Chapter 1 Japan's Current State of Research Capacity and the Challenges Faced in Research

In recent years, it has been pointed out that Japan's research capacity has declined. The number of Japanese Nobel laureates in the natural sciences ranks No. 2 in the world, following the United States; however, this number does not necessarily represent the present research capacity of Japan. The number of papers published, which is a major indicator of research capacity, has been declining in international comparison since the first half of the 2000s. Although research capacity cannot be judged solely on quantitative indicators, such a situation must be taken seriously.

In this chapter, we will analyze Japan's current state of research capacity and the challenges faced in research in comparison to major countries, based on trends in various data, such as the number of papers, number of papers attracting attention, number of researchers at universities, etc. that influences the production of papers, the ratio of time spent on research by researchers, and R&D expenditures.

Nobel Prizes Awarded to Japanese Nationals

Dr. Syukuro Manabe (Senior Meteorologist, Princeton University, Fellow of Japan Agency for Marine-Earth Science and Technology) was selected for the Nobel Prize in Physics along with Dr. Klaus Hasselmann and Dr. Giorgio Parisi on October 5, 2021. Dr. Manabe is Japan's 28th Nobel laureate and the 12th in Physics.

The Nobel Prize is an international award administered according to the last will of Alfred Nobel. As shown in Table 1-1-1, since 1949, when Dr. Hideki Yukawa won the Physics Prize, a total of twenty-five people in Japan have won the Nobel Prize in the natural sciences (Physiology/Medicine, Physics and Chemistry). In this century, Japan ranks No. 2 (19 Nobel laureates) in the world following the U.S., indicating a significant presence.

■ Table 1-1-1/ Japanese Nobel laureates (in natural sciences)

Year	Name	Category	Prize-Winning Work
1949	Hideki Yukawa	Physics prize	Prediction of the existence of mesons on the basis of theoretical work on nuclear forces
1965	Shinichiro Tomonaga	Physics prize	Fundamental work in quantum electrodynamics, with deep-ploughing consequences for the physics of elementary particles
1973	Leo Esaki	Physics prize	Experimental discoveries regarding tunneling phenomena in semiconductors and superconductors
1981	Kenichi Fukui	Chemistry prize	Theories concerning the course of chemical reactions
1987	Susumu Tonegawa	Physiology/ Medicine prize	Discovery of the genetic principle for antibody diversity
2000	Hideki Shirakawa	Chemistry prize	Discovery and development of conductive polymers
2001	Ryoji Noyori	Chemistry prize	Work on asymmetric reactions with chiral catalyst
2002	Masatoshi Koshiba	Physics prize	Pioneering contributions to astrophysics, in particular for the detection of cosmic neutrinos
2002	Koichi Tanaka	Chemistry prize	Development of methods for identification and structural analysis of biological macromolecules
2008	Yoichiro Nambu	Physics prize	Discovery of spontaneous broken symmetry in subatomic physics
2008	Makoto Kobayashi	Physics prize	Contribution to particle physics through the discovery of the origin of the Kobayashi-Maskawa theory and CP symmetry violation
2008	Toshihide Maskawa	Physics prize	
2008	Osamu Shimomura	Chemistry prize	Discovery and development of the Green Fluorescent Protein (GFP)
2010	Eiichi Negishi	Chemistry prize	Development of palladium-catalyzed cross-couplings in organic synthesis
2010	Akira Suzuki	Chemistry prize	
2012	Shinya Yamanaka	Physiology/ Medicine prize	Discovery that mature cells can be reprogrammed to become pluripotent
2014	Isamu Akasaki	Physics prize	Invention of efficient blue light-emitting diodes which has enabled bright and energy-saving white light sources
2014	Hiroshi Amano	Physics prize	
2014	Shuji Nakamura	Physics prize	
2015	Satoshi Ōmura	Physiology/ Medicine prize	Discovery concerning a novel therapy against infections caused by roundworm parasites
2015	Takaaki Kajita	Physics prize	Discovery of neutrino oscillations, proof that neutrinos have mass
2016	Yoshinori Ohsumi	Physiology/ Medicine prize	Discoveries of mechanisms for autophagy
2018	Tasuku Honjo	Physiology/ Medicine prize	Discovery of cancer therapy by inhibition of negative immune regulation
2019	Akira Yoshino	Chemistry prize	Development of lithium-ion batteries
2021	Syukuro Manabe	Physics prize	Research on the physical modelling of Earth's climate, quantifying variability and reliably predicting global warming

Created by MEXT

Dr. Syukuro Manabe's 2021 Nobel Prize in Physics

Dr. Manabe was the first person to successfully develop a model of the Earth's climate by incorporating atmospheric and oceanic motions involved in the prediction of global warming. Changes in the Earth's climate are a phenomenon where there is a movement of heat and water between the atmosphere, land and oceans, and complex changes occur with time. Dr. Manabe expressed this complex relationship using a simple formula and performed computations using a computer for the first time in the world. In his paper published in 1967, Dr. Manabe revealed a prediction for the first time in the world that a two-fold increase in the carbon dioxide levels in the Earth's atmosphere causes the average temperature of the Earth to rise by approximately 2.3°C and that increased levels of carbon dioxide would lead a rise in global temperatures. This climate model is used as the foundation for the current global climate change measures. For example, the model was adopted for the prediction of global warming in the First Assessment Report on Climate Change by the Intergovernmental Panel on Climate Change (IPCC) and also influenced the "Paris Agreement" that was adopted as the international framework in the "21st session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 21[1])" held in 2015.

During a dialogue with MEXT Minister Suematsu after the award presentation, there was a message from Dr. Manabe to children and students in which he said, "This (geophysics) is a fascinating field, and I hope more students join this field" and "Do what you like, and success will follow." Dr. Manabe's research results are used not only for understanding global warming, which has become a global challenge, but also for weather forecasting, which is a part of our daily lives. Japan draws great pride and encouragement from Dr. Manabe's work.

■ Figure 1-1-2/ Minister Suematsu congratulates Nobel Prize winner in physics, Syukuro Manabe, via videoconference (October 2021).

This video contains a message to children and students from Dr. Manabe, who won the Nobel Prize in Physics for the development of the climate model involved in the prediction of global warming.

Minister Suematsu congratulates Nobel Prize winner in Physics, Syukuro Manabe, via videoconference

1 Conference of the Parties

URL: https://www.youtube.com/watch?v=zSpskuBRUkc

Section 1 Paper Index[1]

In recent years, the number of papers, a major indicator of research capacity, has been declining in international comparison. According to a survey by the National Institute of Science and Technology Policy (NISTEP) of the MEXT, factors behind the stagnation of the number of papers in Japanese universities since the first half of the 2000s include a decline in the ratio of time spent on research by university faculty members, slow growth in the number of university faculty members, stagnation of the number of doctoral course students, and stagnation of expenditures on research implementation, such as raw material costs. Chapters 3 and 4 introduce the latest initiatives toward realizing a science and technology nation.

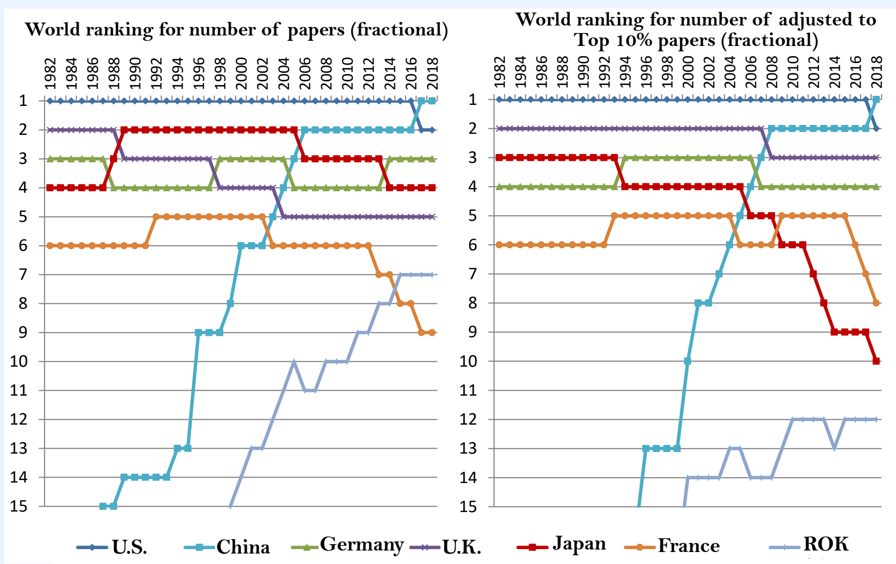
1 World Ranking in Number of Papers

Figure 1-1-3 shows the world ranking of major countries in the number of papers and number of papers attracting attention (highly cited by peers) (adjusted top 10% papers) in the field of natural sciences.

- Twenty years ago, Japan's number of papers ranked No. 2, following the United States (average of 1997 to 1999), but it ranks 4th today (average of 2017 to 2019), and the ranking has been dropping since the first half of the 2000s.
- Japan's number of adjusted top 10% papers, which was 4th 20 years ago, is now 10th.

■ Figure 1-1-3/ Changes in the world ranking of major countries for the number of papers and number of adjusted top 10% papers

Comparison with the year 2000 **Number of papers 2nd → 4th, Number of adjusted top 10% papers 4th → 10th**



Note 1: Articles and Reviews are included in the analysis and analyzed using the fractional counting method. Moving average over 3 years is shown; the 2018 world ranking is based on the average of 2017-2019.

Note 2: Number of top 10% of papers is the number of papers in the top 10% of each field (22 fields) during each year in terms of the number of citations of papers (2020 year-end figures). The number of adjusted top 10% papers is obtained by adjusting the Top 10% papers so that they total to one-tenth of all papers.
It has been aggregated by the NISTEP based on Clarivate Web of Science XML (SCIE, 2020 Year-end version).

Source: "Benchmarking Scientific Research 2021," the NISTEP, MEXT

1 Number of papers referred to in this section includes only the papers in the field of natural sciences.

Table 1-1-4 shows the top 10 countries in the number of papers and the number of adjusted top 10% papers based on the most recent aggregates.

- China, the U.S., Germany, and Japan are the top countries in terms of the number of papers.
- Japan was overtaken by India in the number of adjusted top 10% papers as per the most recent aggregates and dropped to 10th place.

■Table 1-1-4/ Number of papers and number of adjusted top 10% papers by country: top 10 countries (Fractional counting)

All fields	2017-2019 (PY) (Average)		
	Number of papers		
Country/ region name	Fractional counting		
	Number of papers	Share	Ranking
China	353,174	21.8	1
U.S.	285,717	17.6	2
Germany	68,091	4.2	3
Japan	65,742	4.1	4
U.K.	63,575	3.9	5
India	63,435	3.9	6
Rep. of Korea	50,286	3.1	7
Italy	47,772	2.9	8
France	44,815	2.8	9
Canada	42,188	2.6	10

All fields	2017-2019 (PY) (Average)		
	Number of adjusted top 10% papers		
Country/ region name	Fractional counting		
	Number of papers	Share	Ranking
China	40,219	24.8	1
U.S.	37,124	22.9	2
U.K.	8,687	5.4	3
Germany	7,248	4.5	4
Italy	5,404	3.3	5
Australia	4,879	3.0	6
Canada	4,468	2.8	7
France	4,246	2.6	8
India	4,082	2.5	9
Japan	3,787	2.3	10

Source: Prepared by MEXT based on the NISTEP "Japanese Science and Technology Indicators 2021"

Keyword

What are Whole Counting and Fractional Counting?

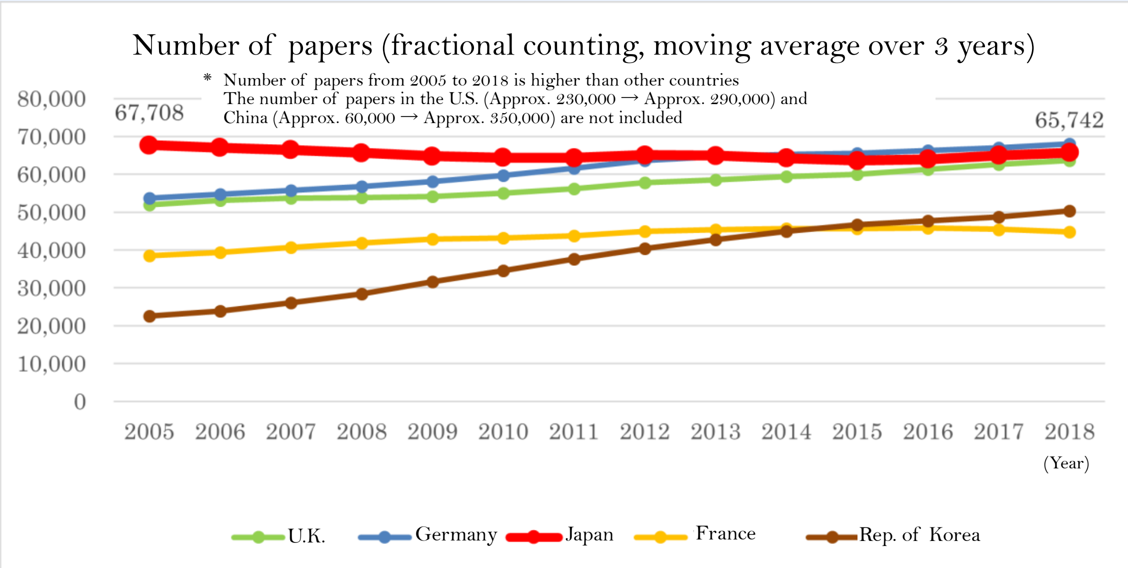
Whole counting and fractional counting are methods for counting papers. Whole counting is an aggregation by country based on the presence or absence of involvement. For example, in the case of a paper co-authored by University A in Japan, University B in Japan, and University C in the U.S., one paper is counted for each of Japan and the U.S. Thus, this method is used to measure "the degree of participation in the production of papers in the world (how much contribution was made to the process of producing papers)."While, fractional counting is an aggregation weighted at the institutional level. For example, if a paper is coauthored by University A in Japan, University B in Japan, and University C in the U.S., each institution is given a weight of one-third. The national total is two-thirds for Japan and one-third for the United States. Thus, this method is used to measure "the degree of contribution to the production of papers in the world (how much contribution was made for one paper)."

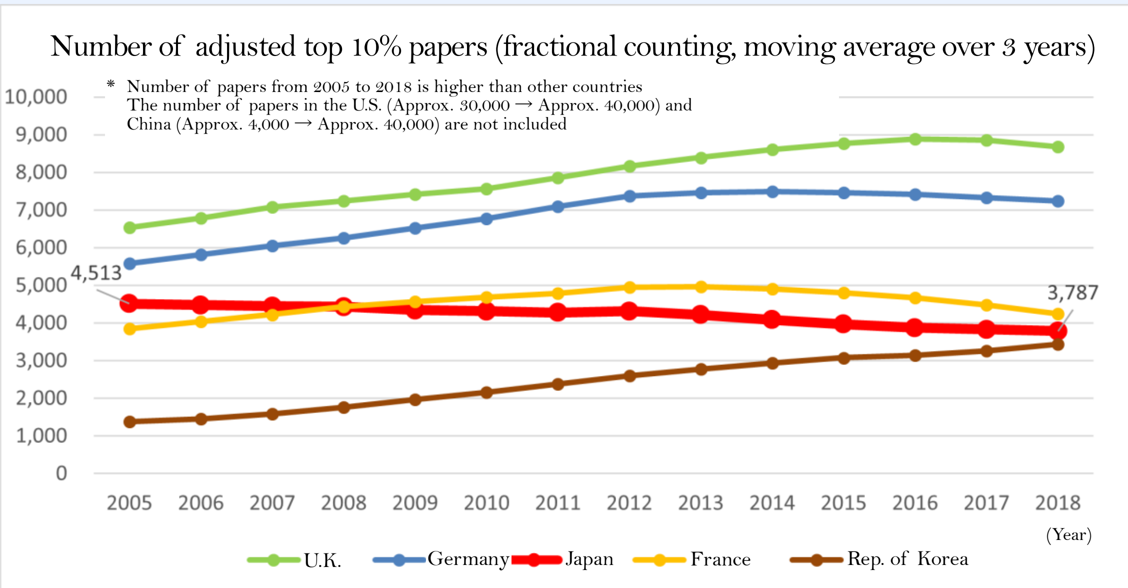
2 Changes in the Number of Papers and Number of Adjusted Top 10% Papers

Figure 1-1-5 shows the changes in the number of papers and number of adjusted top 10% papers (See Figure 1-1-36 for the ratio of the number of adjusted top 10% papers to the number of papers) (Q index)).

- The number of Japan's papers declined from 2005 to 2015, except for a temporary increase, and has slightly increased since then.
- The number of Japan's adjusted top 10% papers is consistently trending downward.

