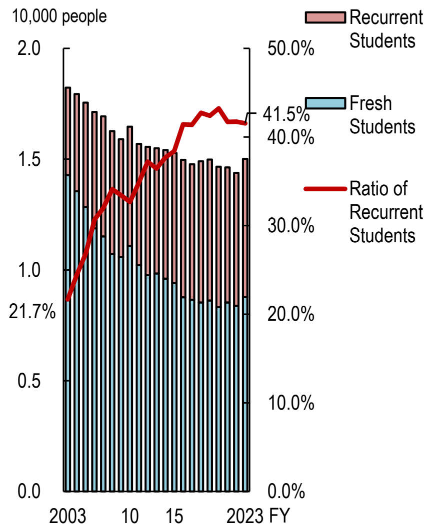
Reference: Chart 3-2-2, Japanese Science and Technology Indicators 2024 (in Japanese)

[Summary Chart 5] The number of new enrollments in graduate schools (doctoral programs)

(A) Changes in the number of enrollments in graduate schools by major subject (doctoral programs)



(B) Changes in the number of recurrent students newly enrolled in graduate schools (doctoral programs)



Reference: Chart 3-2-3, Japanese Science and Technology Indicators 2024 (in Japanese)

Note:
"Others" in the Chart (A) are "Education," "Arts," "Merchant Marine," and "Domestic Science," as well as "Others," which indicates "Others" in the "Departmental Classification Table" of the "Report on School Basic Survey." The names of major study fields included in this category often use words such as "Environment," "Human," "Information," "International," and so on.

(2) Compared to the respective peaks of male and female enrollment in Japanese graduate doctoral programs, female enrollment is down 4% while male enrollment is down 24%.

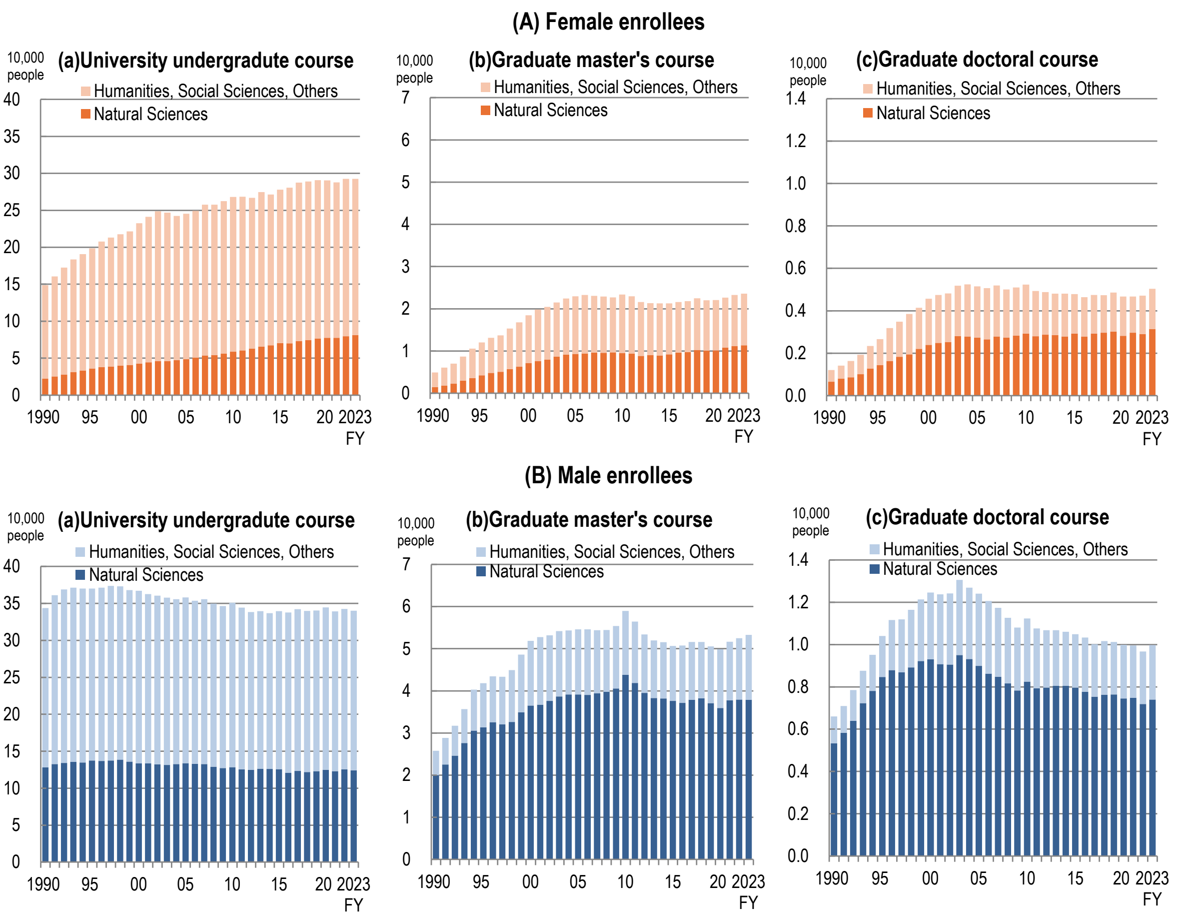
Undergraduate enrollment has continued to increase for females, while it has decreased for males since the late 1990s and leveled off since the mid-2010s. Compared to 1990, the number of females has quadrupled in the "Natural Sciences" and doubled in the "Humanities, Social Sciences, and Others", while the number of males has remained almost flat in both fields.

Enrollment in master's programs increased until the mid-2000s for females and until the early 2000s for males; it temporarily declined in the 2010s, but has been increasing since the mid-2010s for females and since FY2020 for males. Compared to FY1990, the number of females in "Natural Sciences" increased eightfold, and that in "Humanities and Social Sciences and Other" increased fourfold. The number of males in "Humanities, Social Sciences and Others" has tripled, while the number in "Natural Sciences" has doubled.

Enrollment in doctoral programs has been on a downward trend since peaking in 2004 for females and 2003 for males. Compared to the peak, the number of females is down 4%, while the number of males is down 24%. Both males and females enroll more in "Natural Sciences" than in "Humanities, Social Sciences and Others". Compared to the peak, both fields have decreased for males, while the number of females in the "Humanities, Social Sciences and Others" has decreased, but the number of females in the "Natural Sciences" has increased by 12%.

The percentage of female students entering in FY2023 was 46% for undergraduate programs, 31% for master's programs, and 34% for doctoral programs. Compared to FY1990, these figures have all increased, with the proportions for master's and doctoral programs nearly doubling.

[Summary Chart 6] Numbers of students enrolling in undergraduate departments, master's programs, and doctoral programs



Reference: Chart 3-2-6, Japanese Science and Technology Indicators 2024 (in Japanese)

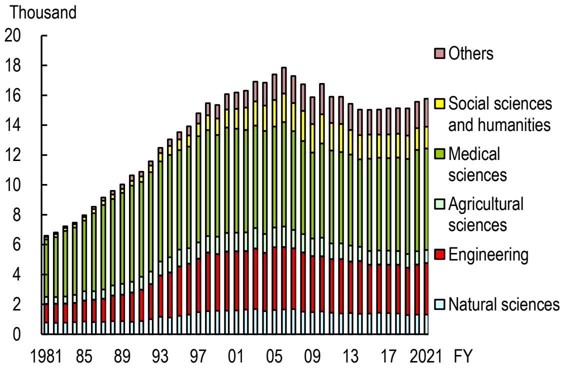
(3) The number of new doctoral degree recipients in Japan has been on a downward trend since its peak in 2006 and has remained almost flat since the mid-2010s but has slightly increased in recent years.

