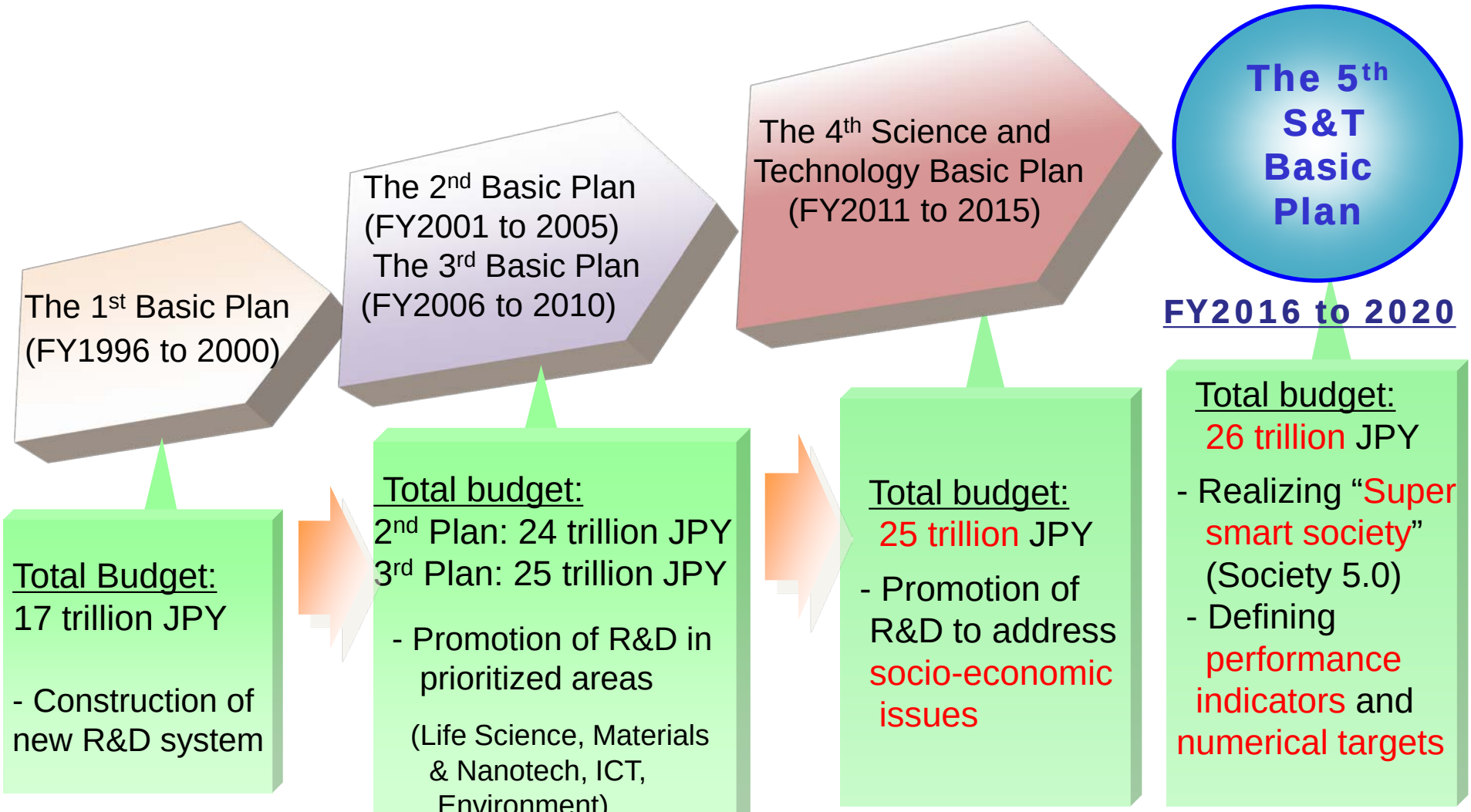
# Recent Trends and Challenges of Science and Technology Policy in Japan