■ Figure 1-1-5/ Changes in the number of papers and number of adjusted top 10% papers of major countries (moving average over 3 years, fractional counting)





Source: Prepared by MEXT based on the NISTEP "Benchmarking Scientific Research 2021"

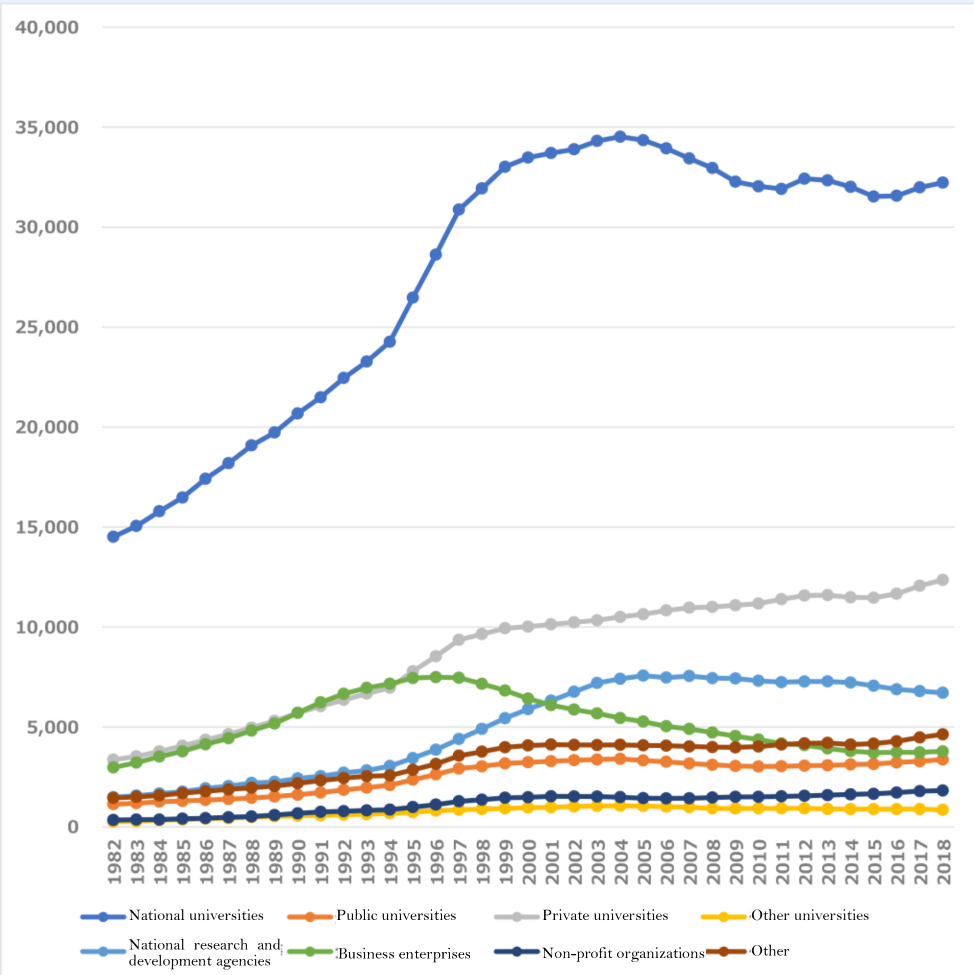
3 Changes in the Number of Papers by Type of Organization

Figure 1-1-6 shows the changes in the number of papers by type of organization.

- The number of papers published by national universities has been trending downward since the mid-2000s, with a slight increase from 2016.
- The number of papers published by private universities is consistently trending upward.
- The number of papers published by national research and development agencies has been on a slight downward trend since the mid-2000s.
- The number of papers published by business enterprises has been trending downward since 1996, 5 years after the collapse of the bubble economy.

As shown above, the number of papers published by private universities has consistently increased, while that of business enterprises has decreased since the mid-1990s, and that of national universities, national research and development agencies, etc., has decreased since the mid-2000s. There has been a slight increase in the number of papers published by national universities since 2016.

■ Figure 1-1-6/ Changes in Japan's number of papers by type of organization (moving average over 3 years, fractional counting)



Source: Prepared by MEXT based on the NISTEP "Benchmarking Scientific Research 2021"

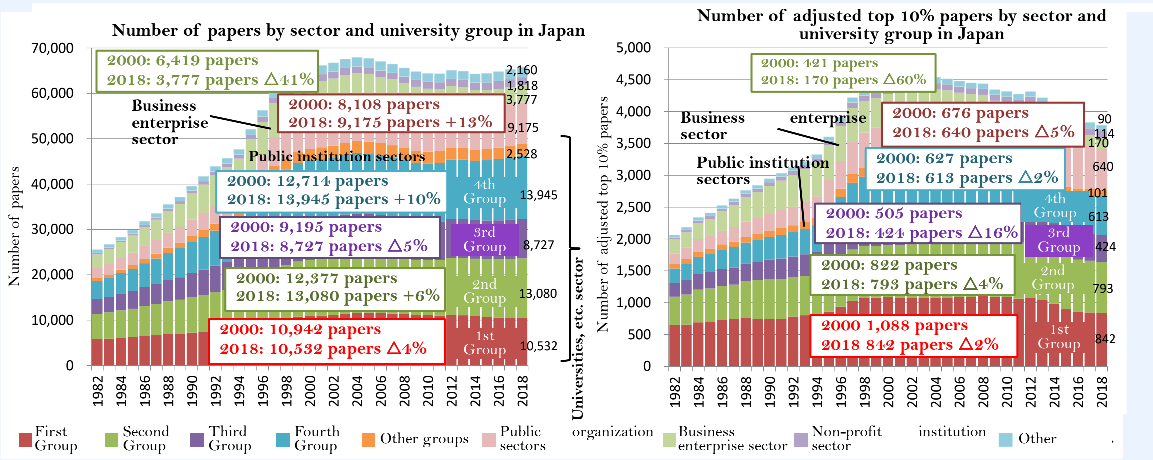
4 Number of Papers and Number of Adjusted Top 10% Papers by Sector and University Group

Figure 1-1-7 shows the breakdown of the number of papers and the number of adjusted top 10% papers by sector.

- Universities, etc. sector, produces over 70% of Japan's papers.
- When universities are grouped by their share of papers, there is a decrease in the number of papers in 2018 compared to 2000 for the First Group (top 4 universities) and the Third Group (mainly regional national universities). The number of adjusted top 10% papers has decreased for all groups, but the decrease is substantial for the First and Third Groups.

■ Figure 1-1-7/ Number of papers and number of adjusted top 10% papers by sector and university group in Japan

Share of the number of papers: Universities, etc. sector 74%, Public institution sector 14%, Business enterprise sector 6%
Share of the number of adjusted top 10% papers: Universities, etc. sector 73%, Public institution sector 17%, Business enterprise sector 4%



University group	Share of Papers	Number of Universities	Name of University
1st group	More than 1% (top 4 universities)	4	Osaka University, Kyoto University, The University of Tokyo, Tohoku University
2nd group	More than 1% ~ (excluding the top 4 universities)	14	Okayama University, Kanazawa University, Kyushu University, Kobe University, Chiba University, University of Tsukuba, Tokyo Medical and Dental University, Tokyo Institute of Technology, Nagoya University, Hiroshima University, Hokkaido University, Keio University, Nihon University, Waseda University
3rd group	More than 0.5% ~ less than 1%	26	Ehime University, Kagoshima University, Gifu University, Kumamoto University, Gunma University, Shizuoka University, Shinshu University, Tokyo University of Agriculture and Technology, Tokushima University, Tottori University, University of Toyama, Nagasaki University, Niigata University, Mie University, Yamagata University, Yamaguchi University, Osaka City University, Osaka Prefecture University, Tokyo Metropolitan University, Yokohama City University, Kitasato University, Kindai University, Juntendo University, Tokai University, Tokyo Women's Medical University, Tokyo University of Science
4th group	More than 0.05% ~ less than 0.5%	137	National universities: 37, Public universities: 18, Private universities: 82

Note 1: Articles and Reviews are included in the analysis and analyzed using the fractional counting method. Shows the 3-year moving average.

Note 2: The "public institution sector" includes national government agencies, national research and development agencies, and organizations of local governments. This is aggregated by the NISTEP based on Clarivate Web of Science XML (SCIE, 2020 Year-end version).

Source: Prepared by MEXT based on the materials presented by the NISTEP at the Subdivision on Science, Council for Science and Technology (84th meeting) (September 2, 2021).

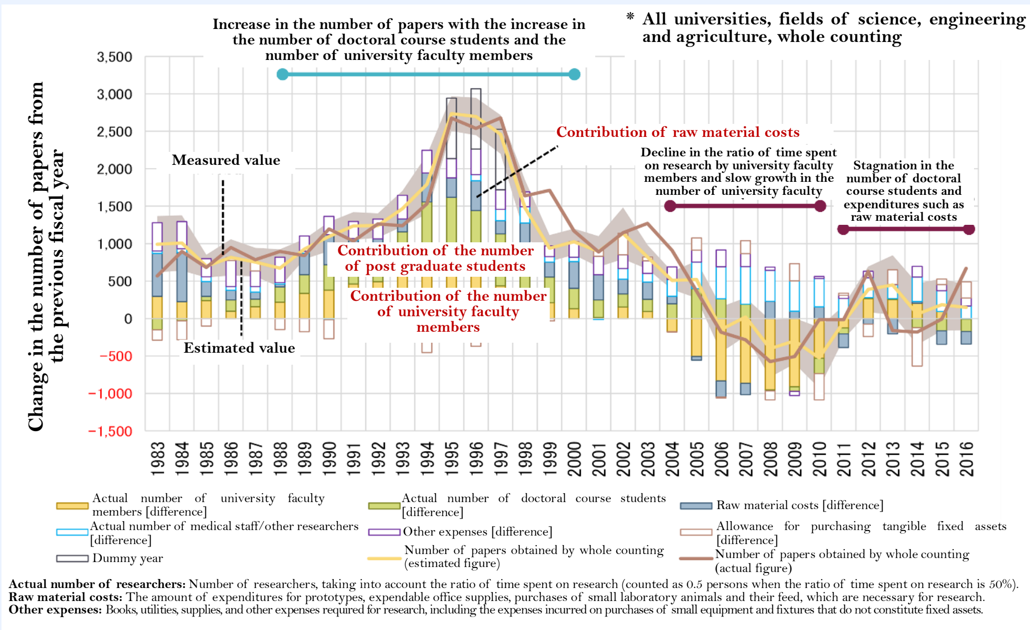
5 Factor Analysis for Number of Papers

Fig 1-1-8 shows the analysis of the factors causing fluctuations in the number of papers by compiling long-term macro data on the number of papers, number of researchers, and R&D expenditure of Japanese universities since the 1980s, conducted by NISTEP, MEXT. The analysis reveals the following trends concerning the fluctuations in the number of papers.

- The main factor behind the increase from the late 1980s to the 1990s was the increase in the number of doctoral course students and university faculty members.
- The main factors behind the decline from the mid-2000s to 2010 were the decline in the ratio of time spent on research by university faculty members and slow growth in the number of university faculty members.
- The main factors behind the decline in the 2010s were the decrease in the number of doctoral course students and stagnation of expenditures on research implementation, such as raw material costs.

As described above, fluctuations in the number of papers are due to multiple complex factors, but in recent years, factors such as a decline in the ratio of time spent on research by university faculty members (see 1 of Section 2), slow growth in the number of university faculty members(see 2 of Section 3), stagnation in the number of doctoral course students (see 5 of Section 3) and expenditures on research implementation, such as raw material costs (see 4 of Section 4 on Total R&D Expenditures), are among the factors contributing to the decline.

■ Figure 1-1-8/ Estimated changes in the number of papers obtained by the whole counting for all universities (fields of science, engineering and agriculture)



The chart shows the estimated changes in the number of papers (all universities in the fields of science, engineering, and agriculture) based on the results of the analysis obtained by whole counting (in the case of internationally co-authored papers, the papers are counted as 1 paper per country). The bar graph indicates the estimated contribution of each factor to the changes in the number of papers, the yellow line indicates the estimated changes in the number of papers, the red line indicates the actual changes in the number of papers, and the gray band indicates the 95% confidence interval for the estimated results.

Source: Prepared by NISTEP, MEXT, based on NISTEP "Analyses on the production of scientific publications in Japanese universities using long-term input and output macro data"

6 Comparison of the Number of Papers of Japanese, English and German Universities

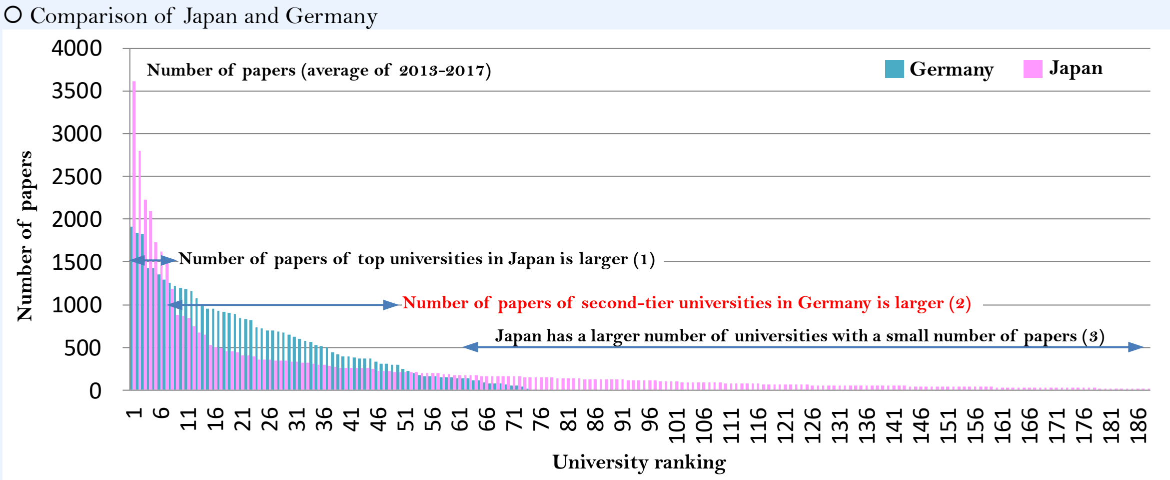
Figure 1-1-9 compares Germany, the U.K., and Japan regarding the number of papers produced by universities. A comparison of the 3 countries reveals the following trends.

- The number of papers from top universities in Japan is larger than that in Germany and similar to that in the U.K.
- The number of papers of second-tier universities in Japan is smaller than that in the U.K. and Germany
- Japan has a larger number of universities with a small number of papers.

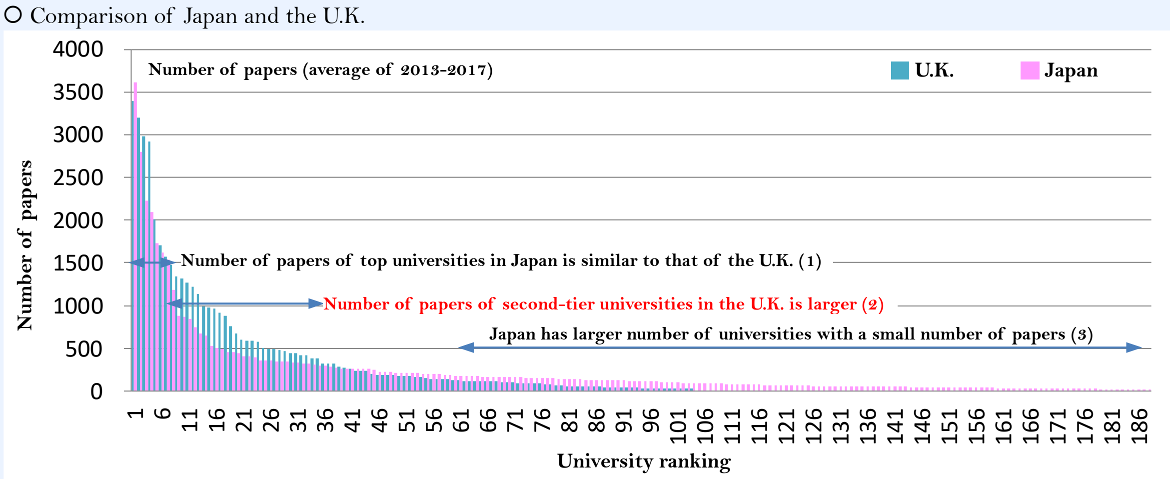
It can be understood from the above that the number of papers in second-tier universities in Japan is smaller, and the number of universities with a small number of papers is larger compared to Germany and the U.K.

■ Figure 1-1-9/ Distribution of the number of papers from German, English and Japanese universities (As of the years 2013 - 2017)

○ Comparison of Japan and Germany



○ Comparison of Japan and the U.K.



Source: Prepared by NISTEP, MEXT based on the NISTEP "Japanese, English, and German university benchmarking 2019 focusing on research papers"

Section 2 Ratio of Time Spent on Research by Researchers

Since 2002, the government has been conducting a "Survey of Full-time Equivalency Data at Universities and Colleges[1]" every 5 years to determine the ratio of time spent on work activities by university faculty members. According to this survey, the ratio of time spent on research or the amount of time spent on research has decreased in the 2018 survey compared to the 2002 survey. When asked about constraints in improving research performance, research time was cited by the maximum number of people. From the viewpoint of improving research capacity, maintaining the ratio of time spent on research by researchers

1 Ratio of Time Spent on Research

Figure 1-1-10 shows the changes in the ratio of time spent on work activities by university faculty members in all fields.

- While the share of hours spent on research activities by university faculty members has declined, the share of hours spent on education and social service activities has increased.
- A comparison of the 2002 and 2018 surveys showed that the share of hours spent on research activities declined by 13.6 points, the share of hours spent on education activity increased by 4.8 points, and the share of hours spent on social service activity increased by 10.8 points.

Figure 1-1-11 shows the changes in the ratio of time spent on work activities by university faculty members by academic field.

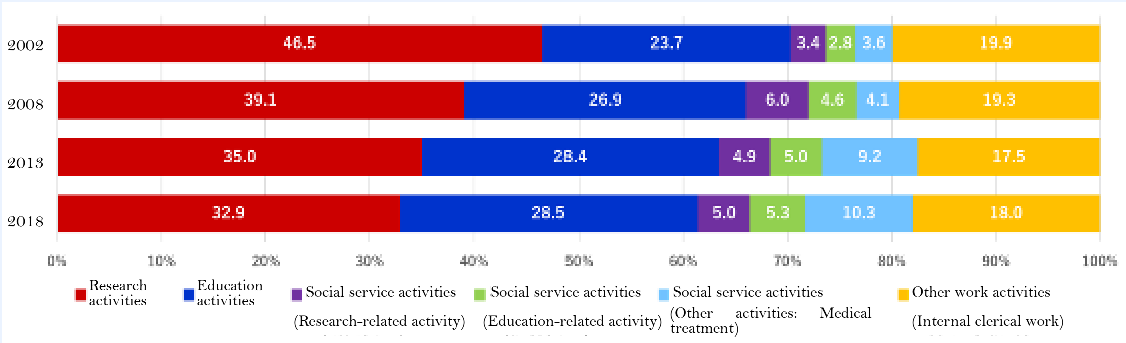
- Comparing the 2002 and 2008 surveys, the share of hours spent on research activities has decreased in all fields.
- In the medical sciences field, the share of hours spent on research activities continued to decline even after the 2008 survey, while the share of hours spent on social service activity (such as medical treatment) increased.
- There has been no significant change since the 2008 survey in fields other than the medical sciences field (medicine, dentistry, pharmacy, etc.).