In FY2021, the number of new doctoral degree recipients in Japan was 15,767. By major field of study, “Medical sciences” was the most common, with 6,796 recipients (43.1% of the total), followed by “Engineering” with 3,436 recipients (21.8%) and “Others” with 1,873 recipients (11.9%).

The number of new doctoral degree recipients by coursework had been continuously increasing, but it showed a downward trend starting in the mid-2000s and has been increasing since FY 2015. The number was 14,010 in FY2021. The number of doctoral degree recipients by thesis only exceeded the number of doctoral degree recipients by coursework until the early 1990s. The number of doctoral degree recipients by thesis only continued to decline thereafter, but in FY2021, it increased by 1.9% from the previous year to 1,757.

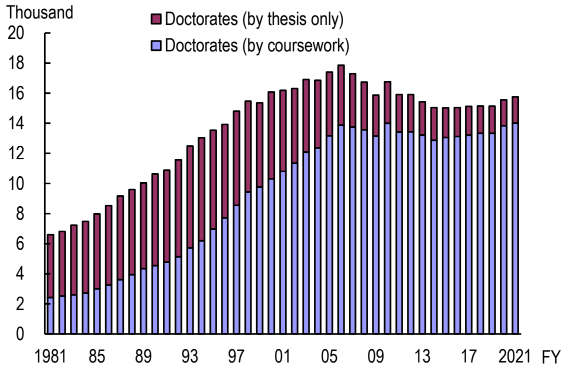
[Summary Chart 7] Changes in the number of new doctoral degree recipients in Japan

(A) By major field of study



Reference: Chart 3-4-5, Japanese Science and Technology Indicators 2024 (in Japanese)

(B) By coursework and thesis only



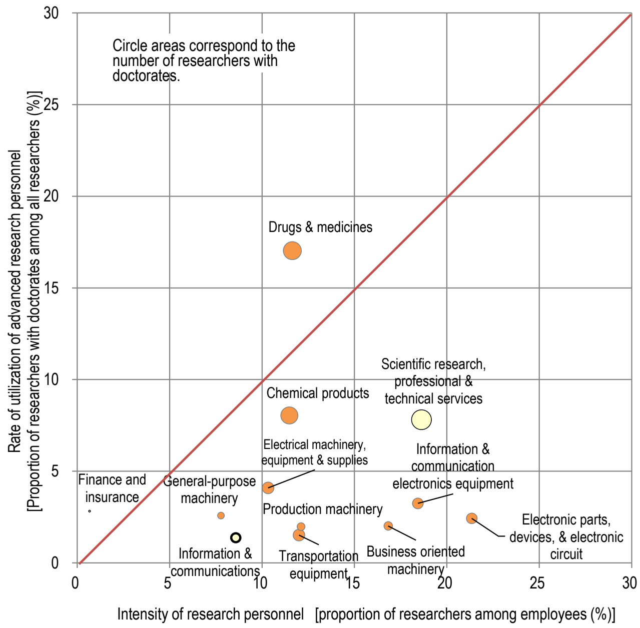
Note:
A doctorate (by coursework) is awarded by completing a doctoral program at a graduate school, while a doctorate (by thesis only) is awarded by submitting a thesis without completing the course of study.
Reference: Chart 3-4-6 Japanese Science and Technology Indicators 2024 (in Japanese)

(4) Japan's rate of utilization of advanced research personnel (the proportion of researchers with doctoral degrees among all researchers) is low, compared with the United States.

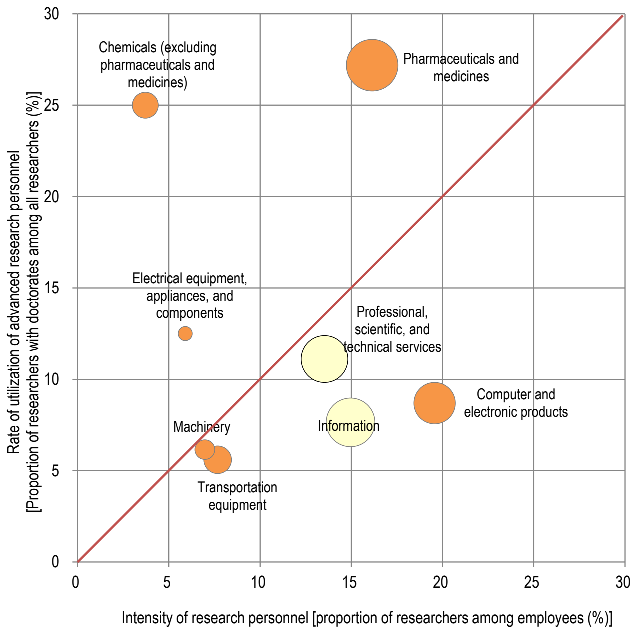
In the U.S., no industry has a ratio of researchers with doctoral degrees (the proportion of researchers with doctoral degrees among all researchers) of less than 5%. However, in Japan, the ratio is less than 5% in many industries. This suggests that Japan tends to utilize advanced research personnel less than the United States.

[Summary Chart 8] Relationship between the intensity of research personnel and the rate of utilization of advanced research personnel by industry

(A) Japan (2023)



(B) U.S. (2021)



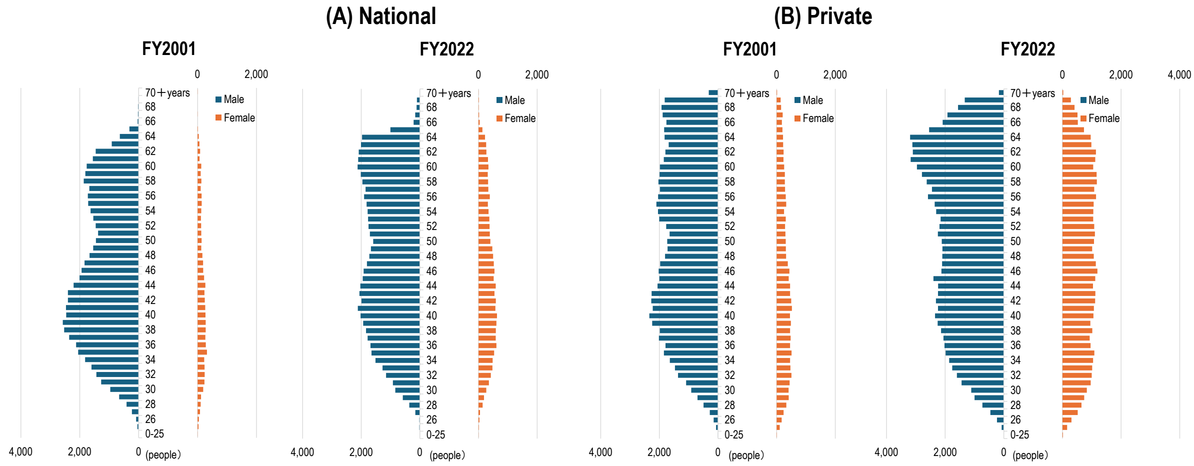
Note:
For both Japan and the United States, this analysis covered business enterprises engaging in R&D. Orange circles denote manufacturing sectors, yellow circles non-manufacturing sectors. This is an aggregation by head count.
Reference: Chart 2-2-9, Japanese Science and Technology Indicators 2024 (in Japanese)

(5) Even considering demographic trends, the aging of university faculty members is progressing, especially among males.

Looking at the age distribution of university faculty members per million population, the number of male faculty members is aging in both national and private universities. Female faculty members per million population tend to be higher in younger generations at national universities, while it is generally similar for all generations at private universities.

Compared to about 20 years ago, the number of faculty members per million population has increased more at private universities than at national universities, and both kinds of universities tend to have more female than male faculty members. As for young male faculty members at national universities, the number has decreased even considering demographic trends (for faculty members in their late 30s, the number has decreased by more than 500 per million population).