– based upon results from surveys and analyses by NISTEP–

September 2020

# Contents

# S&T Basic Plans: Historical development




(Source) The Cabinet Office, Revised by NISTEP

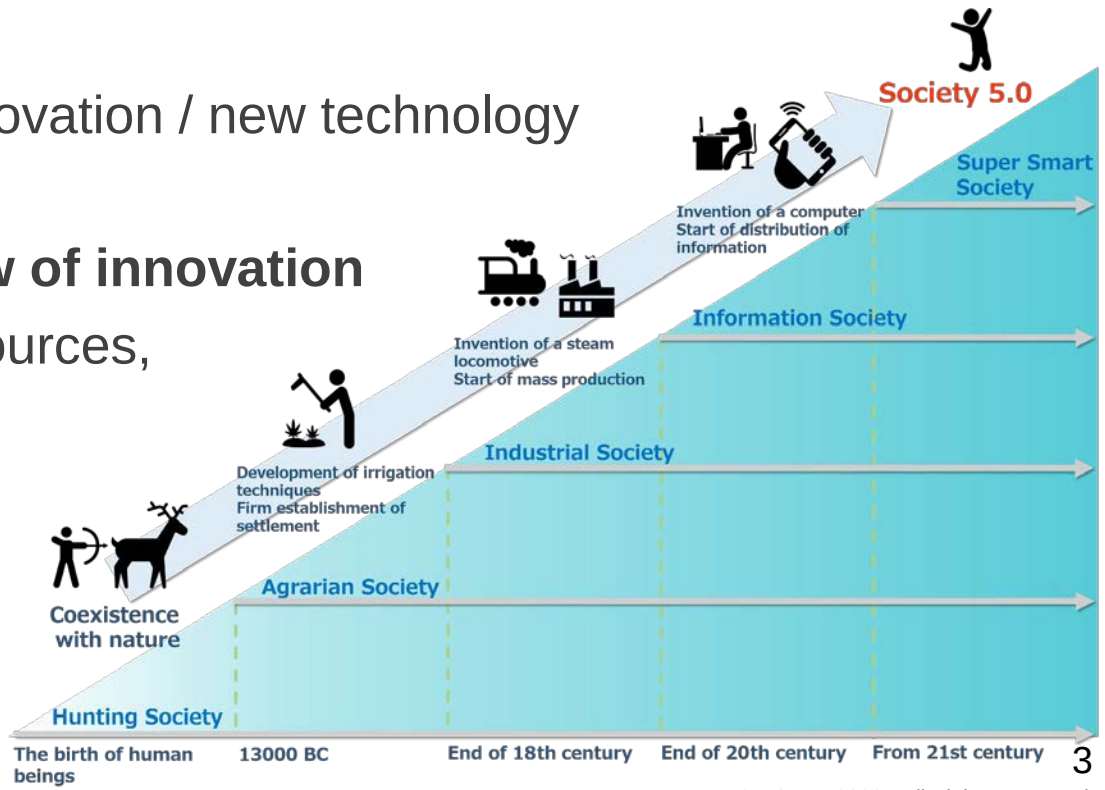
# The 5th S&T Basic Plans (2016 -2020)

## Social vision through STI

- Society 5.0
  - merging real world and cyber space
  - offering finely differentiated customized services that meet diverse user needs
  - a society where people live a comfortable, vigorous life
- Vision-driven
- Transformative power of innovation / new technology

## Introduction of systemic view of innovation

- Virtuous cycle of human resources, knowledge, and capital




(Visual source) Keidanren (Japan Business Federation)

# The Council for Science, Technology and Innovation (CSTI)

- The Council for Science, Technology and Innovation (CSTI) was reorganized in 2014 (from CSTP) in the Cabinet Office to enhance the functions related to the creation of innovation.
- Under the leadership of the Prime Minister and the Minister of State for Science and Technology Policy, CSTI serves as the headquarters for promoting STI policy.
- CSTI has three key missions: 1) investigate and discuss basic policies concerning science and technology (S&T), 2) investigate and discuss S&T budgets and the allocation of human resources, and 3) assess Japan's key research and development.