As shown above, the share of hours spent on research activities has decreased in all fields compared to the 2002 survey. Since the 2008 survey, there has been a consistent decrease in the share of research hours in medical sciences , while it has remained unchanged in other fields.

1 The 2002 survey is for the year in question, and the 2008, 2013 and 2018 surveys are for the previous year's activities.

■ All fields

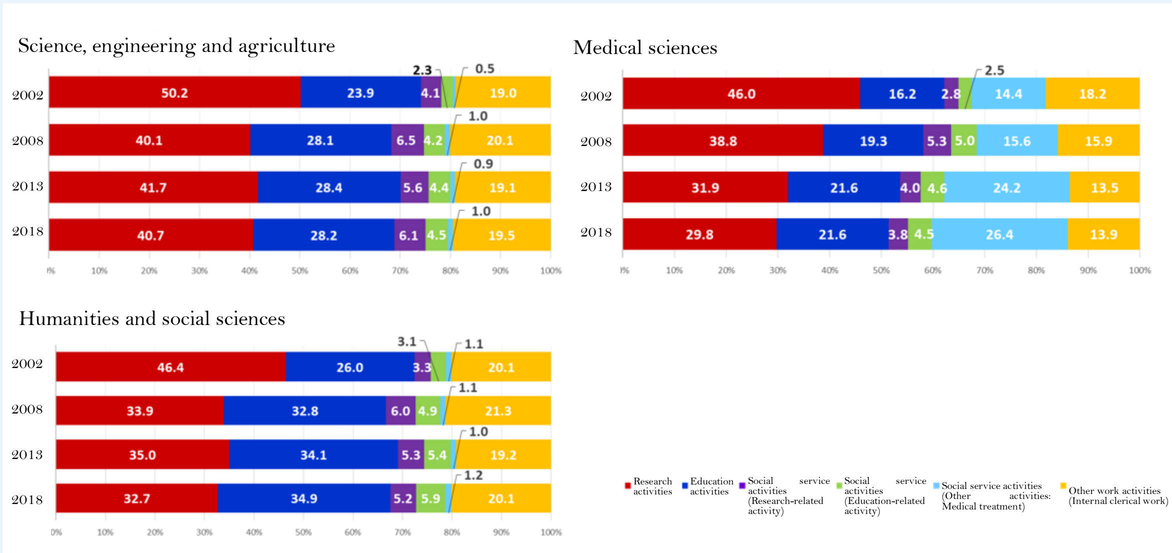
■ Figure 1-1-10/ Changes in the ratio of time spent on work activities by university faculty members in all fields



Source: Prepared by MEXT based on the MEXT "Survey of Full-time Equivalency Data at Universities and Colleges"

■ By academic field

■ Figure 1-1-11/ Changes in the ratio of time spent on work activities by university faculty members by academic field



Source: Prepared by MEXT based on the MEXT "Survey of Full-time Equivalency Data at Universities and Colleges"

2 Number of Research Hours in Annual Total Working Hours

Figure 1-1-12 shows the changes in the annual total working hours of university faculty members.

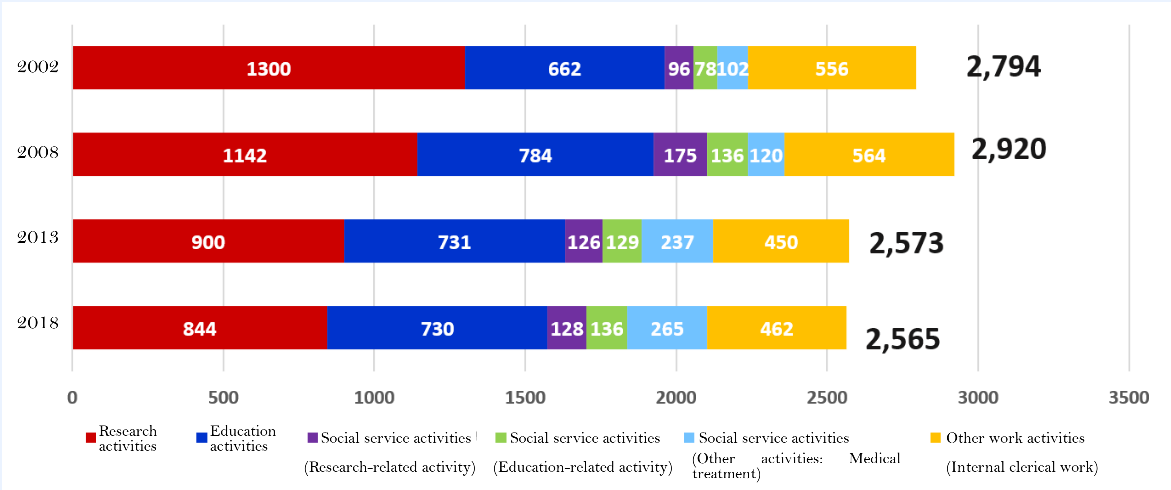
- Comparing the 2002 and 2018 surveys, the number of research hours has decreased to approximately 65%.

Figure 1-1-13 shows the changes in the annual total working hours of university faculty members, excluding the medical sciences field.

- Even when excluding the medical sciences field, where there is a significant decline in the share of hours spent on research activities, the number of research hours has decreased to approximately 78%, comparing the 2002 and 2018 surveys.

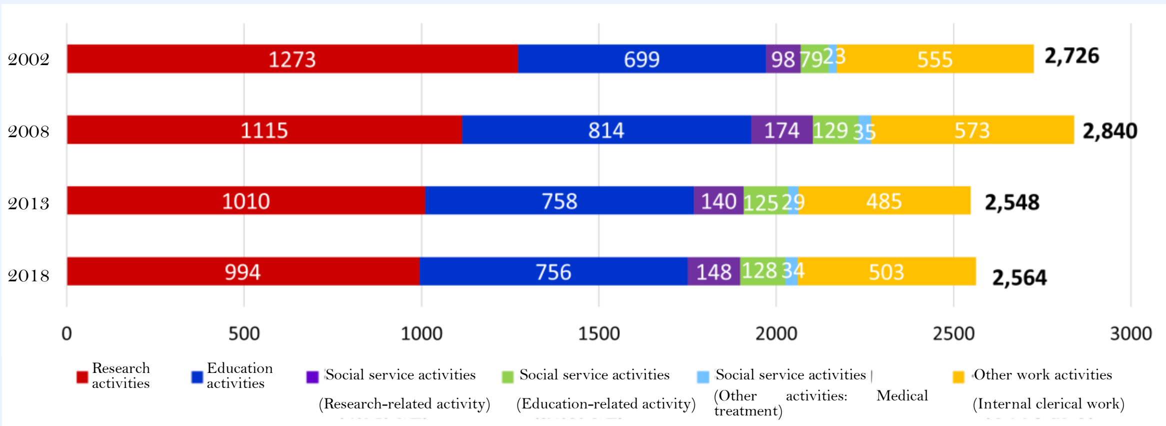
As shown above, the number of research hours spent by university faculty members has been consistently declining, and it has become increasingly important to manage the number of research hours.

■ Figure 1-1-12/ Changes in the annual total working hours of university faculty members



Source: Prepared by MEXT based on the MEXT "Survey of Full-time Equivalency Data at Universities and Colleges"

■ Figure 1-1-13/ Changes in the annual total working hours of university faculty members (excluding the medical sciences field)



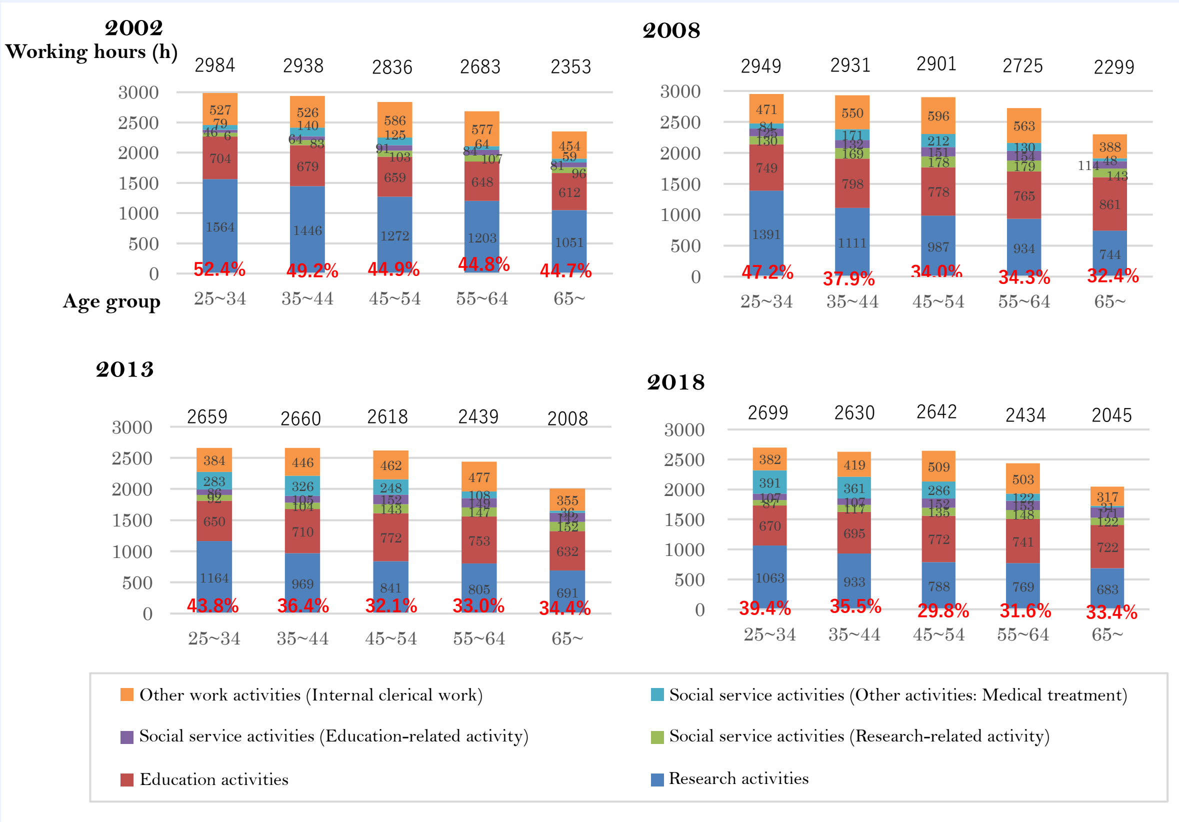
Source: Prepared by MEXT based on the MEXT "Survey of Full-time Equivalency Data at Universities and Colleges"

3 Number and Share of Research Hours by Age Group

Figure 1-1-14 shows the changes in the number of annual total working hours of university faculty members by age group and the share of time spent on research activities.

- The younger the age, the higher the share of time spent on research activities.
- For all age groups, there has been a consistent decline in the number of research hours. For example, comparing the 2002 and 2018 surveys for the number of research hours spent by people aged 25 to 34, has decreased to approximately 68%.

■ Figure 1-1-14/ Changes in the number of working hours of university faculty members (by age group)



Note: The figures in red indicate the percentage of hours spent on research
Source: Prepared by MEXT based on the MEXT "Survey of Full-time Equivalency Data at Universities and Colleges"

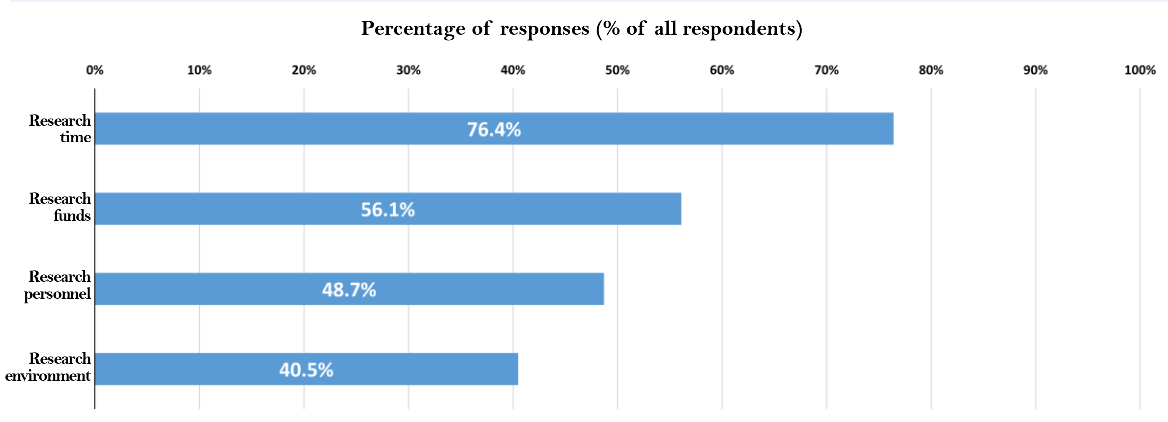
4 Constraints in Improving Research Performance

Figure 1-1-15 shows the responses to a questionnaire about constraints in improving research performance.

- When asked about constraints in improving research performance, research time was cited by the maximum number of people, followed by research funds, research personnel, and research environment, in that order.

As described above, securing research time is recognized by university faculty members as the most significant challenge in improving research performance.

■ Figure 1-1-15/ Percentage of responses related to the four factors considered as constraints by university faculty members in improving research performance



Source: Prepared by MEXT based on the MEXT "Survey of Full-time Equivalency Data at Universities and Colleges (2018)"

5 Specific Constraints in terms of Research Time and Research Funds

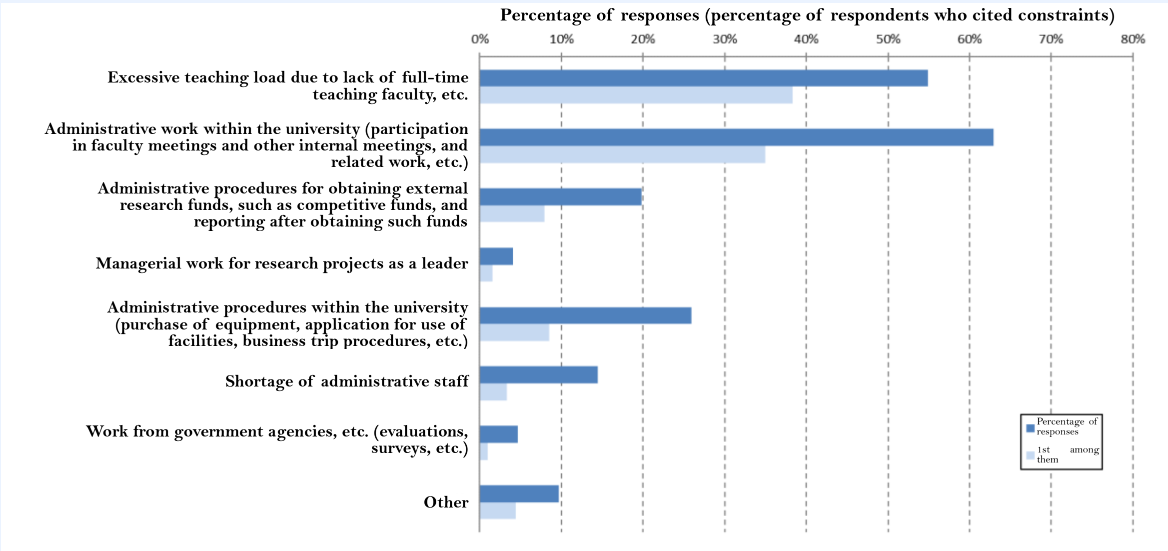
Figure 1-1-16 shows the responses related to specific constraints in terms of research time and research funds, which were cited as the constraints in improving research performance by a large percentage of people.

- In terms of research time, excessive teaching load and administrative work within the university were cited as constraints by a significant percentage of people.
- In terms of research funds, the highest percentage of people cited a lack of basic research funds, followed by difficulties securing external funding, such as competitive funds.

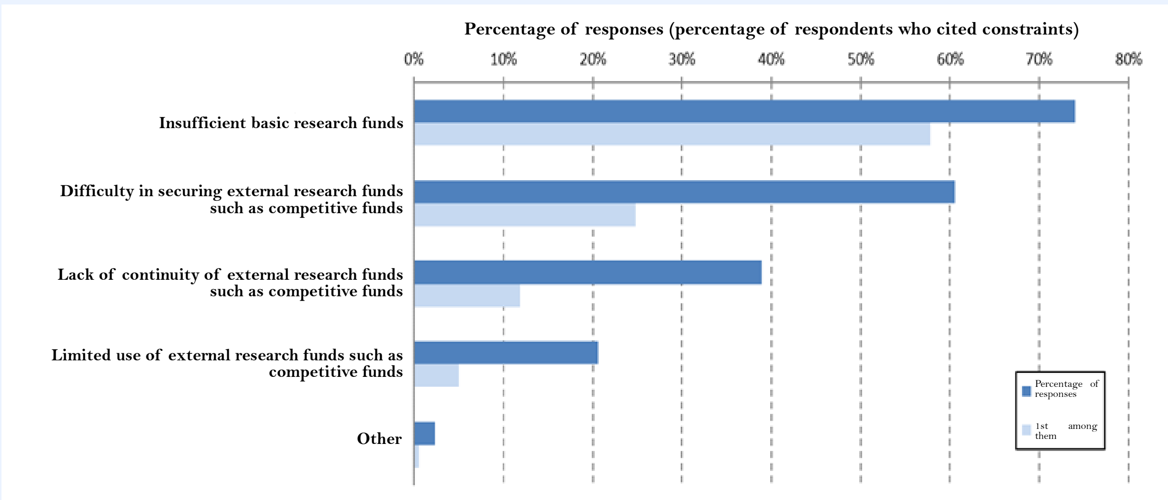
As shown above, specific constraints in improving research performance include the inability to secure research time due to teaching load and administrative work within the university and the inability to secure research funds due to a lack of basic research funds and other factors.