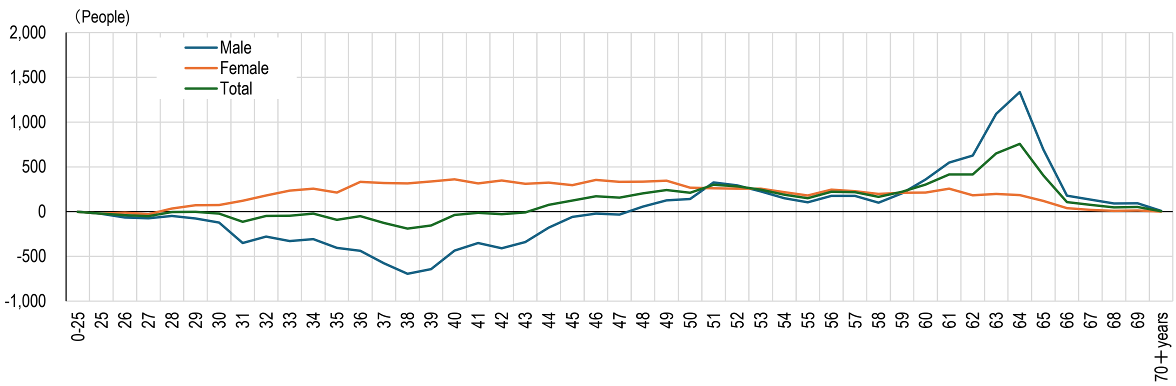
[Summary Chart 9] Age distribution of faculty members per million population by gender



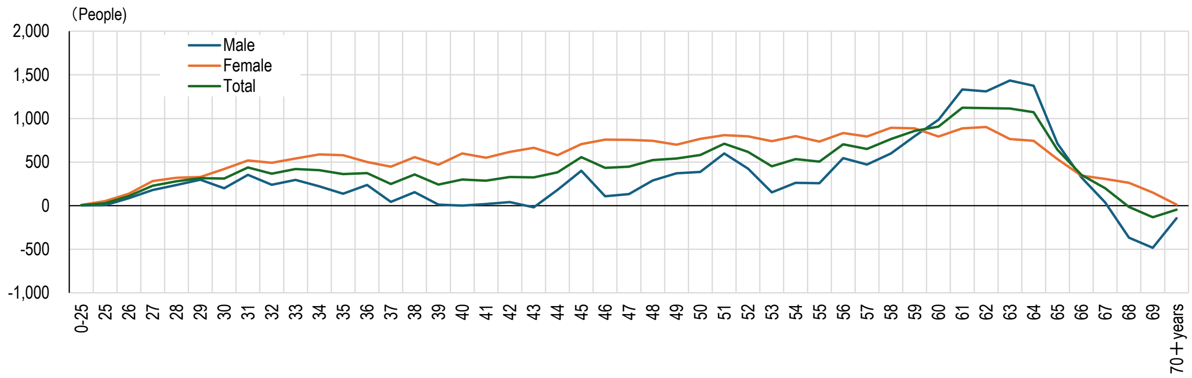
Reference: Column Chart 3-1, Japanese Science and Technology Indicators 2024 (in Japanese)

[Summary Chart 10] Difference in age distribution of faculty members per million population by gender (difference between FY2001 and FY2022)

(A) National



(B) Private



Reference: Column Chart 3-2, Japanese Science and Technology Indicators 2024 (in Japanese)

Note : The number of faculty members of the relevant age and the population of the relevant age were used for each gender.

3. Status of Research and Development Outputs

(1) Japan ranks 5th in the world in terms of the number of papers (fractional counting method). When focusing on highly cited papers, Japan ranks 13th and 12th in the adjusted top 10% and top 1% papers. China ranks first in the world in all categories of papers.

Japan is ranked 5th after China, the U.S., India, and Germany in terms of the number of papers (the average of 2020–2022) counted by the fractional counting method that measures the degree of contribution to paper production. Focusing on highly cited papers, Japan ranks 13th in the number of adjusted top 10% papers. For adjusted top 1% papers, Japan ranks 12th. China ranks first in the world in all categories of papers.

[Summary Chart 11] Top countries/regions in the number of papers and in the numbers of adjusted top 10% and 1% papers in citation counts (in natural sciences, based on the fractional counting method)

All fields	2020 - 2022 (PY) (Average)		
	The number of papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
China	541,425	26.9	1
U.S.	301,822	15.0	2
India	85,061	4.2	3
Germany	74,456	3.7	4
Japan	72,241	3.6	5
U.K.	68,041	3.4	6
Italy	61,124	3.0	7
Korea	59,051	2.9	8
France	46,801	2.3	9
Spain	46,006	2.3	10
Canada	45,818	2.3	11
Brazil	45,441	2.3	12
Australia	42,583	2.1	13
Iran	38,558	1.9	14
Russia	33,639	1.7	15
Türkiye	33,168	1.6	16
Poland	27,978	1.4	17
Taiwan	23,811	1.2	18
Netherlands	23,144	1.1	19
Switzerland	16,723	0.8	20

All fields	2020 - 2022 (PY) (Average)		
	The number of adjusted top 10% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
China	64,138	31.8	1
U.S.	34,995	17.4	2
U.K.	8,850	4.4	3
India	7,192	3.6	4
Germany	7,137	3.5	5
Italy	6,943	3.4	6
Australia	5,151	2.6	7
Canada	4,654	2.3	8
Korea	4,314	2.1	9
France	4,083	2.0	10
Spain	3,991	2.0	11
Iran	3,882	1.9	12
Japan	3,719	1.8	13
Netherlands	2,878	1.4	14
Saudi Arabia	2,140	1.1	15
Brazil	2,131	1.1	16
Switzerland	2,071	1.0	17
Türkiye	2,052	1.0	18
Egypt	1,826	0.9	19
Pakistan	1,696	0.8	20

All fields	2020 - 2022 (PY) (Average)		
	The number of adjusted top 1% papers		
Country/Region	Fractional counting		
	Papers	Share	World rank
China	6,582	32.7	1
U.S.	4,070	20.2	2
U.K.	1,031	5.1	3
Germany	717	3.6	4
Italy	561	2.8	5
India	560	2.8	6
Australia	555	2.8	7
Canada	480	2.4	8
France	379	1.9	9
Korea	354	1.8	10
Spain	351	1.7	11
Japan	311	1.5	12
Netherlands	300	1.5	13
Iran	295	1.5	14
Switzerland	227	1.1	15
Singapore	207	1.0	16
Saudi Arabia	199	1.0	17
Türkiye	170	0.8	18
Pakistan	157	0.8	19
Sweden	150	0.7	20

Note: The number of articles and reviews was counted. Publication year (PY) was used for the year tally. The number of citations is the value at the end of 2023.
Reference: Chart 4-1-6(B), Japanese Science and Technology Indicators 2024 (in Japanese)