## Executive Members (assigned by the Prime Minister <as of April 2020>)

Academia

**Dr. UEYAMA Takahiro**
(Full-time member)

Industry

**Ms. KAJIWARA Yumiko**
Managing Officer,
Fujitsu Ltd.

Academia

**Dr. KOTANI Motoko**
Professor,
Tohoku University

Industry

**Dr. KOBAYASHI Yoshimitsu**
Chairman,
Japan Association of
Corporate Executives

Industry

**Mr. SHINOHARA Hiromichi**
Chairman of the Board, Nippon Telegraph and Telephone Corporation

Academia

**Dr. HASHIMOTO Kazuhito**
President,
The National Institute
of Materials Science

Academia

**Dr. MATSUO Seiichi**
President,
Nagoya University

Head of an Affiliated Organization

**Dr. YAMAGIWA Juichi**
President,
Science Council of Japan

(Source) The Cabinet Office

# Outline: Toward aiming at following-up process of the S&T Basic Plan

## Decision of the 5th S&T Basic Plan by the Cabinet (Jan. 2016)

- The Council for Science, Technology and Innovation (CSTI) submitted a recommendation on the Fifth Science and Technology Basic Plan to Prime Minister's Cabinet Office, and then, the Cabinet has decided the 5th S&T Basic Plan, along the line with the recommendation by CSTI in January 2016, describing future directions of Japan's S&T and innovation policy for the next 5 years starting in FY2016.

- The Special Committee within MEXT's Council for Science and Technology, as well as Experts Committee of CSTI, has proceeded with discussions on this topic using survey and research data such as TEITEN Survey and S&T Foresight provided by NISTEP.

- Topics discussed by CSTI included "*the building of a super-smart society*," "*integrated reform of competitive funds with universities*," "*promotion of 'open science' and 'open innovation*,'" and "*creation of SMEs and venture companies, challenging for new business*."

- NISTEP is trying to follow up progresses of the S&T Basic Plan, including promotion of S&T Foresight and establishment of the PhD Database, both of which were explicitly stated in the 5th S&T Basic Plan.

# Japanese administrative structure to promote STI

**Prime Minister**

Reformed in 2014
CSTP ⇒ CSTI

**The Cabinet Office**

**The Council for Science, Technology and Innovation (CSTI)**
S&T Basic Plan, Resource Allocation Policy ……

**Ministry of Education, Culture, Sports, Science and Technology (MEXT)**
文部科学省

⇄

Other Ministries
METI, MAFF, MHLW …

**795** Universities*

- 86 National universities
- 94 Public universities
- 615 Private universities

* FY2020 School Basic Survey

**10** Public research institutes

- **3** Funding Agencies
  JSPS, JST, AMED
- **7** R&D Institutions
  e.g. JAMSTEC, JAXA, NIMS …

**4** Inter-University Research Institute Corporations (**15** institutions)

(Source) MEXT

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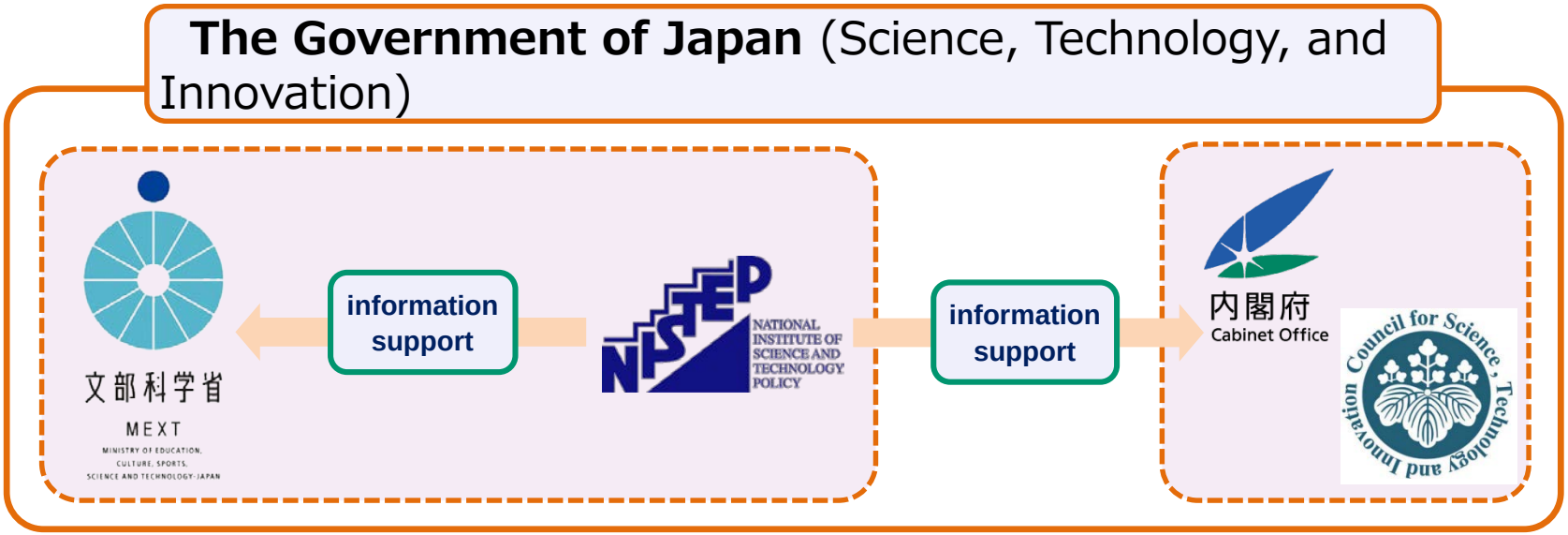
# About NISTEP