■ Figure 1-1-16/ Percentage of responses related to specific constraints in terms of the factors (research time and research funds) felt as constraints by university faculty members in improving research performance

○ **Research time**



○ **Research funds**



Source: Prepared by MEXT based on the MEXT "Survey of Full-time Equivalency Data at Universities and Colleges (2018)"

Section 3 Research Personnel

Japan has the third highest number of researchers in the world, but the ratio of time spent on research has not changed, while in many major countries, the ratio has increased since the 2000s. Regarding full-time university faculty members, the percentage of young faculty members aged less than 40 years is consistently declining, and the number of students enrolled in doctoral courses at graduate schools is trending downward after peaking in FY 2003. Although the percentage of female researchers in Japan has been increasing yearly, the percentage is still low compared to other countries. Securing the number of researchers considering the ratio of time spent on research, especially the number of young researchers and female researchers, is a key issue.

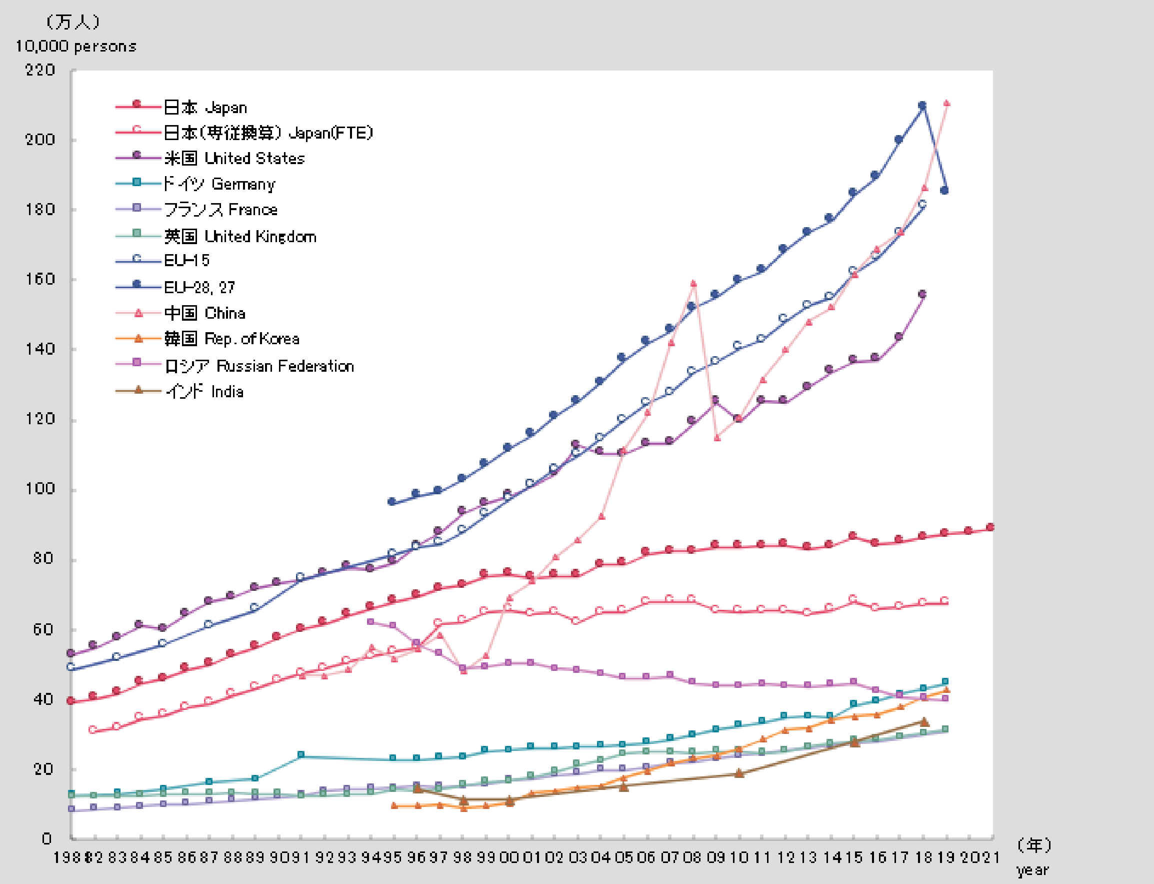
1 Number of Researchers Taking into Account the Ratio of Time Spent on Research

Figure 1-1-17 shows the changes in the number of researchers in major countries, etc.

- As of March 31, 2021, the number of researchers in Japan was 891,000, or 682,000 in full-time equivalent, taking into account the ratio of time spent on research, which is the third largest in the world, following China and the United States.
- The number of full-time equivalent researchers, considering the ratio of time spent on research, has remained unchanged since the 2000s, while it is increasing in many major countries.
- As for the number of researchers (actual number) by type of organization, business enterprises have about 60%, followed by universities, etc., at about 40%, and public institutions s, etc. at about 10% or lower.

As shown above, the number of full-time equivalent researchers in Japan is the third largest in the world and has remained unchanged, while it is on the rise in many major countries.

■ Figure 1-1-17/ Changes in the Number of Researchers in Major Countries, etc.



Note 1: Researchers in humanities and social sciences are included for each country. However, they were not included until 2006 for Rep. of Korea.
2. The figures for Japan are as of April 1 for 2001 and earlier, and as of March 31 for 2002 and later.
3. Japan's full-time equivalent figures are OECD estimates until 1995.
4. The number of researchers in China does not comply with the Frascati Manual of the OECD until 2008.
5. The figures for the U.S. after FY 2000 are OECD estimates.
6. The figures for Germany for FY 1996, 1998, 2000, 2002, 2008, and 2010 are estimates.
7. The figures for France for FY 2012, 2013, and 2018 are estimates, while those for FY 2017 are provisional figures.
8. The U.K. figures through 1983 show the total number of employees in industrial (scientists and engineers) and national research institutions (degree-holding researchers and above) and do not include universities and private research institutions. The figures for 1999-2010, 2012, 2014, and 2016-18 are OECD estimates, while those for 2019 are provisional figures.
9. The figures for the EU are OECD estimates.

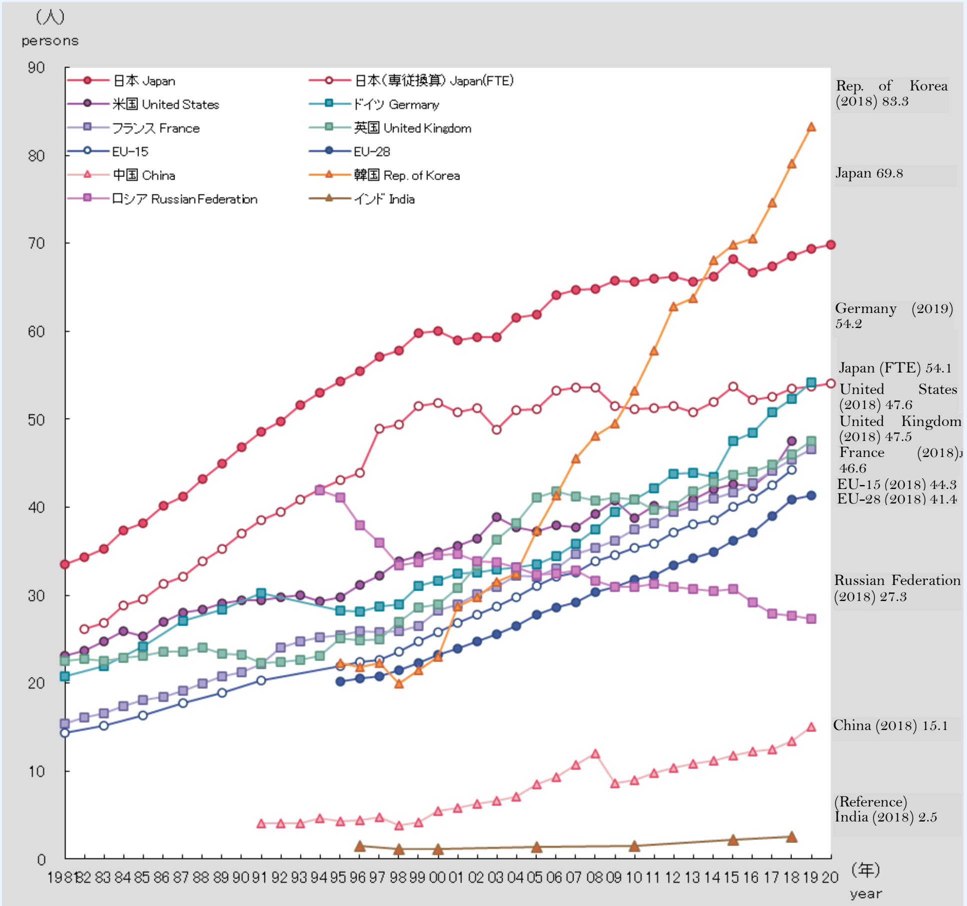
Document: Japan: (Number of researchers) "Report on the Survey of Research and Development" by the Statistics Bureau, Ministry of Internal Affairs and Communications of Japan
(Full-time equivalent figures) OECD, Main Science and Technology Indicators, Vol. 2022/1.
India: UNESCO Institute for Statistics S&T database
Other countries: OECD, Main Science and Technology Indicators, Vol. 2022/1.

Source: "Indicators of science and technology 2021," MEXT

Figure 1-1-18 shows a comparison of the number of researchers per population of 10,000, given the size of each country.

- The number of researchers in Japan was the highest among the major countries until 2009, when Rep. of Korea and Germany surpassed Japan (full-time equivalent) in 2010 and 2019, respectively.

■ Figure 1-1-18/Changes in the number of researchers per population of 10,000 in major countries, etc.



Note 1: Researchers in humanities and social sciences are included for each country. However, they were not included until 2006 for Rep. of Korea.

2. The number of researchers per population of 10,000 is estimated by MEXT based on the population and number of researchers.
3. The number of researchers in Japan is as of April 1 for 2001 and earlier, and as of March 31 for 2002 and later.
4. The full-time equivalent figures for Japan are OECD estimates until 1995.
5. The figures for the U.S. after FY 2000 are OECD estimates.
6. The number of researchers in the EU is OECD estimates.
7. The figures for Germany for 1996, 1998, 2000, and 2010 are estimates.
8. The figures for France for 2012, 2013, and 2019 are estimates, while those for 2017 and 2018 are provisional figures.
9. The U.K. figures through 1983 show the total number of employees in industrial (scientists and engineers) and national research institutions (degree-holding researchers and above) and do not include universities and private research institutions. The figures for 1999-2010, 2012, 2014, and 2016-18 are OECD estimates; the figures for 2019 are provisional.
10. The number of researchers in China does not comply with the Frascati Manual of the OECD until 2008.
11. The number of researchers in India is per 10,000 residents.

Document: Japan: (Number of researchers) "Report on the Survey of Research and Development" by the Statistics Bureau, Ministry of Internal Affairs and Communications of Japan
(Full-time equivalent figures) OECD, Main Science and Technology Indicators, Vol. 2022/1.
(Population) "Population Estimates Series," Statistics Bureau, Ministry of Internal Affairs and Communications (as of October 1 of each year)
India: UNESCO Institute for Statistics S&T database
Other countries: OECD, Main Science and Technology Indicators, Vol. 2022/1.

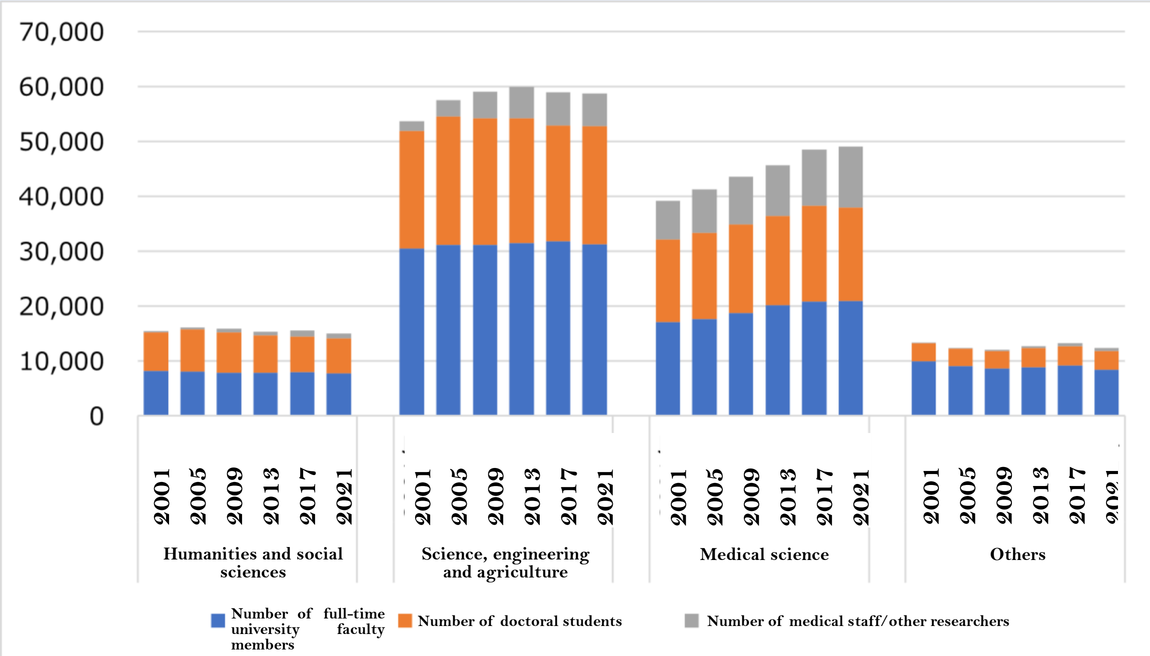
Source: "Indicators of science and technology 2021," MEXT

2 Number of Researchers by Field at National Universities, etc.

Figure 1-1-19 shows the changes in the number of researchers (figures without full-time research equivalent) by the field at Japanese national universities.

- The changes in the number of researchers by field at Japanese national universities show that the number of full-time university faculty members and medical staff/other researchers in the medical sciences field has increased, while the number of researchers in fields other than medical sciences has remained nearly the same.

■ Figure 1-1-19/Changes in the number of researchers by the field at national universities, etc.



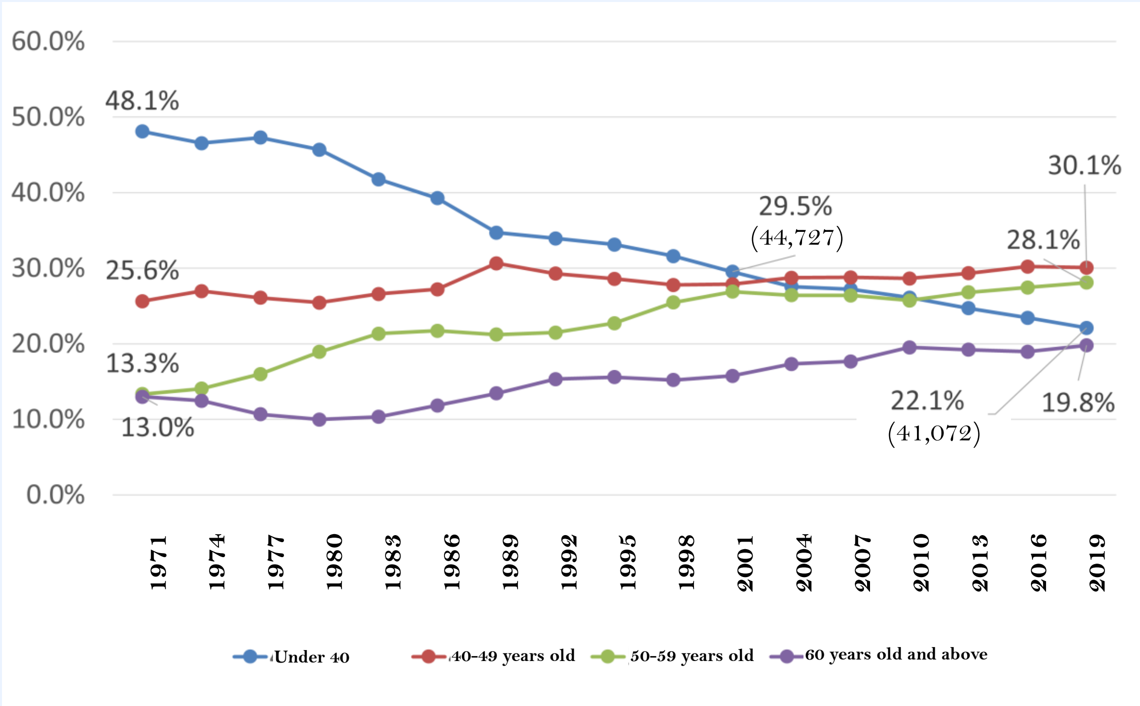
Source: Prepared by MEXT based on the "Report on the Survey of Research and Development" by the Ministry of Internal Affairs and Communications, Japan

3 Percentage of Full-time University faculty members by Age Group

Figure 1-1-20 shows the changes in the percentage of full-time university faculty members by age group.