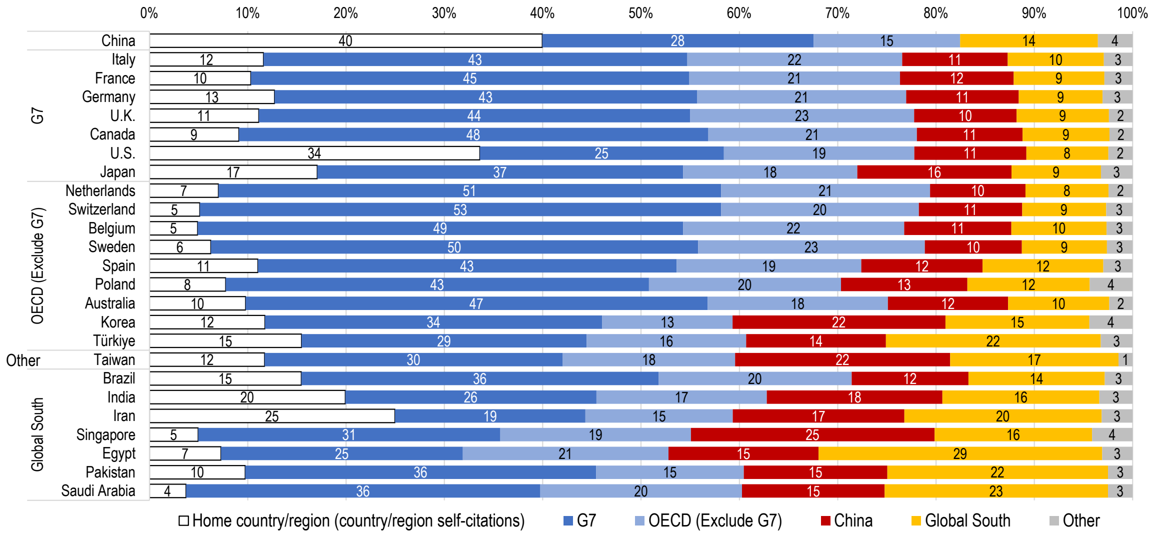
(2) The citation structure of papers has changed over the past two decades, and the presence of China and the Global South has increased.

In the citation structure of the top 25 countries/regions in the adjusted top 10% papers in 2020-2022, China has the largest citation share from China, i.e., country self-citations, with the share rising from 40% in 2000-2002 to 62% in 2020-2022.

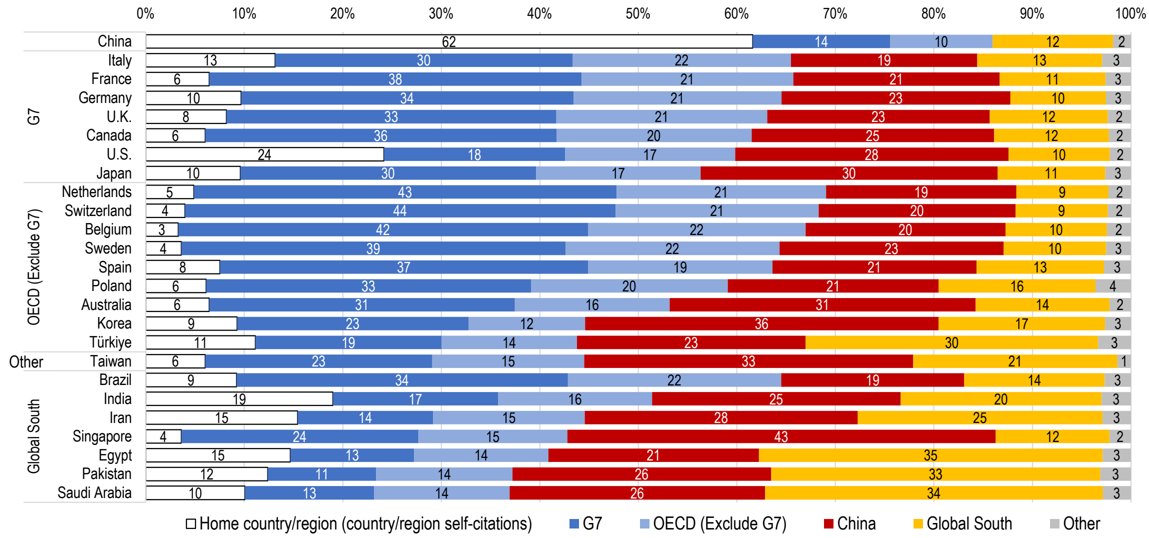
In the latter period, the percentage of country self-citations tends to be large in the U.S., India, Iran, and Egypt. In Iran, Egypt, Pakistan, and Saudi Arabia, about 70% of the citations to the adjusted top 10% papers were country/region self-citations and citations from China and Global South countries.

[Summary Chart 12] Citation structure of the top 25 countries/regions in the number of adjusted top 10% papers

(A)2000-2002 (PY)



(B)2020-2022 (PY)



Notes:
1) The number of articles and reviews was counted. Publication year (PY) was used for the year tally. Citation counts are analyzed by the fractional counting.
2) The citation structure of the adjusted top10% papers was analyzed for the top 25 countries/regions, ranked by the number of adjusted top 10% papers (fractional counting, 2020-2022 average).
3) Citations from the "Home country/region (country/region self-citations)" are included in the country self-citations and excluded from other applicable categories.
4) Countries and regions of the Global South are those participating in the Voice of the Global South Summit 2023 (https://mea.gov.in/voice-of-global-summit.htm) and the Group of 77 (G-77, http://www.fc-ssc. org/en/partnership_program/south_south_countries).

Reference: Column Chart 5-2, Japanese Science and Technology Indicators 2024 (in Japanese)

(3) Over the past twenty years, the presence of China and Global South countries has increased alongside G7 and OECD countries in the production and exchange of scientific knowledge, leading to a shift in the meaning of highly cited papers.

The position of each country/region is plotted from the citation count structure (Summary Chart 13). A positive value means that the G7 and OECD countries account for a large percentage of citations in the citation structure. In contrast, a negative value means that China and the Global South countries account for a large percentage of citations. In Summary Chart 13, the percentages of country/region self-citations shown in Summary Chart 12 are included in the relevant category.

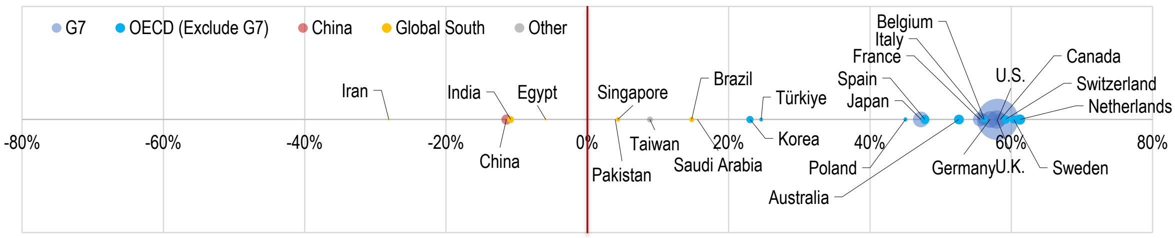
In 2000–2002, the G7 and OECD countries/regions had many adjusted top 10% papers, and their position in the citation structure was on the right-hand (positive) side. In other words, G7 and OECD countries played a major role in producing and exchanging scientific knowledge.

In 2020–2022, China and the Global South countries/regions increased in size, and their position in the citation structure was on the left-hand (negative) side. The positions for G7 and OECD countries/regions were also shifting toward the left-hand (negative) side. These results suggest an increasing presence of China and Global South countries in the production and exchange of scientific knowledge over the past two decades, as well as a shift in the meaning of highly cited papers.