**NISTEP** is a national institution established under the direct jurisdiction of the Ministry of Education, Culture, sports, Science and Technology (MEXT) to be engaged in the Japanese government's science and technology policy-planning process.




## Mission

1. To forecast future policy issues and investigate them through autonomous research
2. To carry out research in response to requests from government agencies
3. To be a core institution in the field of science and technology policy research

# Brief history & outline of NISTEP

## History

1988：National Institute of Science and Technology Policy was established (restructured from the National Institute of Resources)
2001：Ministry of Education, Culture, Sports, Science and Technology (MEXT) was formed due to administrative reform. NISTEP became an affiliated research institute under MEXT. The Science and Technology Foresight Center was founded as a part of NISTEP.
2013：Reorganized the structure of NISTEP (Japanese organization's name)
2016：Reorganized the structure of NISTEP (Group restructured)
2018: International symposium of the 30th Anniversary

## Major Research Activities

- **Analysis of Science and Technology and Academic Activities**
- **Analysis of the Innovation Process**
- **Science of Science, Technology and Innovation Policy**
- **Science and Technology Foresight, and Science and Technology Trends**

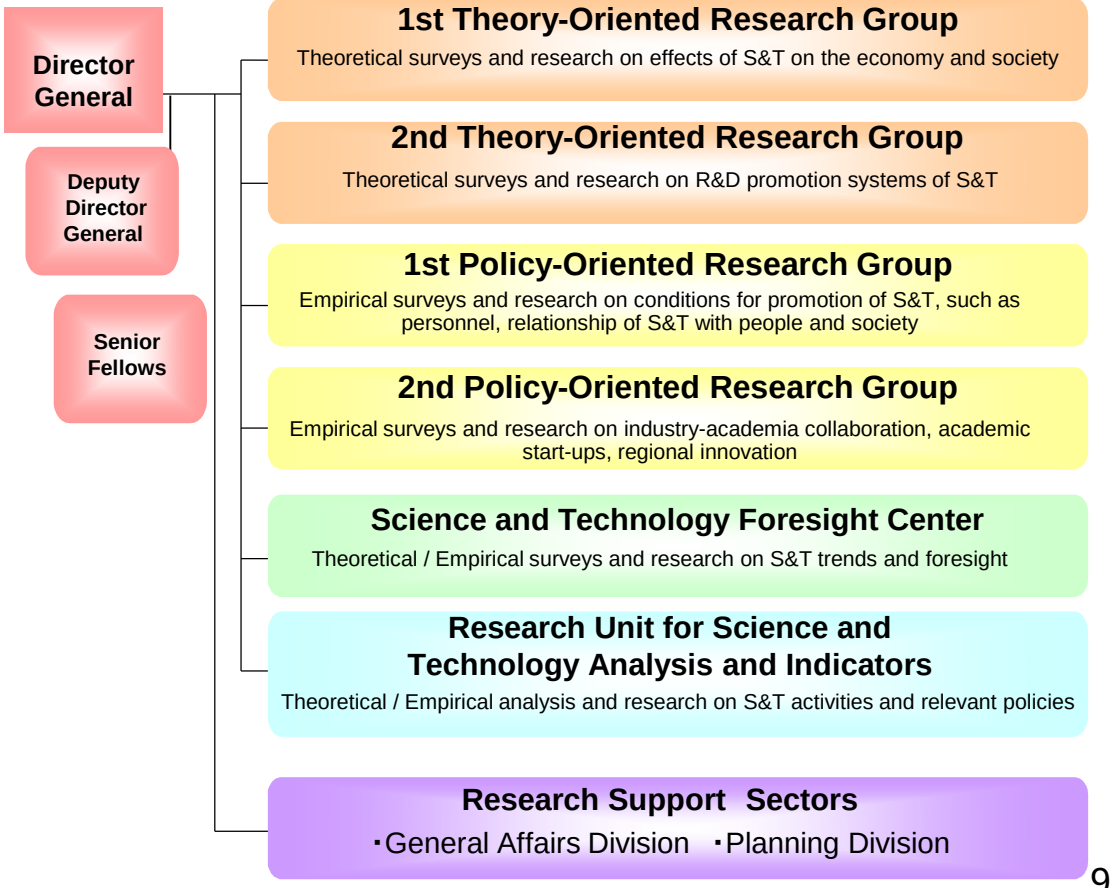
## Budget

Approx. 8.4 Hundred Million Yen ($7.9M US)