- The percentage of university faculty members under the age of 40 has consistently declined and was 29.5% in FY 2001 and 22.1% in FY 2019.
- On the other hand, the percentage of university faculty members aged 50 to 59 years, and 60 years and above, has been rising, increasing to 28.1% and 19.8%, respectively, in FY 2019.
- The number of faculty members under the age of 40 was 44,727 in FY 2001 and 41,072 in FY 2019.

■ Figure 1-1-20/Changes in the percentage of full-time university faculty members by age group



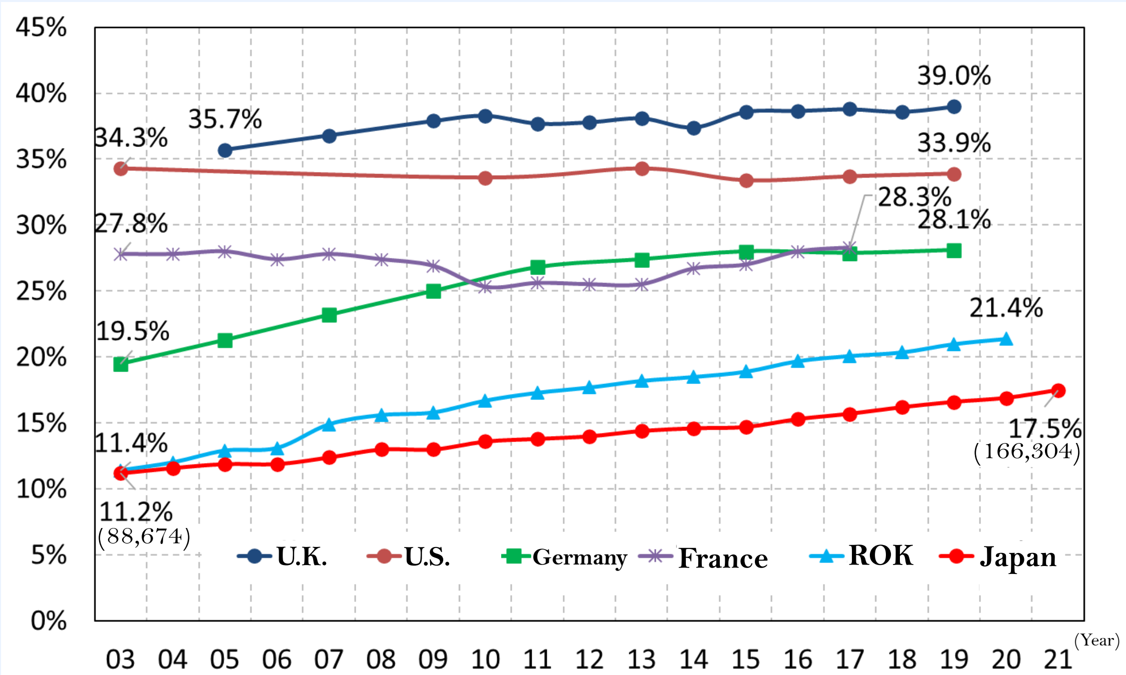
Source: Prepared by MEXT based on the MEXT "School Teachers Survey"

4 Percentage of Female Researchers

Figure 1-1-21 shows the trend in the percentage of female researchers in major countries.

- Female researchers are also expected to play an active part in increasing diversity among researchers. Although the percentage of female researchers in Japan has been increasing yearly, the percentage is still low compared to various foreign countries.
- The number of female researchers in Japan was 88,674 in 2003 and 166,304 in 2021.

■Figure 1-1-21/ Percentage of Female Researchers in Various Foreign Countries



Note: 1. A "Researcher" in Japan refers to persons who have completed a course in the university (excluding junior college) or who have specialized knowledge equivalent to or superior to such courses and are conducting research on a specific theme. In addition to universities, researchers from public institutions and business enterprises, etc., have also been included in the survey.

2. When surveying and counting researchers in Japanese universities, in addition to university faculty members (professors, associate professors, lecturers and assistant professors), medical staff and those enrolled in graduate school doctoral programs have been included.

Source: Created by MEXT based on the "Report on the Survey of Research and Development" by the Ministry of Internal Affairs and Communications, Japan, "Science and Engineering Indicator" by NSF, United States, and "Main Science and Technology Indicators" by OECD for other countries.

5 Number of Students Enrolled in the Doctor's Course

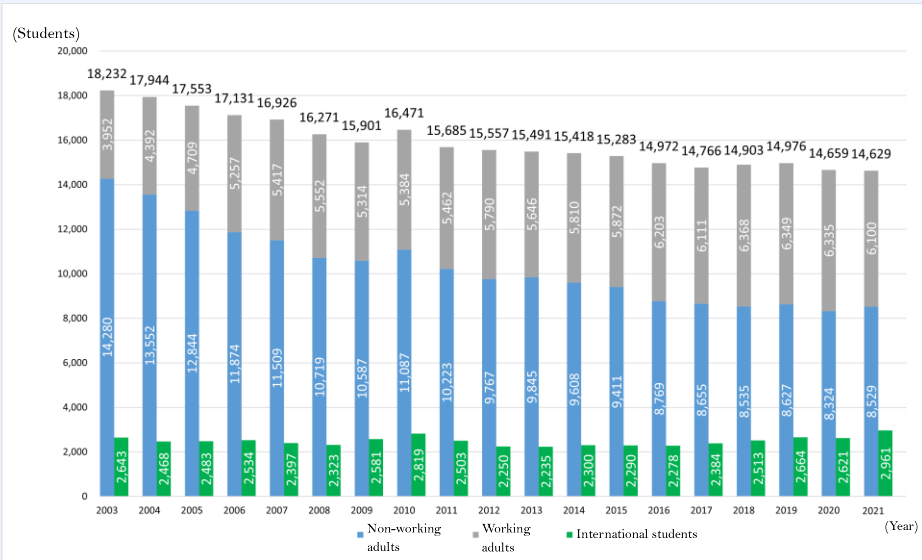
Figure 1-1-22 shows the trends in the number of students enrolled in the doctor's course.

- The number of Japanese students enrolled in the doctor's courses at graduate schools is trending downward after peaking in FY 2003 and is approximately 15,000 in FY 2021.
- The number of working students enrolled in the doctor's course is trending upward, and their percentage of the total number of students has doubled compared to FY 2003.

Figure 1-1-23 shows trends in the number and percentage of students advancing from master's course to doctor's course.

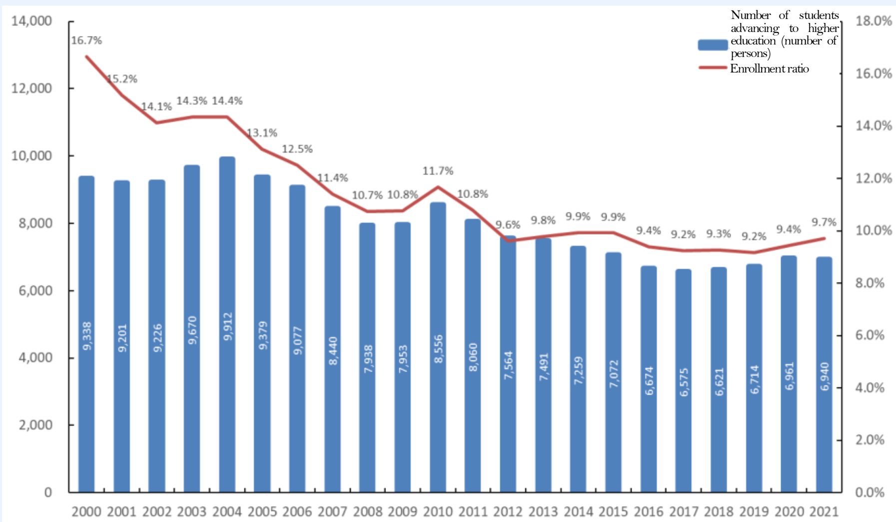
The percentage of students advancing from master's to doctor's courses was trending downward and was 9.7% in FY 2021.

■ Figure 1-1-22/ Changes in the number of students enrolled in the doctor's course



Source: Prepared by MEXT based on the MEXT "School Basic Statistics"

■ Figure 1-1-23/ Changes in the number and percentage of students advancing from master's course to doctor's course



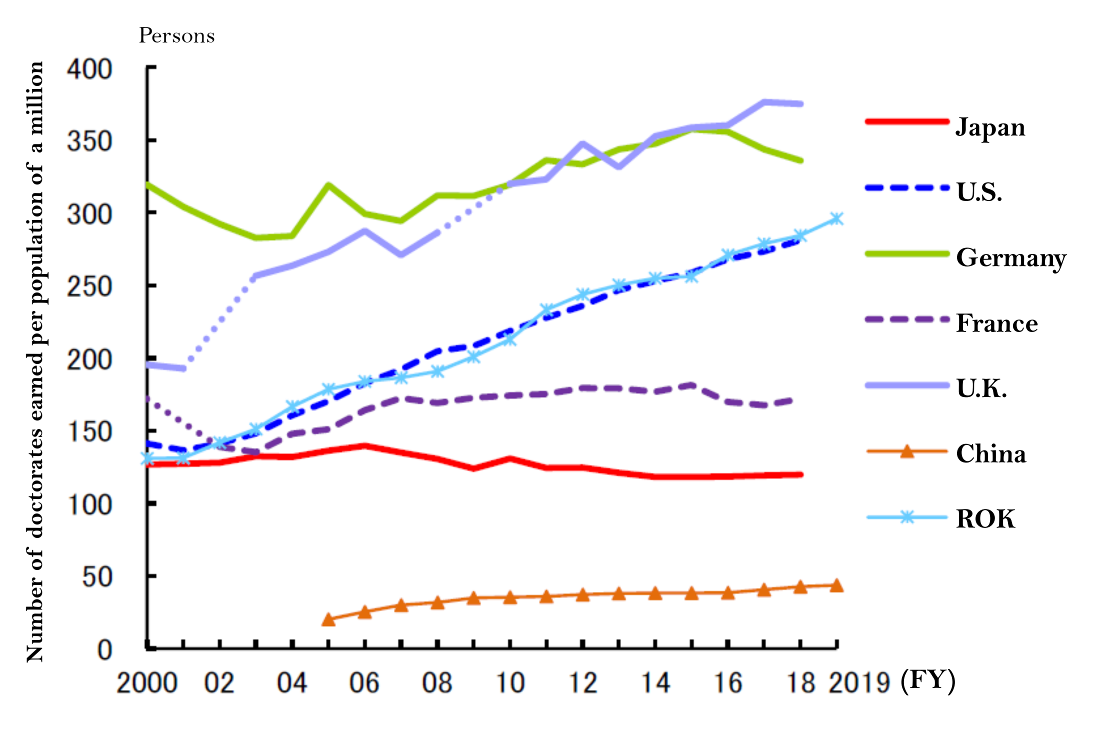
Source: Prepared by MEXT based on the MEXT "School Basic Statistics"

6 Number of Doctoral Degree Recipients per Population

Figure 1-1-24 shows the doctoral degree recipients per million population.

- In FY 2018, the U.K. (375 students) was followed by Germany (336 students), and the number in Japan (120 students) was one-third that of the U.K. and Germany.

■ Figure 1-1-24/ International comparison of doctoral degree recipients per million population



Note: The number of doctoral degree recipients in the United States is the value calculated by subtracting all the figures for "Professional fields" (formerly referred to as First-professional degree) from the figures for "Doctor's degrees" stated in the "Digest of Education Statistics."

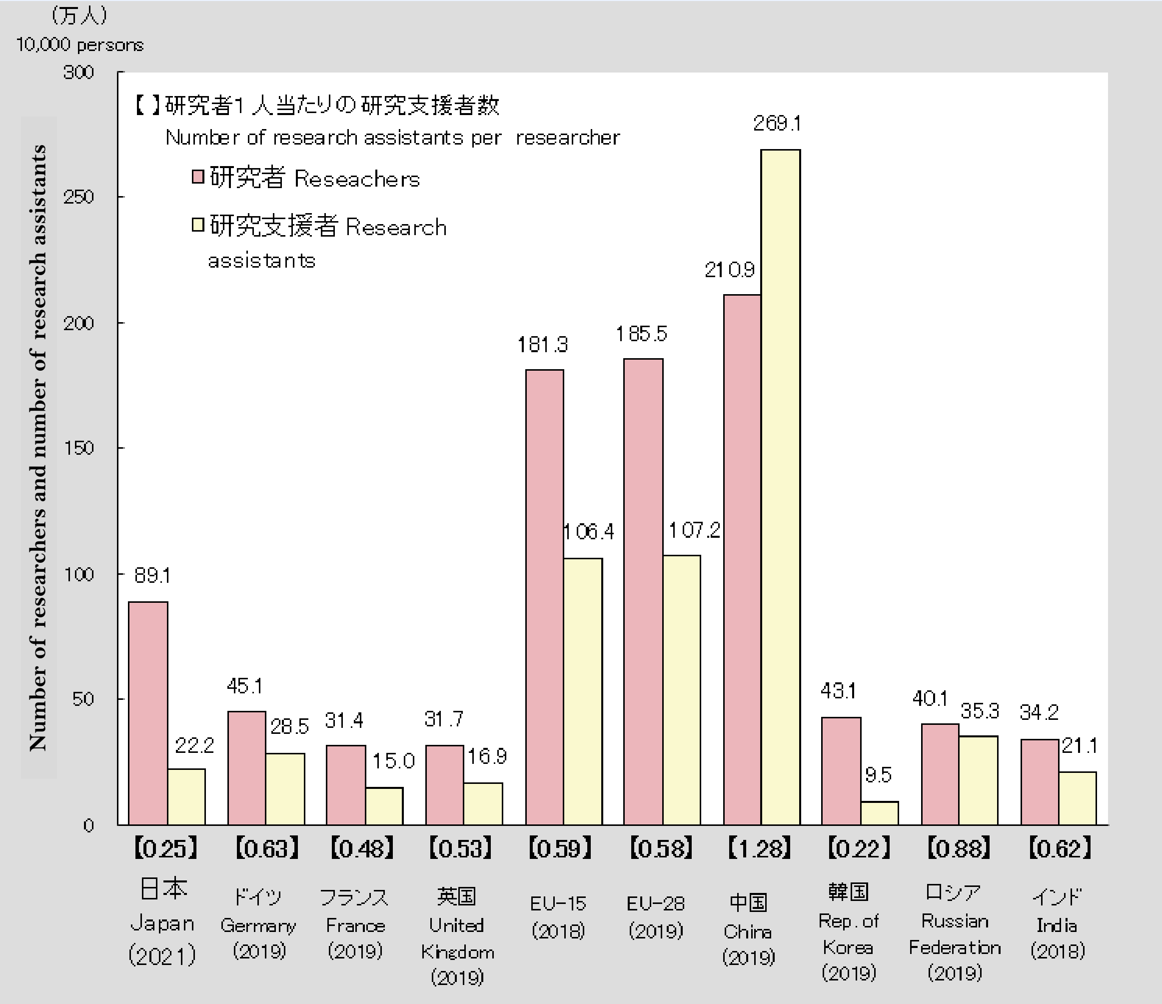
Source: "Japanese Science and Technology Indicators 2021," NISTEP, MEXT

7 Number of Research Assistants

Figure 1-1-25 shows the number of research assistants per researcher in major countries, etc.

- Though research assistants play an important part in research and development, the number of research assistants per researcher in Japan is 0.25, which is negligible compared with numbers in other major countries, etc.

■ Figure 1-1-25/ Number of research assistants per researcher in major countries, etc.



Note 1: The number of research assistants per researcher is estimated by MEXT based on the number of researchers and research assistants.
2. Research assistants in humanities and social sciences are included for each country.
3. Research assistants refer to people who assist researchers, people who provide technical services that add value to research, and people employed in research administration, which in Japan is referred to as assistant research workers, technicians, and clerical and other supporting personnel.
4. The figures for France are estimates.
5. The figures for the U.K. are estimates, and they underestimate the number of research assistants.
6. The figures for the EU are OECD estimates.

Document: Japan: "Report on the Survey of Research and Development" by the Statistics Bureau, Ministry of Internal Affairs and Communications of Japan
India: UNESCO Institute for Statistics S&T database
Other countries: OECD, Main Science and Technology Indicators, Vol. 2022/1.

Source: "Indicators of science and technology 2021," MEXT

Section 4 Research and Development Expenditures

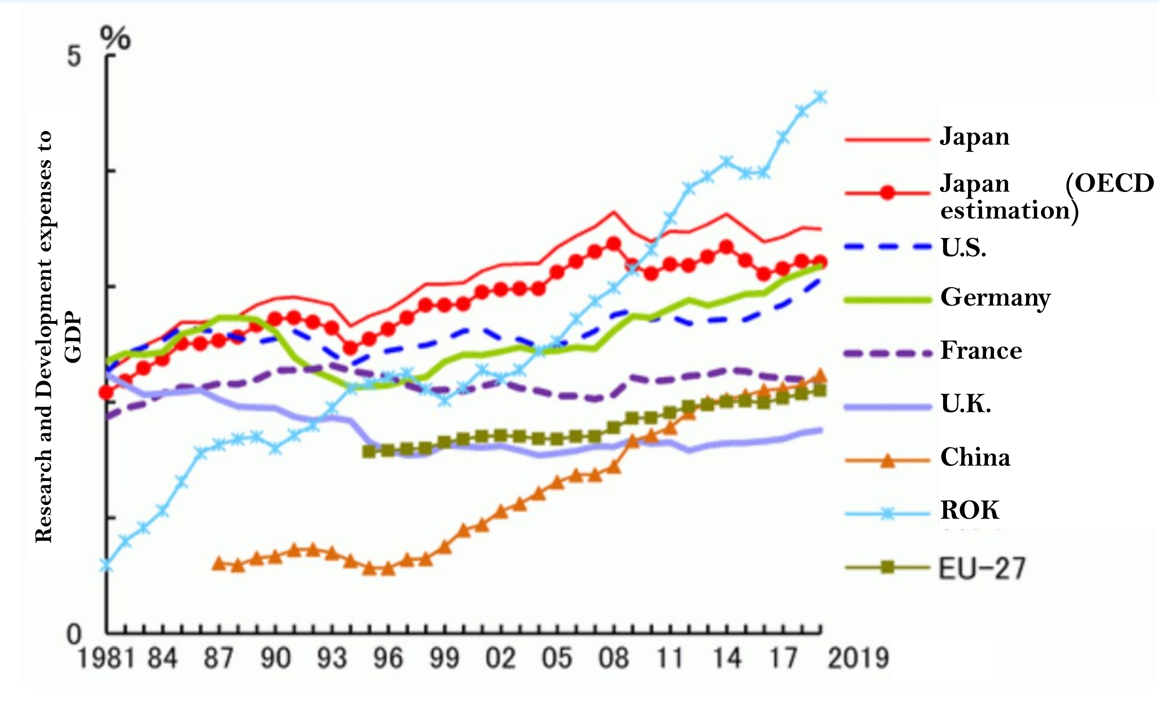
Compared to other major countries, in Japan, the ratio of budget appropriations for R&D expenditures (research expenditures spent by research institutions) and science and technology to GDP is high, but in recent years, R&D expenditures in the university sector, public institution sector, and business enterprise sector have been stagnant.