[Summary Chart 13]　Position of the top 25 countries/regions in the citation structure

(A)2000-2002（PY）

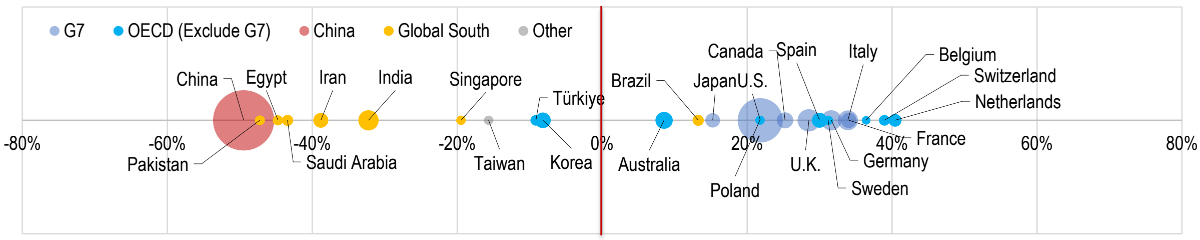
←Large percentage of citations from China and Global South countries　　Large percentage of citations from G7 and OECD countries →



Position of each country/region ＝
Total percentage of citations from G7 and OECD countries – Total percentage of citations from China and Global South countries

(B)2020-2022（PY）

←Large percentage of citations from China and Global South countries　　Large percentage of citations from G7 and OECD countries →



Position of each country/region ＝
Total percentage of citations from G7 and OECD countries –Total percentage of citations from China and Global South countries

Notes:
1）The citation structure of the adjusted top 10% papers was analyzed for the top 25 countries/regions, ranked by the number of adjusted top 10% papers (fractional counting, 2020-2022 average). Publication year (PY) was used for the year tally.
2）The position of each country/region was calculated by subtracting the total percentage of citations from China and Global South countries from the total percentage of citations from G7 and OECD countries. In this calculation, the percentages for country/region self-citations shown in Summary Chart 12 were included in the relevant category.
3）The area of the circles in the chart represents the number of adjusted top 10% papers for each country/region during the relevant period.
Reference: Column Chart 5-3, Japanese Science and Technology Indicators 2024 (in Japanese)

(4) The world's ranking of adjusted top 10% papers varies depending on which country's or region's citation counts are considered.

A trial count of the number of adjusted top 10% papers based on citations from the U.S. shows that Japan's world rank for 2020-2022 is ninth. The rank is higher than the 13th, as shown in Summary Chart 11, where citations from all countries/regions are counted. On the other hand, the world ranks of countries such as India and Iran fell significantly below the rankings shown in the same chart. Additionally, Saudi Arabia, Egypt, and Pakistan were outside the top 20.

The changes in the ranking are because the papers from Global South counties/regions are mainly cited by countries/regions other than the United States, as shown in Summary Tables 12 and 13. Consequently, the world's ranking of the number of adjusted top 10% papers will vary depending on which country or region's citation counts are considered.

[Summary Chart 14] World rank of adjusted top 10% papers using number of citations from the U.S. only

All fields	2020 ― 2022 (PY) (Average) The number of adjusted top 10% papers using number of citations from the U.S. only			
Country/Region	Fractional counting			
	Papers	Share	World rank	
U.S.	98,510	48.9	1	
China	24,833	12.3	2	
U.K.	8,834	4.4	3	
Germany	7,405	3.7	4	
Canada	5,734	2.8	5	
Italy	4,713	2.3	6	
Australia	4,425	2.2	7	
France	4,216	2.1	8	
Japan	3,237	1.6	9	
Korea	3,157	1.6	10	
Spain	3,067	1.5	11	
India	2,863	1.4	12	
Netherlands	2,817	1.4	13	
Switzerland	2,435	1.2	14	
Sweden	1,550	0.8	15	
Brazil	1,466	0.7	16	
Iran	1,296	0.6	17	
Singapore	1,240	0.6	18	Saudi Arabia : No. 28
Belgium	1,239	0.6	19	Egypt : No. 38
Denmark	1,202	0.6	20	Pakistan : No.39

Notes:
1) The number of citations from the U.S. was calculated using the fractional count method. Using the number of citations from the U.S. only, the number of papers in the top 10% of each field (22 fields) in each year was identified and then adjusted to 1/10 of the actual number.
2) Publication year (PY) was used for the year tally.
Reference: Column Chart 5-4(B), Japanese Science and Technology Indicators 2024 (in Japanese)

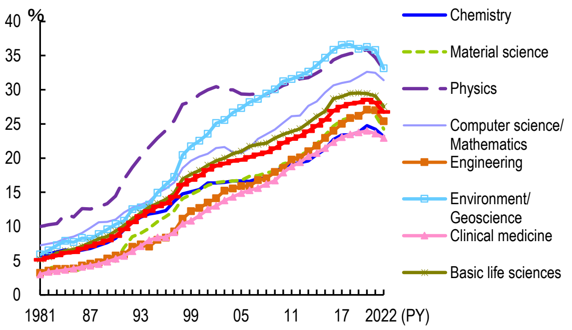
(5) The percentage of international co-authored papers had been on an upward trend but has been declining in all fields since around 2020. Among selected countries, the decline in China is significant.

Looking at the percentages of international co-authored papers as of 2022 for each field, “Environment/Geosciences” and “Physics” have higher percentages than other fields, at 33.1% and 32.9%, respectively. The percentage of internationally co-authored papers is the lowest in “Clinical Medicine” at 22.9%. The percentage of internationally co-authored papers has been decreasing in all fields from around 2020.

Looking at the selected countries, the U.S. and Germany have remained flat since around 2020, while Japan and France have declined slightly after peaking in 2020. China has been declining since 2018. Especially in 2022, China was down 3.4 points from the previous year.

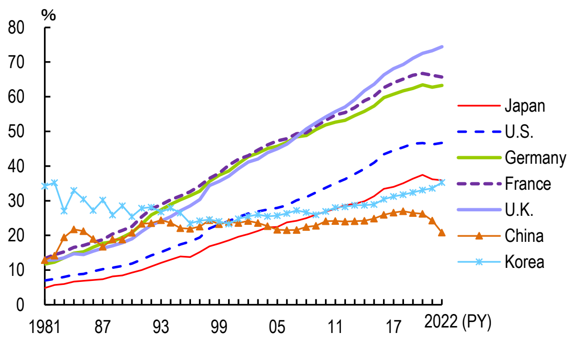
[Summary Chart 15] Percentage of international co-authored papers

(A) Trends by fields



Reference: Chart 4-1-4(A), Japanese Science and Technology Indicators 2024 (in Japanese)

(B) Trends by selected countries



Reference: Chart 4-1-3, Japanese Science and Technology Indicators 2024 (in Japanese)

Note: The number of articles and reviews was counted. Publication year (PY) was used for the year tally.

(6) Japan has maintained the 1st position in the world in the number of patent families (patents filed in two or more countries/regions).

This section examines the status of patent applications by analyzing the number of patent families, which is the number of inventions created in each country/region measured in an internationally comparable manner.

Between 1997 and 1999, the United States was ranked first, and Japan was second. Between 2007 and 2009 and between 2017 and 2019, Japan was ranked first, and the United States was ranked second.

Note that Japan's global share has been declining since the mid-2000s, and that China was in the third place in 2017–2019, steadily increasing the number of patent families.

[Summary Chart 16] The number of patent families by selected countries/region: top 10 countries/regions

1997 - 1999(Average)			
Country/Region	Number of patent families (Whole counting)		
	Patent Families	Share	World rank
U.S.	35,042	27.6	1
Japan	34,410	27.1	2
Germany	22,419	17.6	3
France	8,014	6.3	4
U.K.	6,880	5.4	5
Korea	4,827	3.8	6
Italy	3,592	2.8	7
Netherlands	3,085	2.4	8
Switzerland	2,859	2.3	9
Canada	2,845	2.2	10

2007 - 2009(Average)			
Country/Region	Number of patent families (Whole counting)		
	Patent Families	Share	World rank
Japan	58,426	29.2	1
U.S.	44,460	22.3	2
Germany	27,603	13.8	3
Korea	17,179	8.6	4
France	10,564	5.3	5
China	10,320	5.2	6
Taiwan	9,813	4.9	7
U.K.	8,140	4.1	8
Canada	5,219	2.6	9
Italy	5,122	2.6	10

2017 - 2019(Average)			
Country/Region	Number of patent families (Whole counting)		
	Patent Families	Share	World rank
Japan	67,082	25.5	1
U.S.	56,987	21.7	2
China	36,363	13.8	3
Germany	28,199	10.7	4
Korea	23,071	8.8	5
Taiwan	11,346	4.3	6
France	11,184	4.3	7
U.K.	8,734	3.3	8
Italy	5,461	2.1	9
Canada	5,454	2.1	10

Note:
Reference: Chart 4-2-5(B), Japanese Science and Technology Indicators 2024 (in Japanese)

(7) Japan's technology (patent families) cites scientific achievements (scientific papers) at a lower rate compared to other countries. The proportion of Japanese scientific papers cited by global technology is about the global average.