## Organization and Personnel

Staff: 44 (about 37 Research Staff incl. Visiting Researchers)

[ *As of FY2020 ]



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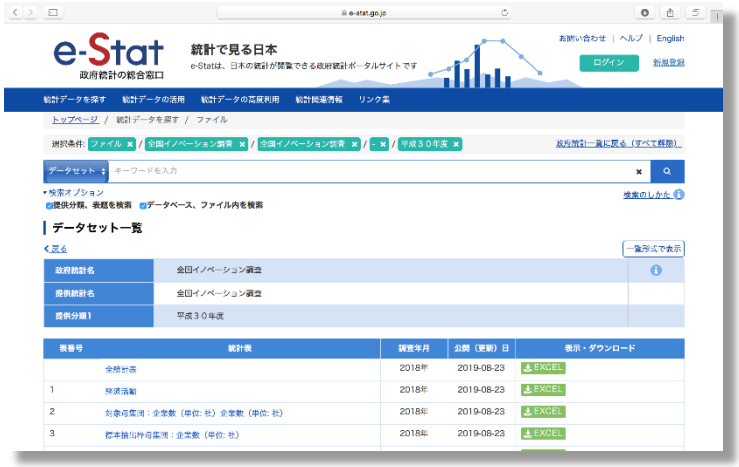
# Japanese National Innovation Survey 2018 (J-NIS 2018) (1/5)
## Outlines of the J-NIS 2018

- J-NIS 2018 is an official statistical survey on innovation in Japan. It is designed to be internationally comparable by following the definitions and recommendations in the *Oslo Manual 2018*, international guidelines for collecting, reporting, and using data on innovation, published by OECD and Eurostat. The target population consists of the enterprises in almost all of the economic activities (industries) that are located in Japan. The results were published in the form of a report, *NISTEP Report*, No. 182, as well as statistical tables (e-Stat).
- J-NIS 2018 reveals some features of the recent innovation system in Japan.

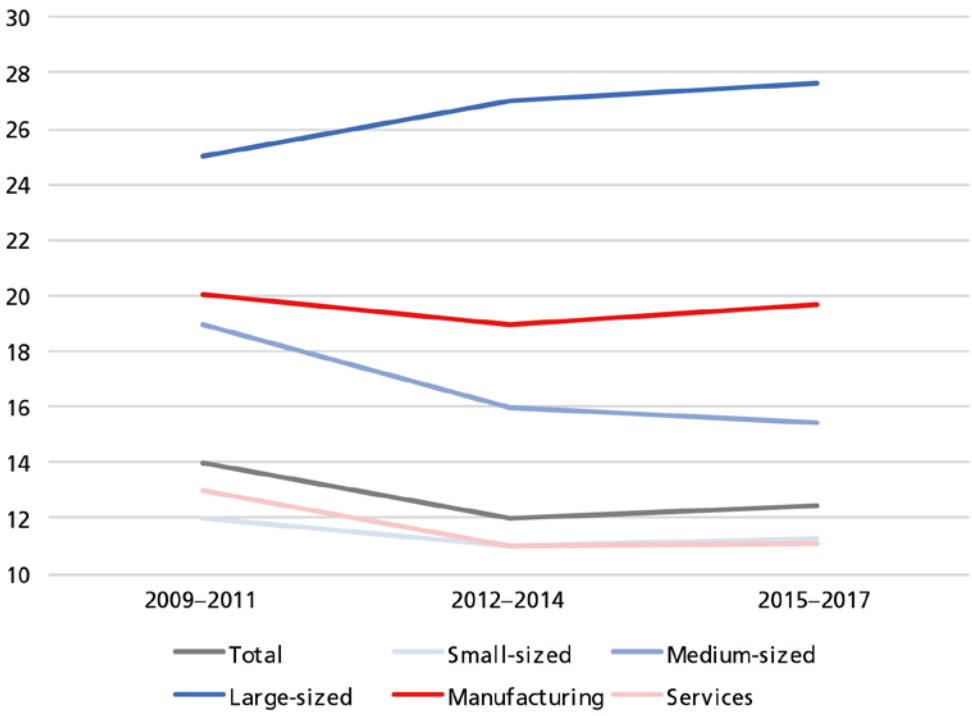




*Source:* NISTEP (2019) "Report on the Japanese National Innovation Survey 2018 (J-NIS 2018)," *NISTEP Report*, No.182, National Institute of Science and Technology Policy, Tokyo. https://doi.org/10.15108/nr182 .