1 Changes in the Ratio of Total R&D Expenditures to GDP

Figure 1-1-26 shows the changes in the ratio of R&D expenditures to GDP in major countries combined for the public and private sectors.

- Japan's ratio of R&D expenditures to GDP is high compared to other major countries.
- In Japan, the business enterprise sector accounts for about 73% of the R&D expenditures, the university sector accounts for about 19%, and the public institution sector accounts for about 7%.

■ Figure 1-1-26/ Changes in the ratio of total R&D expenditures to GDP in major countries



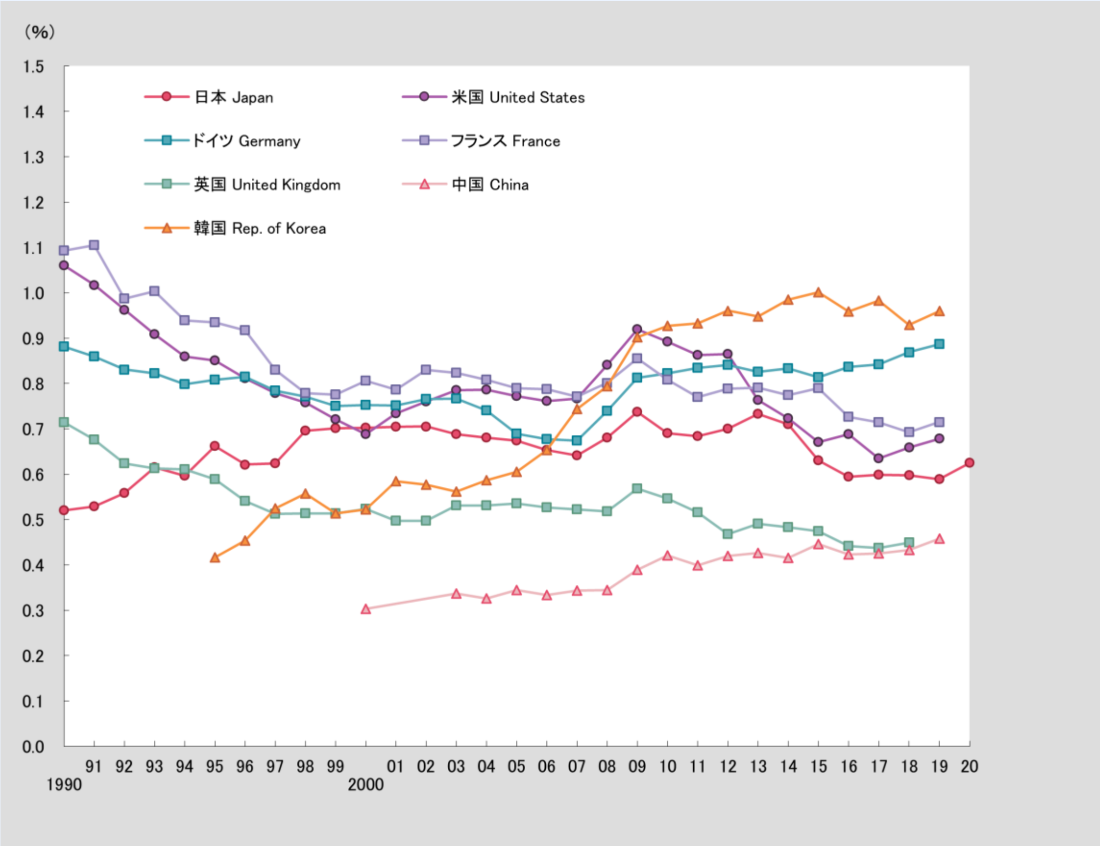
Source: "Japanese Science and Technology Indicators 2021," NISTEP, MEXT

2 Changes in the Ratio of Government-Funded Research Expenditure to GDP in Major Countries

Figure 1-1-27 shows the changes in the ratio of government-funded research expenditure to GDP in major countries.

- The ratio of government-funded research expenditure to GDP is similar to that of major countries.

■ Figure 1-1-27/ Ratio of government-funded research expenditure to GDP in major countries, etc.



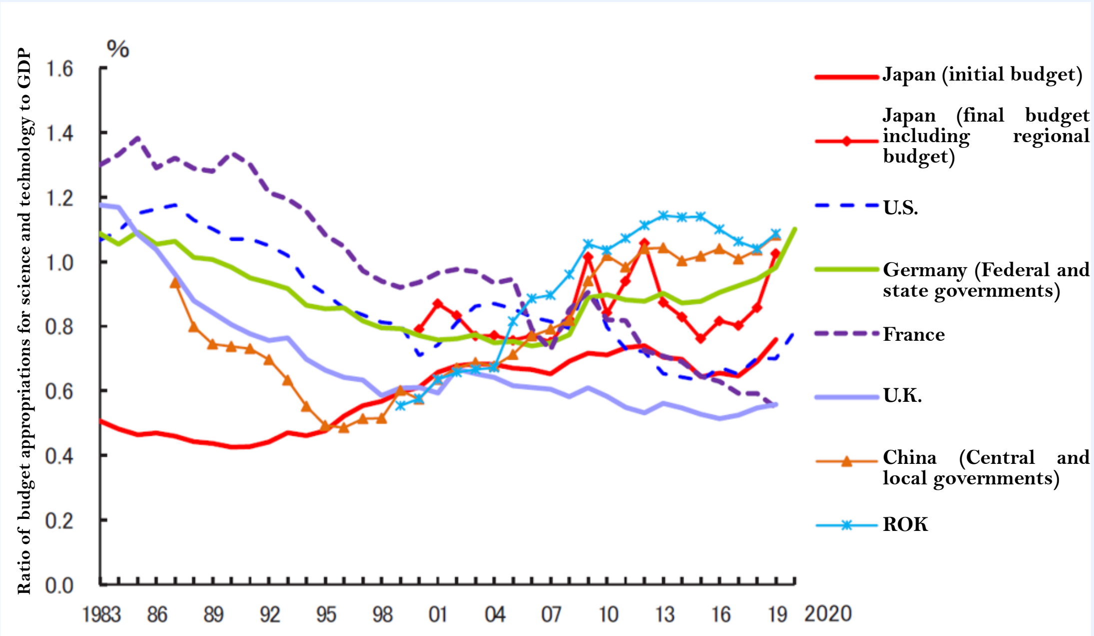
Source: Prepared by MEXT based on the MEXT "Indicators of science and technology 2021"

3 Changes in the Ratio of Governments Budget Appropriations for Science and Technology to GDP in Selected Countries

Figure 1-1-28 shows the changes in the ratio of government budget appropriations for science and technology to GDP in major countries.

- Compared to other major countries, the ratio is high in Japan (final budget including regional budget) at 1.03% in 2019, with China at 1.08% and Rep. of Korea at 1.09%.

■ Figure 1-1-28/ Changes in the ratio of government budget appropriations for science and technology to GDP in major countries

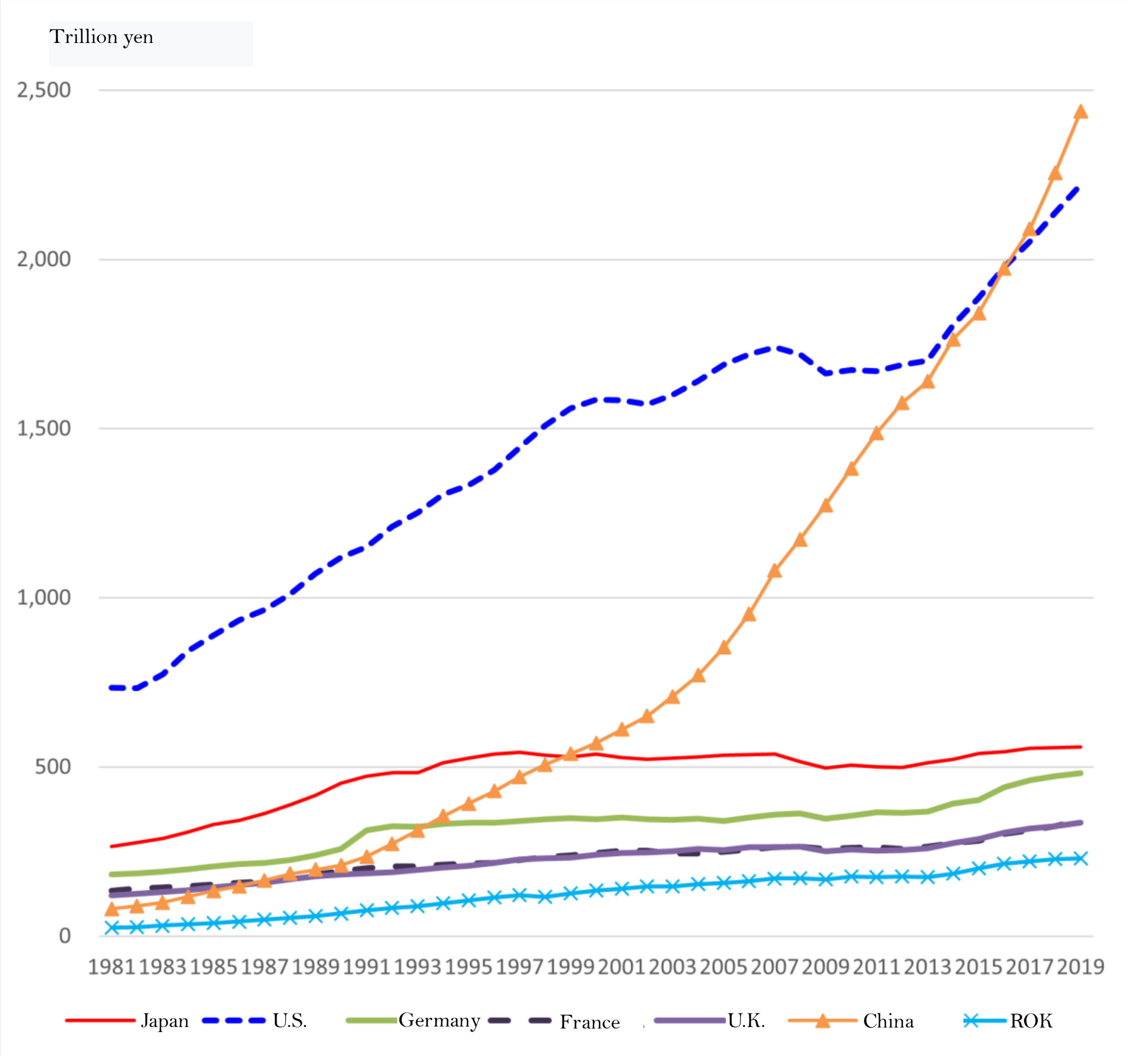


Source: "Japanese Science and Technology Indicators 2021," NISTEP, MEXT

Figure 1-1-29 shows GDP changes for major countries.

- While GDP is growing in other major countries, Japan's GDP has only slightly increased.

■ Figure1-1-29/ Changes in the Gross Domestic Product (GDP) of major countries (OECD purchasing power parity equivalent)



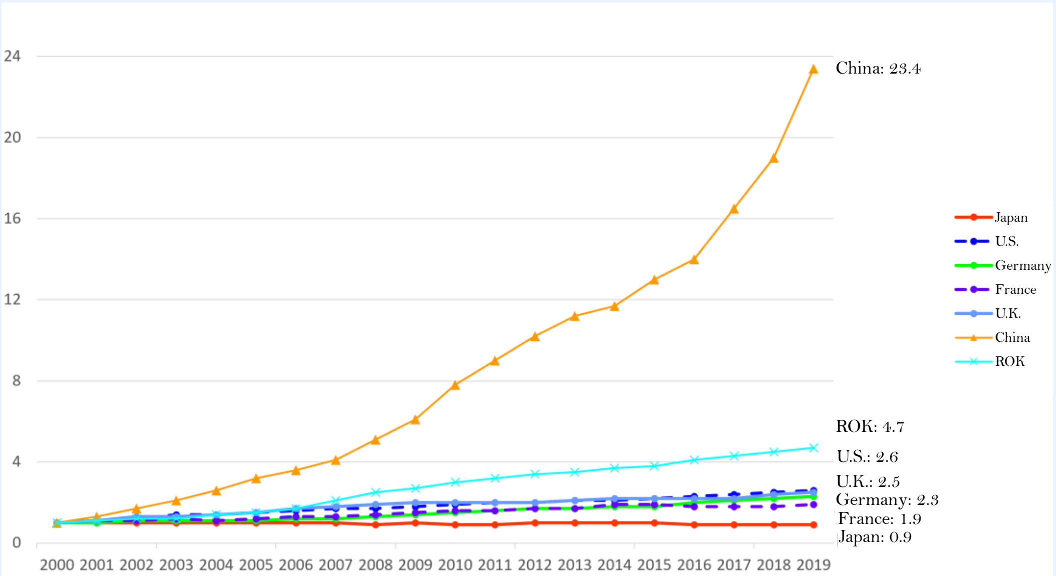
Source: Prepared by MEXT based on the NISTEP "Japanese Science and Technology Indicators 2021"

4 Changes in R&D Expenditures

Figure 1-1-30, Figure 1-1-31, and Figure 1-1-32 show changes in R&D expenditures (nominal amount (OECD purchasing power parity equivalent)) in the university sector, public institution sector, and business enterprise sector on a 2000 base year.

- In all sectors, the R&D expenditures of Japan are stagnant, while those of China and Rep. of Korea are growing strongly.
- In particular, the gap between Japan and other major countries is widening in the university sector.

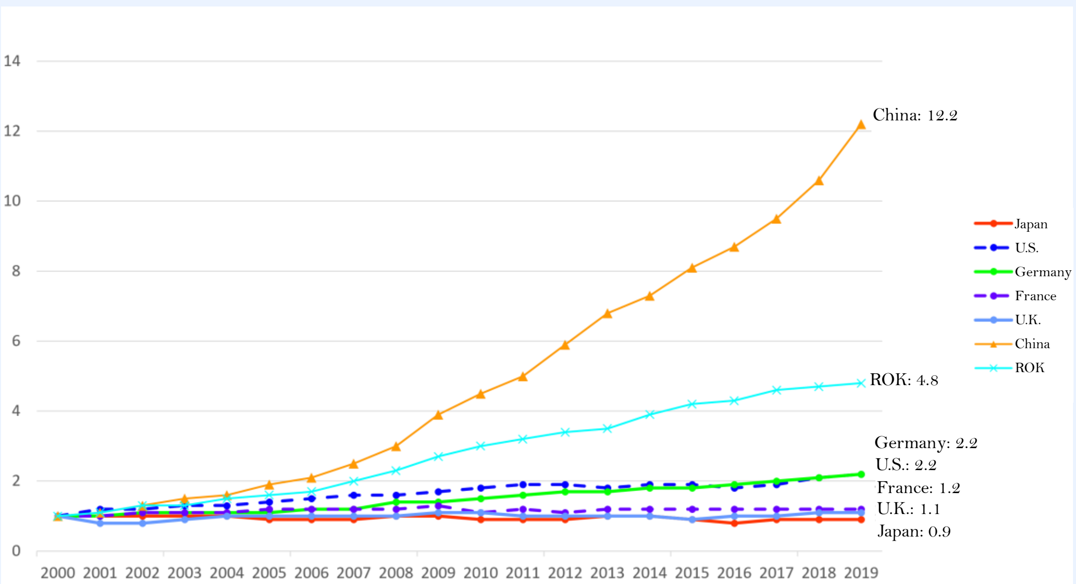
■ Figure 1-1-30/ Index of R&D expenditures in university sector (nominal amount (OECD purchasing power parity equivalent)) on a 2000 base year



Note: The figure for Japan is based on full-time equivalent personnel expenses for university faculty members for international comparisons (provided by the OECD).