To examine the linkage between science and technology, information on papers cited by patent families (the total in the 2012–2019 period) was analyzed. Japan ranks second in the world regarding the number of patent families that cite papers. However, the number of Japanese patent families that cite papers accounts for only 6.7% of its total patent families.

The number of Japanese papers cited by patent families during the 2012-2019 period (the total in the 1981–2019 period) is the fourth highest in the world. The ratio of the number of Japanese papers cited in patent families to the total number of papers is 3.2%, about the average for the countries/regions shown here.

[Summary Chart 17] The number of patent families that are citing papers: top 10 countries/regions

Whole counting		2012–2019 (Total)			
		(A) Patent families citing papers		(B) Total number of patent families	
No.	Country / Region	No. of patent families	Global share of (A)	No. of patent families	Percentage of patent families citing papers (A) / (B)
1	U.S.	103,877	31.2	439,178	23.7
2	Japan	34,328	10.3	513,862	6.7
3	Germany	27,808	8.4	221,303	12.6
4	China	21,239	6.4	217,114	9.8
5	France	18,038	5.4	89,373	20.2
6	U.K.	16,338	4.9	69,443	23.5
7	Korea	16,010	4.8	184,767	8.7
8	Canada	9,474	2.8	43,033	22.0
9	Netherlands	9,013	2.7	34,895	25.8
10	Switzerland	8,000	2.4	31,797	25.2

Reference: Chart 4-3-2, Japanese Science and Technology Indicators 2024 (in Japanese)

[Summary Chart 18] The number of papers that are cited by patent families: top 10 countries/regions

Whole counting		1981-2019 (Total)			
		(C) Papers cited by patent families		(D) Total number of papers	
No.	Country / Region	No. of papers	Global share of (C)	No. of papers	Percentage of papers cited by patent families (C) / (D)
1	U.S.	440,247	33.7	9,652,700	4.6
2	U.K.	90,139	6.9	2,569,158	3.5
3	Germany	88,118	6.8	2,557,871	3.4
4	Japan	76,517	5.9	2,382,581	3.2
5	China	74,195	5.7	3,628,413	2.0
6	France	57,003	4.4	1,846,020	3.1
7	Canada	48,660	3.7	1,452,528	3.4
8	Italy	40,991	3.1	1,368,242	3.0
9	Netherlands	34,210	2.6	791,345	4.3
10	Korea	29,564	2.3	839,228	3.5

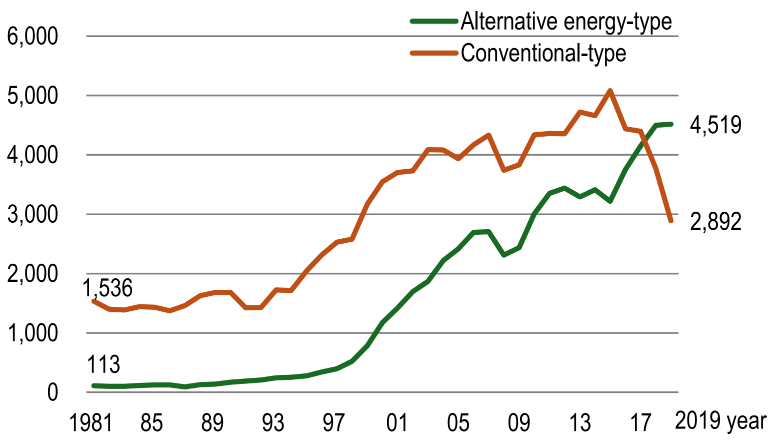
Reference: Chart 4-3-3, Japanese Science and Technology Indicators 2024 (in Japanese)

(8) The number of alternative energy-type patent families useful for the development of electric vehicles has continued to grow since the late 1990s, surpassing the number of conventional-type patent families useful for gasoline engines in 2018. Alternative energy technologies are more closely related to scientific knowledge than conventional technologies.

The number of conventional patent families grew since the mid-1990s before peaking in 2015 and beginning to decline. The number of alternative energy patent families has continued to grow since the late 1990s, surpassing the number of conventional patent families in 2018, reaching 4,519 in 2019.

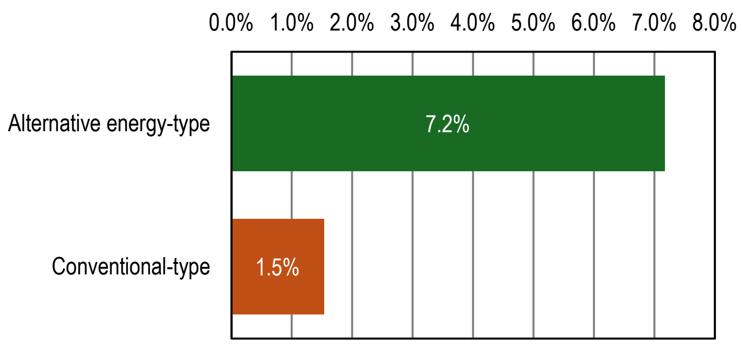
The percentage of patent families citing papers stands at 7.2% for alternative energy-type technologies and 1.5% for conventional technologies. This indicates that the connection with scientific knowledge is stronger for alternative energy-type technologies than for conventional technologies.

[Summary Chart 19] Number of patent families for alternative energy-type and conventional-type technologies



Reference: Column Char 6-2(A), Japanese Science and Technology Indicators 2024 (in Japanese)

[Summary Chart 20] Percentage of patent families citing papers



Reference: Column Char 6-5, Japanese Science and Technology Indicators 2024 (in Japanese)

Note: Patents related to the automotive industry were analyzed. Alternative energy-type technologies are those that are useful for the development of electric vehicles, etc. Conventional-type technologies are those that are useful for gasoline engines. For specific technology classifications, please refer to Column Chart 6-1 in Chapter 4 of this report (in Japanese).

(9) In many countries and regions, the number of alternative energy patent families has increased over the past ten years, while the number of conventional patent families has decreased.

Regarding the number of alternative energy-type patent families, Japan ranks first in the world for 2017–2019. Many countries/regions have increased the number of patent families over the past ten years, with China showing a particularly significant increase. Regarding the number of conventional-type patent families, Japan is the leader in 2017–2019. The decrease rate is particularly high in Germany and Italy.

[Summary Chart 21] Number of patent families for alternative energy-type and conventional-type technologies: Top 12 countries/regions

(A) Alternative energy-type

2007 - 2009(Average)				2017 - 2019(Average)			
Number of patent families (Whole counting)				Number of patent families (Whole counting)			
Country/Region	Patent Families	Share	World rank	Country/Region	Patent Families	Share	World rank
Japan	1,060	42.7	1	Japan	1,615	36.8	1
U.S.	519	20.9	2	Germany	837	19.1	2
Germany	355	14.3	3	U.S.	676	15.4	3
Korea	223	9.0	4	Korea	481	11.0	4
France	118	4.7	5	China	253	5.8	5
Taiwan	65	2.6	6	France	203	4.6	6
U.K.	47	1.9	7	U.K.	85	1.9	7
China	47	1.9	8	Austria	69	1.6	8
Canada	45	1.8	9	Italy	68	1.6	9
Italy	33	1.3	10	Sweden	67	1.5	10
Sweden	23	0.9	11	Canada	58	1.3	11
Austria	19	0.8	12	Taiwan	42	1.0	12