# Japanese National Innovation Survey 2018 (J-NIS 2018) (2/5)
## Issues of medium-sized enterprises

- In the three years from 2015 to 2017, 12% of the enterprises realised product innovations. In particular, less and less ratios of the medium-sized enterprises (50-249 persons employed) tend to realise product innovations in the recent three rounds of survey, although the same or more ratios of them receive public financial supports as those of the large-sized enterprises (250 or more persons employed).

Figure 1.6 Ratios of product innovative firms (Trend): Proportion to the total of the firms (%)




*Sources:* Japanese National Innovation Survey 2018 (J-NIS 2018), NISTEP, Statistical Table 14; "Report on the Fourth Round of the Japanese National Innovation Survey (J-NIS 2015)," *NISTEP Report*, No.170, NISTEP; "Report on the Japanese National Innovation Survey 2012," *NISTEP Report*, No.156, NISTEP.

# Japanese National Innovation Survey 2018 (J-NIS 2018) (3/5)
## Gross turnover from product innovations in Japan

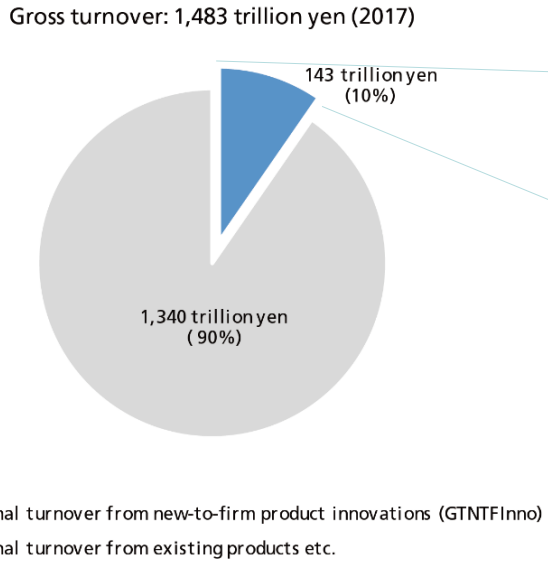
- It is likely that gross national turnover from *new-to-firm* product innovations increases, and gross national turnover from *new-to-market* (i.e. higher in novelty) product innovations, on the other hand, decreases.

Table 5.3 Gross turnover and gross national turnover from product innovations: Trend

| | | 2014 | 2017 | Change rate |
|---|---|---|---|---|
| **Gross turnover** | (trillion yen) | 1,342 | 1,483 | 10% |
| Gross national turnover from new-to-firm product innovations (GTNTFInno) | (trillion yen) | 105 | 143 | 36% |
| Gross national turnover from new-to-market product innovations (GTNTMInno) | (trillion yen) | 42 | 31 | -27% |
| Target population | (enterprise) | 380,224 | 505,917 | – |

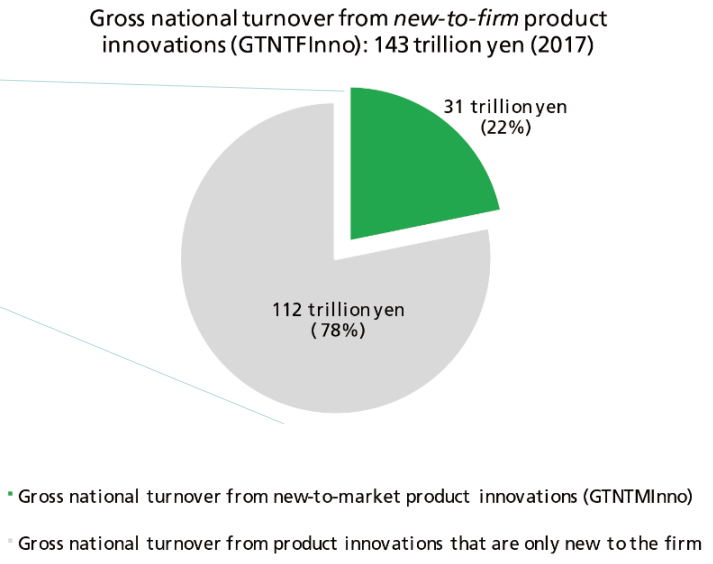
*Sources:* Japanese National Innovation Survey 2018 (J-NIS 2018), NISTEP, Statistical Table 47; "Gross national turnover from new-to-market product innovation (GTNTMInno): A newly proposed indicator on the impact of introducing new products to the market and the preliminary estimation," *NISTEP Research Material*, No.277, NISTEP.