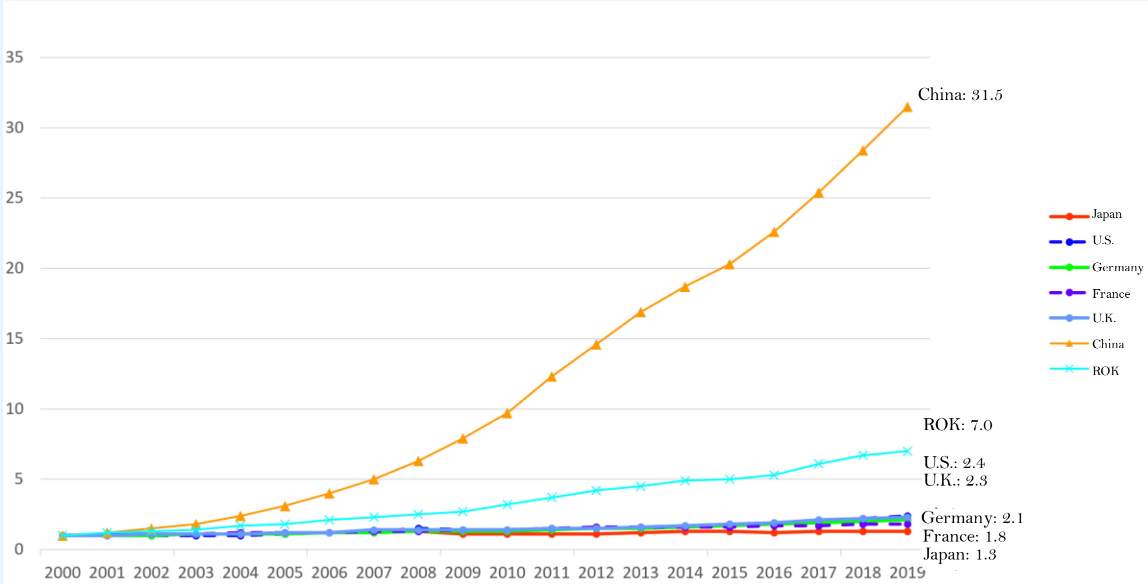
Source: Prepared by MEXT based on the NISTEP “Japanese Science and Technology Indicators 2021”

■ Figure 1-1-31/ Index of R&D expenditures in public institution sector (nominal amount (OECD purchasing power parity equivalent)) on a 2000 base year



Source: Prepared by MEXT based on the NISTEP “Japanese Science and Technology Indicators 2021”

■ Figure 1-1-32/ Index of R&D expenditures in business enterprise sector (nominal amount (OECD purchasing power parity equivalent)) on a 2000 base year



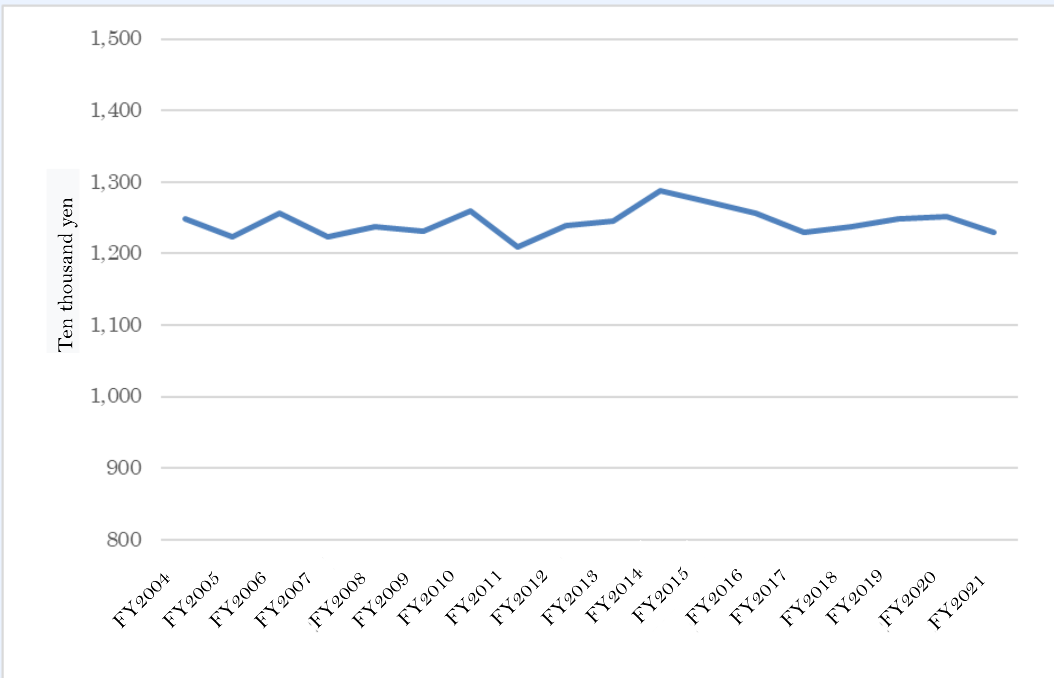
Source: Prepared by MEXT based on the NISTEP "Japanese Science and Technology Indicators 2021"

5 Research Expenditure per Full-time Researchers in University Sector

Figure 1-1-33 shows the changes in research expenditure per full-time researcher in the university sector.

- Research expenditure per full-time researcher in the university sector remains unchanged at 12.48 million yen in FY 2004 and 12.3 million yen in FY 2021.

■ Figure 1-1-33/ Changes in research expenditure per full-time researcher



Source: Prepared by MEXT based on the "Report on the Survey of Research and Development" by the Ministry of Internal Affairs and Communications, Japan

Section 5 International Brain Circulation

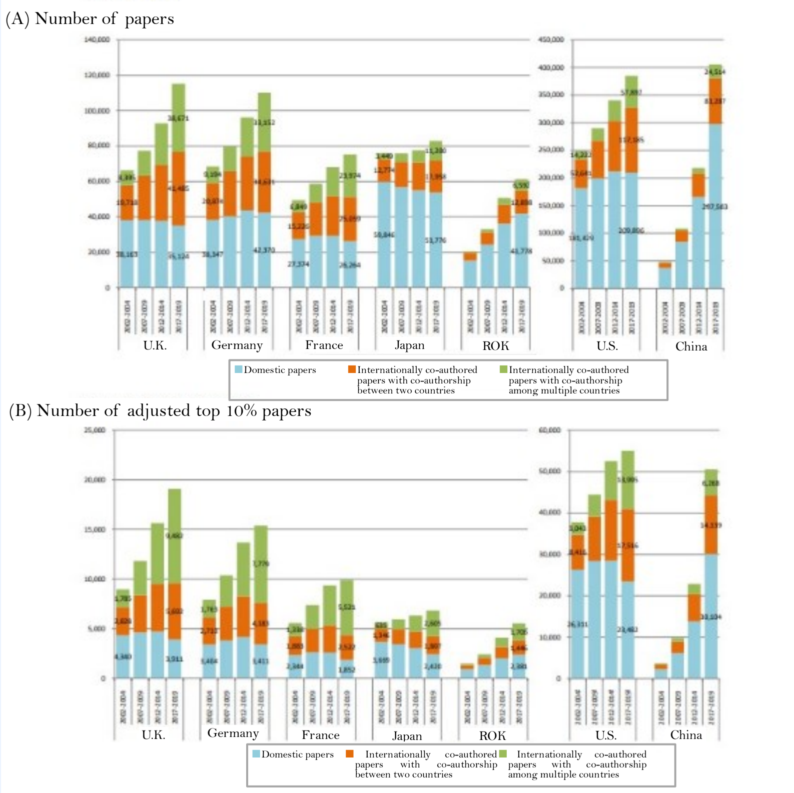
Although the percentage of internationally co-authored papers is increasing in Japan, it is still lower than in the U.K., Germany, and France. As for the number of researchers dispatched abroad, the number for short-term dispatch for less than 6 months is rising, while the number for mid-to-long-term dispatch is stagnant. Furthermore, doctoral degree recipients in the U.S. have dropped by half in the last decade.

1 Domestic Papers and Internationally Co-authored Papers in the Number of Papers and Number of Adjusted Top 10% Papers in Major Countries

Figure 1-1-34 shows the number of domestic papers (the number of papers written only by researchers belonging to domestic research institutions) and the number of internationally co-authored in the number of papers, and the number of adjusted top 10% papers in major countries.

- (A) The number of internationally co-authored papers has increased in each county. However, unlike the U.K., Germany, and France, Japan has more domestic papers than internationally co-authored papers.
- (B) Japan has fewer adjusted top 10% papers than the U.K., Germany, and France. Also, similar to the U.K., Germany, and France, the number of internationally co-authored papers is larger than that of domestic papers.

■ Figure 1-1-34/ Changes in domestic papers and internationally co-authored papers in the number of papers and number of adjusted top 10% papers (whole counting)



Note: Articles and Reviews are included in the analysis and analyzed using whole counting. Shows the 3-year average.
Aggregated by NISTEP based on Clarivate Web of Science XML (SCIE, 2020 Year-end Version).

Source: "Benchmarking Scientific Research 2021," the NISTEP, MEXT

Figure 1-1-35 compares the ratio of international co-authorship for major countries between 2007 -2009 and 2017-2019.

- The ratio of international co-authorship for Japan has increased by 10.1 percentage points in 10 years to 35.2%; however, the increase in ratio is higher for the U.K., Germany, France, and the United States.

■ Figure 1-1-35/ Relationship between domestic and internationally co-authored papers

	Ratio of international co-authorship						Number of internationally co-authored papers	
	2007-2009			2017-2019 (Figures in parentheses show changes from 2007-2009)			2007-2009 (Mean value)	2017-2019 (Mean value)
		Papers with co-authorship between two countries	Papers with co-authorship among multiple countries		Papers with co-authorship between two countries	Papers with co-authorship among multiple countries		
U.K.	50.6%	32.3%	18.3%	69.5% (+19.0 percentage points)	36.0% (+3.7 percentage points)	33.5% (+15.3 percentage points)	39,157	80,156
Germany	49.3%	31.8%	17.5%	61.5% (+12.3 percentage points)	31.4% (-0.4 percentage points)	30.1% (+12.6 percentage points)	39,186	67,783
France	50.2%	32.1%	18.1%	65.1% (+14.9 percentage points)	33.3% (+1.2 percentage points)	31.8% (+13.7 percentage points)	29,482	49,033
U.S.	31.2%	23.5%	7.7%	45.5% (+14.2 percentage points)	30.4% (+6.9 percentage points)	15.0% (+7.3 percentage points)	90,535	175,082
Japan	25.1%	18.7%	6.4%	35.2% (+10.1 percentage points)	21.7% (+3.0 percentage points)	13.5% (+7.1 percentage points)	19,011	29,158
China	22.3%	18.6%	3.8%	26.6% (+4.3 percentage points)	20.5% (+2.0 percentage points)	6.0% (+2.3 percentage points)	24,241	107,801
ROK	26.5%	21.2%	5.4%	31.8% (+5.3 percentage points)	21.1% (-0.1 percentage points)	10.8% (+5.4 percentage points)	8,781	19,490

Articles and Reviews are included in the analysis and analyzed using the whole counting. A paper with co-authorship among multiple countries indicates a paper with joint participation from research institutions of three or more countries.
Source: "Benchmarking Scientific Research 2021," the NISTEP, MEXT

Figure 1-1-36 shows the ratio of the number of adjusted top 10% papers to the total number of papers (Q index).

- In recent years, Japan's Q index has been the lowest among the countries listed here.
- In particular, the Q index of domestic papers, that account for about 65% of all papers in Japan, has been declining year by year, and the ratio of decline is larger than that of other countries.
- The Q index of internationally co-authored papers in Japan has been increasing yearly as in other countries and is slightly lower than that of other countries.
- In all countries, the Q index of internationally co-authored papers is higher than that of domestic papers.

The above shows that the Q index of Japan is low among major countries, especially the Q index of domestic papers has been declining.

■ Figure 1-1-36/ Ratio of Q index for domestic papers and internationally co-authored papers (two countries and multiple countries)

Percentage of adjusted top 10% papers

	Publication Year (PY)	Overall	Domestic papers	Internationally co-authored paper(s)		
					Papers with co-authorship between two countries among internationally co-authored papers	Papers with co-authorship among multiple countries among internationally co-authored papers
U.K.	2002-2004	13.5%	11.4%	16.4%	14.3%	21.3%
	2007-2009	15.3%	12.0%	18.4%	15.1%	24.3%
	2012-2014	16.8%	12.5%	19.8%	15.2%	26.1%
	2017-2019	16.6%	11.1%	18.9%	13.7%	24.5%
Germany	2002-2004	11.5%	8.9%	15.0%	13.1%	19.2%
	2007-2009	13.0%	9.4%	16.7%	13.5%	22.6%
	2012-2014	14.2%	9.5%	18.2%	13.5%	24.6%
	2017-2019	14.0%	8.1%	17.6%	12.1%	23.5%
France	2002-2004	11.2%	8.6%	14.6%	12.4%	19.5%
	2007-2009	12.6%	8.9%	16.2%	12.6%	22.4%
	2012-2014	13.7%	8.9%	17.4%	12.1%	24.5%
	2017-2019	13.1%	7.1%	16.4%	10.1%	23.0%
U.S.	2002-2004	15.2%	14.5%	17.1%	16.0%	21.4%
	2007-2009	15.3%	14.2%	17.7%	15.7%	23.8%
	2012-2014	15.4%	13.4%	18.7%	16.1%	25.2%
	2017-2019	14.3%	11.2%	18.0%	14.9%	24.2%
Japan	2002-2004	7.4%	6.1%	12.2%	10.5%	18.4%
	2007-2009	7.8%	6.0%	13.2%	10.7%	20.8%
	2012-2014	8.2%	5.5%	14.5%	10.6%	23.1%
	2017-2019	8.2%	4.5%	15.1%	10.1%	23.3%
China	2002-2004	7.6%	6.1%	12.7%	11.6%	18.4%
	2007-2009	9.0%	7.3%	15.0%	13.8%	21.1%
	2012-2014	10.5%	8.3%	17.2%	15.4%	24.8%
	2017-2019	12.5%	10.1%	18.9%	17.0%	25.6%
ROK	2002-2004	7.2%	5.9%	11.0%	9.9%	16.2%
	2007-2009	7.3%	5.5%	12.3%	10.3%	20.1%
	2012-2014	8.1%	5.6%	14.5%	11.0%	24.1%
	2017-2019	9.0%	5.7%	16.2%	11.2%	25.9%

Articles and Reviews are included in the analysis and analyzed using the whole counting. Shows the 3-year average

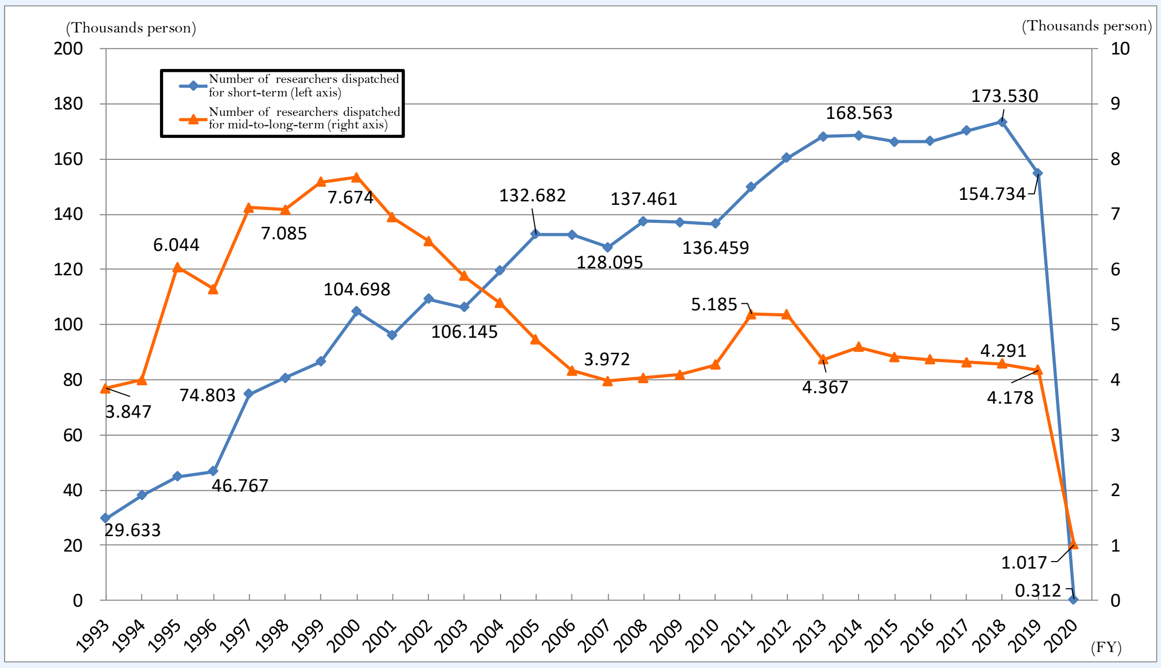
Source: Prepared by NISTEP based on the NISTEP "Benchmarking Scientific Research 2021"

2 Researchers Dispatched Abroad

Figure 1-1-37 shows the changes in the number of researchers dispatched abroad by national, public and private universities and Incorporated Administrative Agencies by classifying them into short-term (maximum period of stay of one month) and mid-to-long-term (period of stay exceeding one month).

- The number of short-term researchers dispatched has been trending upward since the start of the survey, but in FY 2020, there was a significant decrease compared to the previous year.
- The number of mid-to-long-term researchers dispatched began to decline from FY 2001 and has remained nearly the same, but in FY 2020, there was a significant decrease compared to the previous year.
- The significant decrease in FY 2020 was because of the 3 months affected by the COVID-19 pandemic from January to March 2020 in FY 2019, whereas it was the entire year in FY 2020.