(B) Conventional-type

2007 - 2009(Average)				2017 - 2019(Average)			
Number of patent families (Whole counting)				Number of patent families (Whole counting)			
Country/Region	Patent Families	Share	World rank	Country/Region	Patent Families	Share	World rank
Japan	1,487	37.5	1	Japan	1,365	37.0	1
Germany	1,034	26.1	2	U.S.	745	20.2	2
U.S.	772	19.5	3	Germany	697	18.9	3
France	215	5.4	4	Korea	222	6.0	4
Italy	129	3.3	5	France	188	5.1	5
U.K.	113	2.9	6	U.K.	106	2.9	6
Korea	105	2.6	7	Italy	94	2.6	7
Austria	77	1.9	8	China	77	2.1	8
Sweden	60	1.5	9	Austria	67	1.8	9
Canada	46	1.2	10	Sweden	64	1.7	10
Switzerland	39	1.0	11	Canada	52	1.4	11
China	34	0.8	12	India	49	1.3	12

Note: Patents related to the automotive industry were analyzed. Alternative energy-type technologies are those that are useful for the development of electric vehicles, etc. Conventional-type technologies are those that are useful for gasoline engines. For specific technology classifications, please refer to Column Chart 6-1 in Chapter 4 of this report (in Japanese).
Reference: Column Char 6-3, Japanese Science and Technology Indicators 2024 (in Japanese)

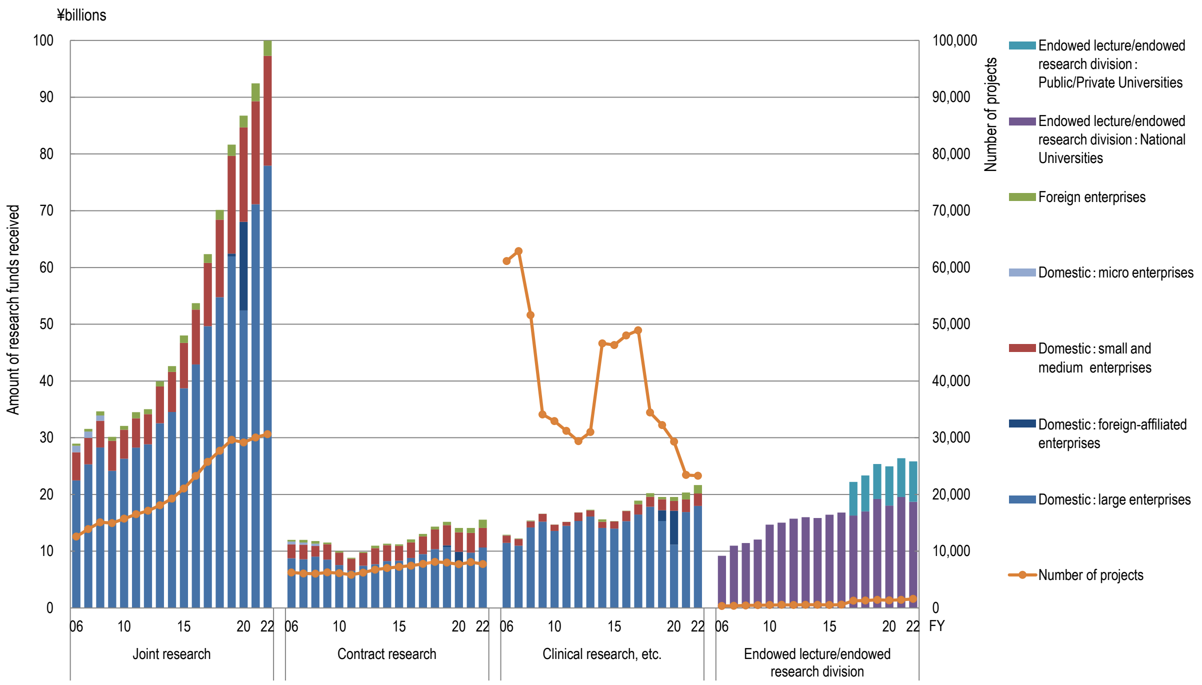
4. Status of Science, Technology and Innovation

(1) The amount of "joint research" between Japanese universities and private business enterprises has continuously increased, reaching 100 billion yen in FY2022.

Among the changes in the funds received and the number of projects with private business enterprises, "joint research" is the largest in the amount (100 billion yen) and the number (31,000) of projects, respectively, in FY2022. Joint research projects are largely funded by large enterprises, amounting to 77.9 billion yen in the same fiscal year. Concerning "joint research" and "contract research," the "ratio of indirect expenses to direct expenses" has been steadily increasing. Comparing FY2006 and FY2022, joint research increased significantly from 8.5% to 24.5% (19.7 billion yen), and contract research from 10.1% to 19.6% (2.6 billion yen).

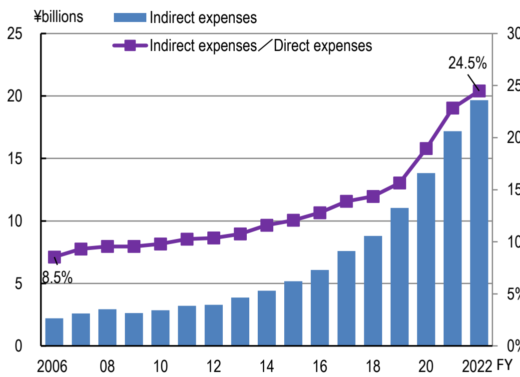
[Summary Chart 22] Changes in the funds received (breakdown) and number of projects implemented for joint research, etc., by Japanese universities and private business enterprises, etc.

(A) Changes in the amount of funds received (breakdown) and number of projects implemented

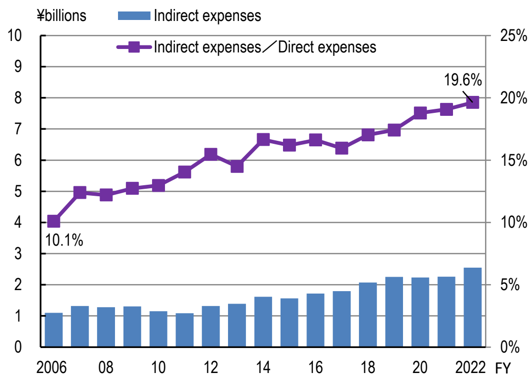


(B) Status of indirect expenses

(a)Joint research



(b)Contract research



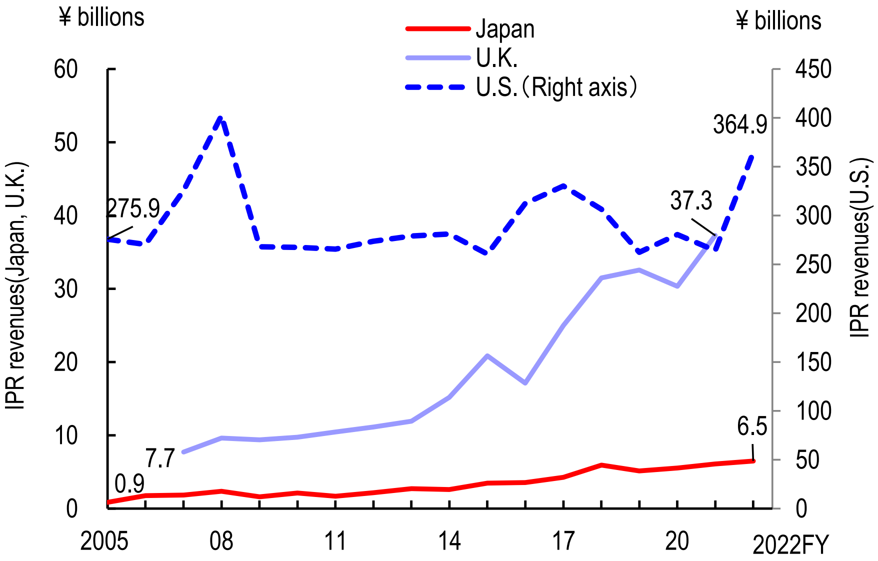
Notes:
1) Joint research: Joint research and development by institutions and private business enterprises, etc., in which the other party bears the expenses. Until FY2008, the amount of funding and the number of projects were classified according to the size of the enterprises - small and medium, micro and large enterprises.
2) Contract research: R&D conducted primarily by universities, etc., under a commission from private business enterprises, etc., the costs of which are paid for by the private business enterprises, etc.
3) Clinical research, etc.: Clinical research on pharmaceuticals and medical equipment, etc., conducted primarily and independently by universities, etc., based on a contract with outside parties, the costs of which are paid for by the consignee. Clinical research includes histopathological examination outside the range of clinical research as well as similar tests and surveys.
4) Endowed lecture/endowed research division: Values shown are only for national universities.
5) Regarding the breakdown of domestic enterprises, data have been available for large enterprises, small and medium enterprises, and micro enterprises from 2006. However, data of micro enterprises was provided only up to FY2008, and data of foreign-affiliated enterprises only in FY2019 and FY2020.
6) Direct expenses are those expenses that are directly required for the joint research, and indirect expenses are those expenses for promoting industry-academia collaboration, expenses other than direct expenses, and administrative expenses.

Reference: Chart 5-4-5, Japanese Science and Technology Indicators 2024 (in Japanese)

(2) Revenues from intellectual property rights at Japanese universities have been increasing over the long term, about sevenfold from FY2005 to FY2022.

Intellectual Property Rights (IPR) revenues at Japanese universities have been increasing over the long term, reaching 6.5 billion yen in FY2022, about seven times higher than in FY2005. IPR revenues in the U.K. has been increasing over the long term, reaching 37.3 billion yen in the most recent year. IPR revenues in the United States are much higher than those in Japan and the U.K., amounting to 364.9 billion yen in FY2022. In the long term, except for a temporary increase in FY 2008, the amount had been hovering around 300 billion yen, but grew significantly in the latest year.

[Summary Chart 23] Trends in IPR revenues in Japan, the U.S., and the U.K.



Notes:
1) Intellectual property rights in Japan include patent rights, utility model rights, design rights, trademark rights, copyrights, other intellectual property (breeder's rights, layout design exploitation rights, etc.), know-how, etc., and tangible objects (materials, etc.).
2) Intellectual property rights in the U.S. include running royalties, license income, license issuance fees, option-based payments, end-user licenses for software and biological substances (over $1 million), etc.
3) Intellectual property rights in the U.K. include patent rights, copyrights, designs, trademarks, etc.

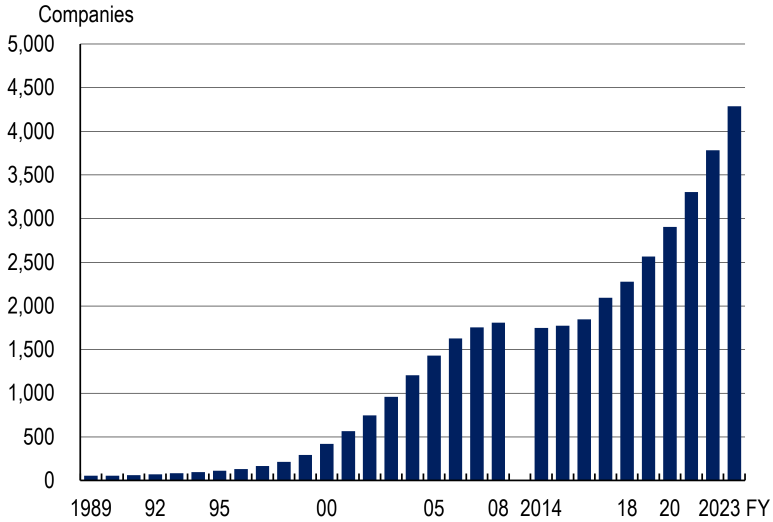
Reference: Chart 5-4-7, Japanese Science and Technology Indicators 2024 (in Japanese)

(3) PhD holders account for a large percentage of employees in Japan's university-launched venture companies.

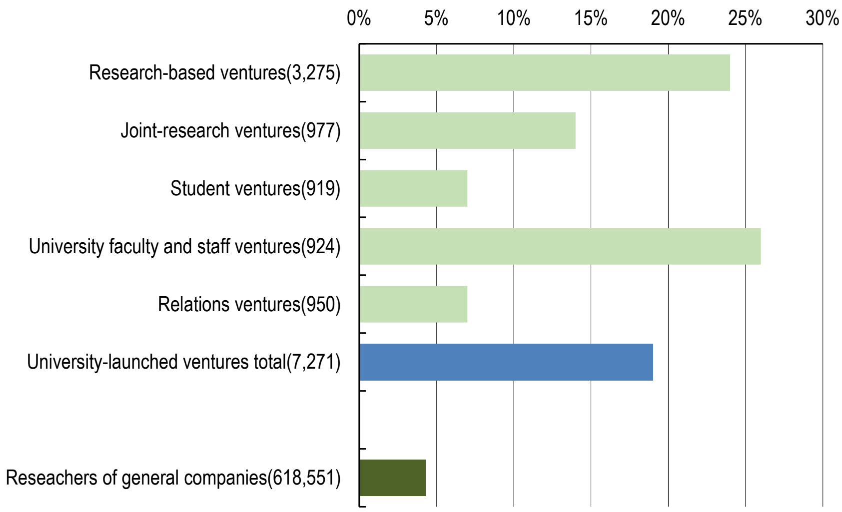
The number of university-launched venture companies in Japan is steadily increasing, with 4,288 companies (cumulative value) in FY2023, a 2.5-fold increase compared to FY2014. PhD holders account for 19% of the total number of employees in university-launched venture companies, substantially higher than the percentage of PhD holders among researchers in general companies (4%).

[Summary Chart 24] The status of university-launched venture companies

(A) Changes in the number of university-launched venture companies



(B) Percentage of PhD holders among the employees by venture category (FY2023 survey)



Notes:

1) Summary Chart 24(B) is sourced from the Survey on University-Developed Venture Businesses (2024), showing the results of the survey of university-launched venture companies identified in the "Survey on the Establishment of University-Developed Venture Businesses (2024)," of which contact information was available (682/4,288 cases were collected, for a response rate of 15.9%).
2) Figures in parentheses ( ) are the number of employees, and the number of researchers for the figure of "researchers of general companies." Technology-transfer ventures are not listed due to the small number of employees.

Reference: Chart5-4-8(A),10(A), Japanese Science and Technology Indicators 2024 (in Japanese)

Characteristics of the Japanese Science and Technology Indicators

"The Japanese Science and Technology Indicators" is published annually to present the most recent statistics/indicators at the time of publication. The statistics/indicators are selected considering the following two conditions: 1) the indicators should allow either of the time-series comparison or the comparison among selected countries and 2) the indicators should be able to be updated annually in principle.

NISTEP conducted analysis of paper and patent databases

Paper data were aggregated and analyzed by NISTEP using Web of Science provided by Clarivate Analytics. Patents family data were aggregated and analyzed by NISTEP using PATSTAT (the patent database of the European Patent Office).

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 are collected in line with the OECD's manuals. However, differences in methods or scope of collecting data 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 chronological trends are marked "attention to trend." Specifics for such points requiring attention are provided in the notes of individual charts.

To download the collection of statistics (numerical data for the graphs in this report)

The numerical data for the graphs in this report can be downloaded from the following URL or QR code.

https://www.nistep.go.jp/research/indicators

The references shown below the summary charts in this report indicate the table numbers in the collection of statistics.

RESEARCH MATERIAL No. 341

Digest of Japanese Science and Technology Indicators 2024

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