■ Figure 1-1-37/ Changes in the number of researchers dispatched abroad (short-term and mid-to-long-term)



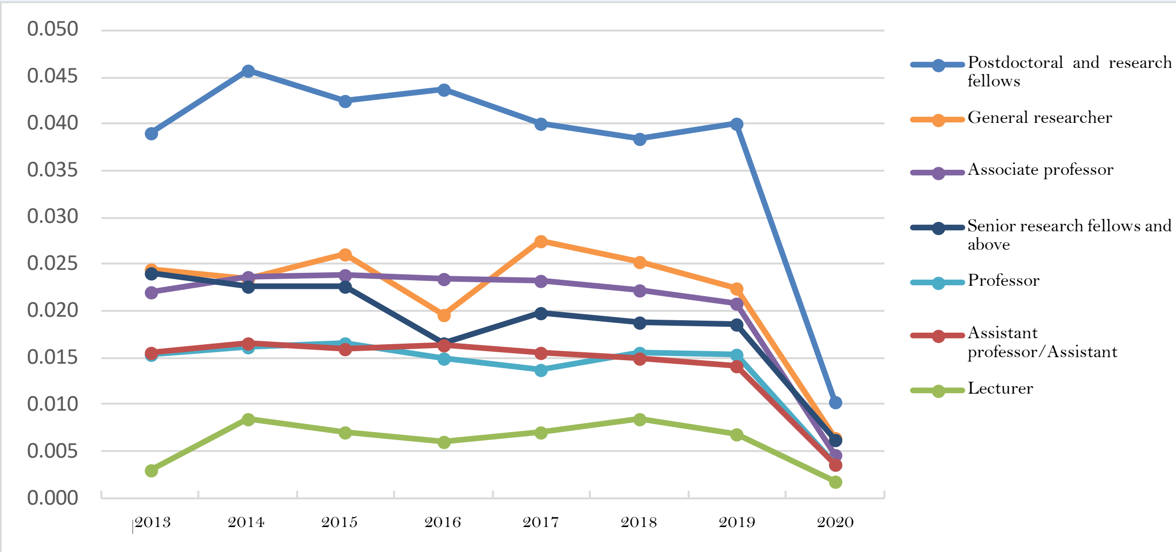
Source: Prepared by MEXT based on the "Survey on International Researcher Mobility," Science and Technology Testing and Research Commissioned Projects, 2021

3 Ratio of Researchers Dispatched Abroad (Mid-to-Long-Term) to Researchers Enrolled at Research Institutions

Figure 1-1-38 shows the changes in the ratio of researchers dispatched abroad (mid-to-long-term) to researchers enrolled at research institutions.

- In FY 2020, the ratio declined significantly from the previous year due to the impact of COVID-19.
- The ratio of postdoctoral and research fellows was the highest, followed by general researchers and senior research fellows and above. On the other hand, the ratio of lecturers was the lowest.

■ Figure 1-1-38/ Ratio of researchers dispatched abroad (mid-to-long-term) to researchers enrolled at research institutions.



Note: "Short-term" refers to a maximum period of dispatch and acceptance of 30 days, and "Mid-to-long-term" refers to a period exceeding 30 days. (Doctoral course students are omitted).

Note: In the surveys conducted before FY 2007, it is unclear whether postdoctoral and research fellows should be included in the survey, but postdoctoral fellows were added from the FY 2008 survey, and postdoctoral and research fellows were added from the FY 2010 survey.

Note: The questionnaire was sent to 862 organizations [National universities (86), Inter-university research institute corporations (4), National, public and private colleges of technology (57), Public universities (94), and Private universities (621)]. The questionnaire was sent out to a total of 54 institutions [National research and development agencies (27), Incorporated administrative agencies (11), and national experiment and research institutions (16)]

Source: "Survey on International Researcher Mobility," Science and Technology Testing and Research Commissioned Projects, 2021

4 Changes in Doctoral Degree Recipients in the U.S.[1]

Table 1-1-39 shows the changes in doctoral degree recipients in the U.S.

- Compared to 2012, the number for Japan has decreased to less than half in 2020, which is the highest percentage of decrease among the countries listed.
- In 2020, Japan had 114 research doctorate recipients, which is about one-tenth of the number in Rep. of Korea.

■ Table 1-1-39/ Changes in doctoral degree recipients in the U.S. by country and region

Country	2012	2014	2016	2018	2020	2020 (% with 2012 as baseline)
Japan	240	173	166	117	114	47.5
China (Including Hong Kong)	4,222	4,982	5,527	6,188	6,337	150.1
India	2,248	2,316	2,195	2,045	2,256	100.4
Rep. of Korea	1,472	1,284	1,229	1,040	1,054	71.6
Germany	200	203	183	144	150	75.0
U.K.	91	97	115	109	119	122.7
France	110	115	105	133	118	107.3

Note: All figures for China, India and Rep. of Korea are published as of 2020
All figures for Germany, the U.K., and France are published as of the respective years
For Japan, 2012, 2014, and 2016 figures are published in 2016; 2018 and 2020 figures are published as of the respective years
Source: Prepared by MEXT based on NSF, Science and Engineering Indicators, "Survey of Earned Doctorates"

1 Research doctorates

Section 6 Patents, Technology Trade, and Cooperation between Industry and Academia

Japan maintains[1] the first place in the number of patent families. As for the trade balance, Japan's high-technology industries (pharmaceuticals, electronic equipment, aircraft and spacecraft) have import surpluses, while the medium-high-technology industries have export surpluses. In addition, the amount and number of joint research projects conducted by Japanese universities, etc., with private enterprises are on the rise.

1 Number of Patent Families

Table 1-1-40 shows the changes in the top 10 countries/regions regarding the number of patent families.

- Japan maintained its first place in the number of patent families, an internationally comparable measure of inventions produced in each country/region that focuses on patent applications.

■ Table 1-1-40/ Number of patent families in major countries/regions (top 10 countries/regions)

1994–1996 (PY) (Average)			
Country/region name	Number of patent families (whole counting)		
	Count	Share	Ranking
U.S.	28,002	28.4	1
Japan	26,830	27.3	2
Germany	16,573	16.8	3
France	6,194	6.3	4
U.K.	5,268	5.4	5
Rep. of Korea	3,767	3.8	6
Italy	2,841	2.9	7
Switzerland	2,333	2.4	8
Netherlands	2,102	2.1	9
Canada	2,072	2.1	10

2004–2006 (PY) (Average)			
Country/region name	Number of patent families (whole counting)		
	Count	Share	Ranking
Japan	60,827	29.9	1
U.S.	49,259	24.2	2
Germany	28,459	14.0	3
Rep. of Korea	18,273	9.0	4
France	10,467	5.1	5
U.K.	8,735	4.3	6
Taiwan	7,957	3.9	7
China	7,355	3.6	8
Italy	5,146	2.5	9
Canada	5,139	2.5	10

2014–2016 (PY) (Average)			
Country/region name	Number of patent families (whole counting)		
	Count	Share	Ranking
Japan	61,955	26.0	1
U.S.	54,272	22.8	2
Germany	27,217	11.4	3
Rep. of Korea	23,430	9.8	4
China	23,359	9.8	5
France	11,153	4.7	6
Taiwan	10,087	4.2	7
U.K.	8,581	3.6	8
Canada	5,168	2.2	9
Italy	4,790	2.0	10

Source: "Japanese Science and Technology Indicators 2021," NISTEP, MEXT

1 Patent families are groups of patent applications to 2 or more countries that are directly or indirectly linked through priority rights. Generally, patent applications made to several countries with the same content belong to the same patent family.

2 Number of Papers Cited in Patent Families

Table 1-1-41 shows the number of papers by country/region cited in patent families.

- Japan has the third highest number of papers cited in patent families after the U.S. and Germany.

■ Table 1-1-41/ Number of papers cited in patent families: Top 25 countries/regions

1981-2016 (total number)					
Country/ region name	(C) Number of papers cited in patent families			(C) Percentage of (D) in the number of papers	Ranking based on (D)
	Number of papers				
	Count	Share	Ranking		
U.S.	367,448	35.0	1	4.3	1
Germany	72,754	6.9	2	3.3	12
Japan	72,642	6.9	3	3.4	11
U.K.	72,244	6.9	4	3.3	13
France	47,671	4.5	5	2.9	17
China	46,555	4.4	6	1.9	21
Canada	38,858	3.7	7	3.1	15
Italy	31,909	3.0	8	2.8	18
Netherlands	25,954	2.5	9	3.9	4
Rep. of Korea	22,857	2.2	10	3.5	9
Switzerland	21,808	2.1	11	4.2	3
Australia	21,171	2.0	12	2.6	19
Spain	20,294	1.9	13	2.4	20
Sweden	18,128	1.7	14	3.5	8
Belgium	13,556	1.3	15	3.7	6
India	13,343	1.3	16	1.5	22
Taiwan	11,867	1.1	17	3.0	16
Israel	11,140	1.1	18	3.8	5
Denmark	10,398	1.0	19	3.6	7
Austria	8,870	0.8	20	3.5	10
Finland	7,557	0.7	21	3.2	14
Russia	6,820	0.6	22	0.7	25
Brazil	6,730	0.6	23	1.3	24
Singapore	6,550	0.6	24	4.3	2
Poland	6,109	0.6	25	1.5	23

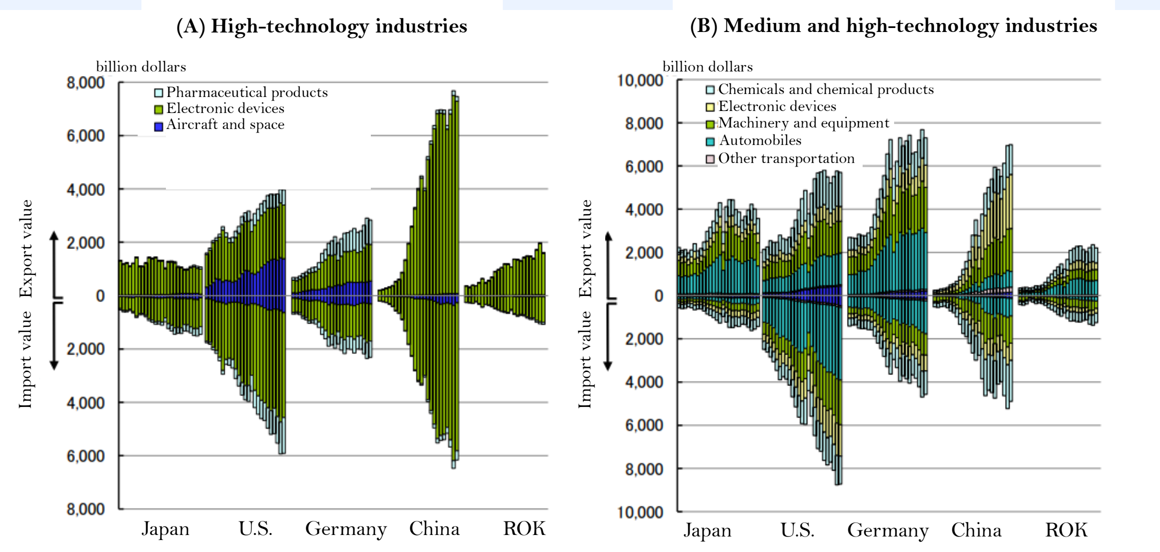
Source: "Japanese Science and Technology Indicators 2021," NISTEP, MEXT

3 Changes in Industrial Trade Volume in Major Countries

Figure1-1-42 shows changes in industrial trade value in major countries.

- In terms of trade volume in the high-technology industries (pharmaceuticals, electronic equipment, aircraft and spacecraft), the figure is increasing in many countries where "electronic devices" accounts for the majority of both imports and exports. The trade balance ratios (the latest year for each country) show that Japan and the U.S. have surplus imports (trade deficit) while Germany, China and Rep. of Korea have surplus exports (trade surplus).
- In terms of export volume in medium and high-technology industries (the latest year for each country), Japan and Germany dominate in "automobiles," the U.S. and Rep. of Korea in "chemicals and chemical products," and China in "electronic devices." The trade balance ratios show that Japan, Germany, China and Rep. of Korea have surplus exports, while the U.S. has surplus imports.

■ Figure 1-1-42/ Changes in industrial trade value in major countries



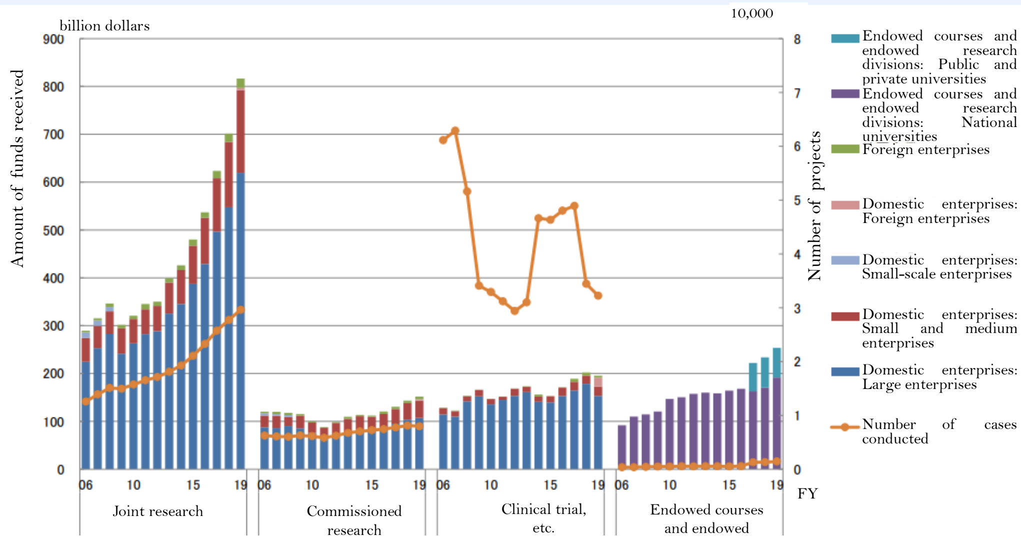
Source: Prepared by MEXT based on the NISTEP "Japanese Science and Technology Indicators 2021"

4 Joint Research Projects between Universities and the Private Enterprises

Figure 1-1-43 shows the changes in the amount and number of joint research projects conducted by Japanese universities, etc. with private enterprises.

- The amount of funds received for research projects shows an increase in all categories, as seen in the figure, with a particularly sharp increase in joint research.
- Except for clinical trials, the number of published research papers is also on the rise, with a significant increase in the area of joint research.

■ Figure 1-1-43/ Changes in the amount received (breakdown) and the number of joint research projects between Japanese universities and the private enterprises



Note:
1) Joint research: Joint research and development between institutions and private enterprises, where the other party funds the research. Until FY 2008, the amount of funds received and number of papers published were categorized into small and medium enterprises, small scale enterprises and large enterprises.
2) Commissioned research: Research and development commissioned by private enterprises and conducted primarily by universities, with expenses covered by the private enterprises.
3) Clinical trials, etc.: Clinical research on pharmaceutical products and medical devices commissioned by external organizations and conducted primarily by universities, with required expenses covered by the consignor. In addition, histopathological examinations and similar tests and studies.
4) Endowed courses and endowed research divisions: Figures available only for national universities until FY 2016. Figures for public and private universities were collected beginning in FY 2017. The "Number of projects" for endowed courses and endowed research divisions refers to the "number of courses and divisions."

Document:
Recalculated by NISTEP using individual data from "Status of Industry-Academia Collaboration at Universities " (obtained on April 26, 2021), MEXT.

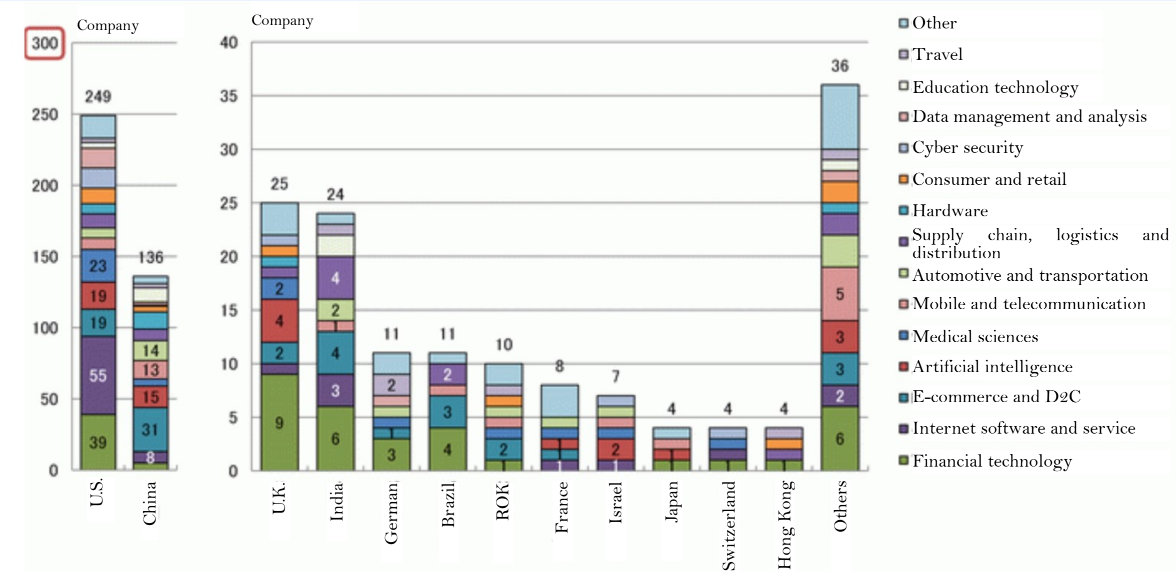
Source: "Japanese Science and Technology Indicators 2021," NISTEP, MEXT

5 Number of Unicorn Enterprises

Figure 1-1-44 shows the number of unicorn enterprises in major countries, classified by industry.

- There are few unicorn enterprises in Japan compared to other major countries, while there are a significantly large number of unicorn enterprises in the U.S. and China.

■ Figure 1-1-44/ Number of unicorn enterprises by industry and country (total of 2010 to 2020)



Note: 1) Prepared by NISTEP based on data of unlisted enterprises with a corporate value of $1 billion or more (as of April 22, 2021) that were identified as unicorn enterprises in a survey by CB Insights.

2) The items presented by CB Insights were provisionally translated by NISTEP for the classification. D2C is an abbreviation for direct-to-consumer.

3) The year in which the corporate value was determined to be $1 billion or more by CB Insights.

Document: Downloaded from the CB Insights website on May 27, 2021.

Source: "Japanese Science and Technology Indicators 2021," NISTEP, MEXT