Figure 5.1 Gross national turnover from *new-to-firm* product innovations (GTNTFInno) (2017): Total in Japan (trillion yen)




*Source:* Japanese National Innovation Survey 2018 (J-NIS 2018), NISTEP, Statistical Table 81.

Figure 5.2 Gross national turnover from *new-to-market* product innovations (GTNTMInno): Total in Japan (trillion yen)

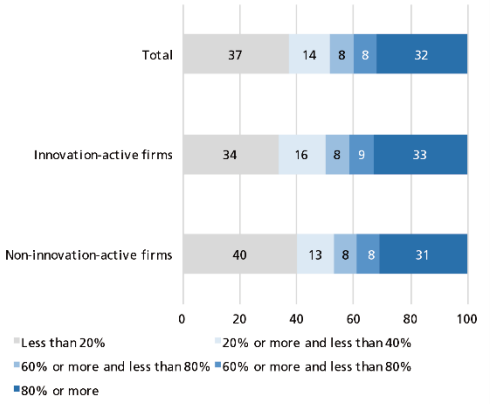



*Source:* Japanese National Innovation Survey 2018 (J-NIS 2018), NISTEP, Statistical Table 81.

# Japanese National Innovation Survey 2018 (J-NIS 2018) (4/5)
## Innovation personnel

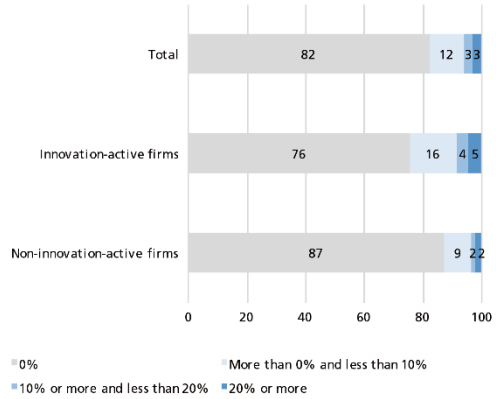
- Firms in terms of the ratios of persons who completed tertiary education are distributed in a bipolarised manner (in a U-shape).
- Persons who completed master or doctoral course in a graduate school and persons who hold a doctoral degree are employed by a very limited proportion of the firms.
- Nevertheless, the persons who completed master or doctoral course in a graduate school and the persons who hold a doctoral degree are employed more in the proportion by innovation-active firms rather than by non-innovation-active firms.

Figure 2.3 Ratios of persons who completed tertiary education to the total of the persons employed (2017): Distribution of proportions (%)



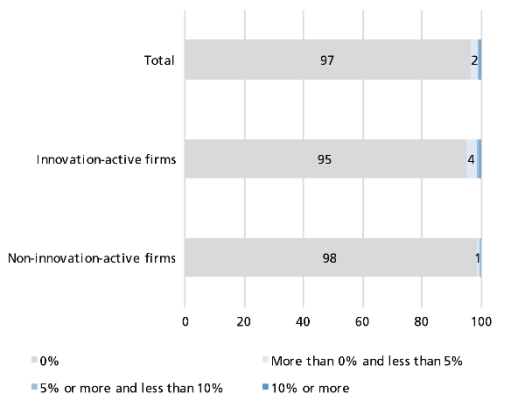

*Sources:* Japanese National Innovation Survey 2018 (J-NIS 2018), NISTEP, Statistical Tables 27–29.

Figure 2.4 Ratios of persons who completed master or doctoral course in a graduate school to the total of the persons employed (2017): Distribution of proportions (%)




*Sources:* Japanese National Innovation Survey 2018 (J-NIS 2018), NISTEP, Statistical Tables 27–29.

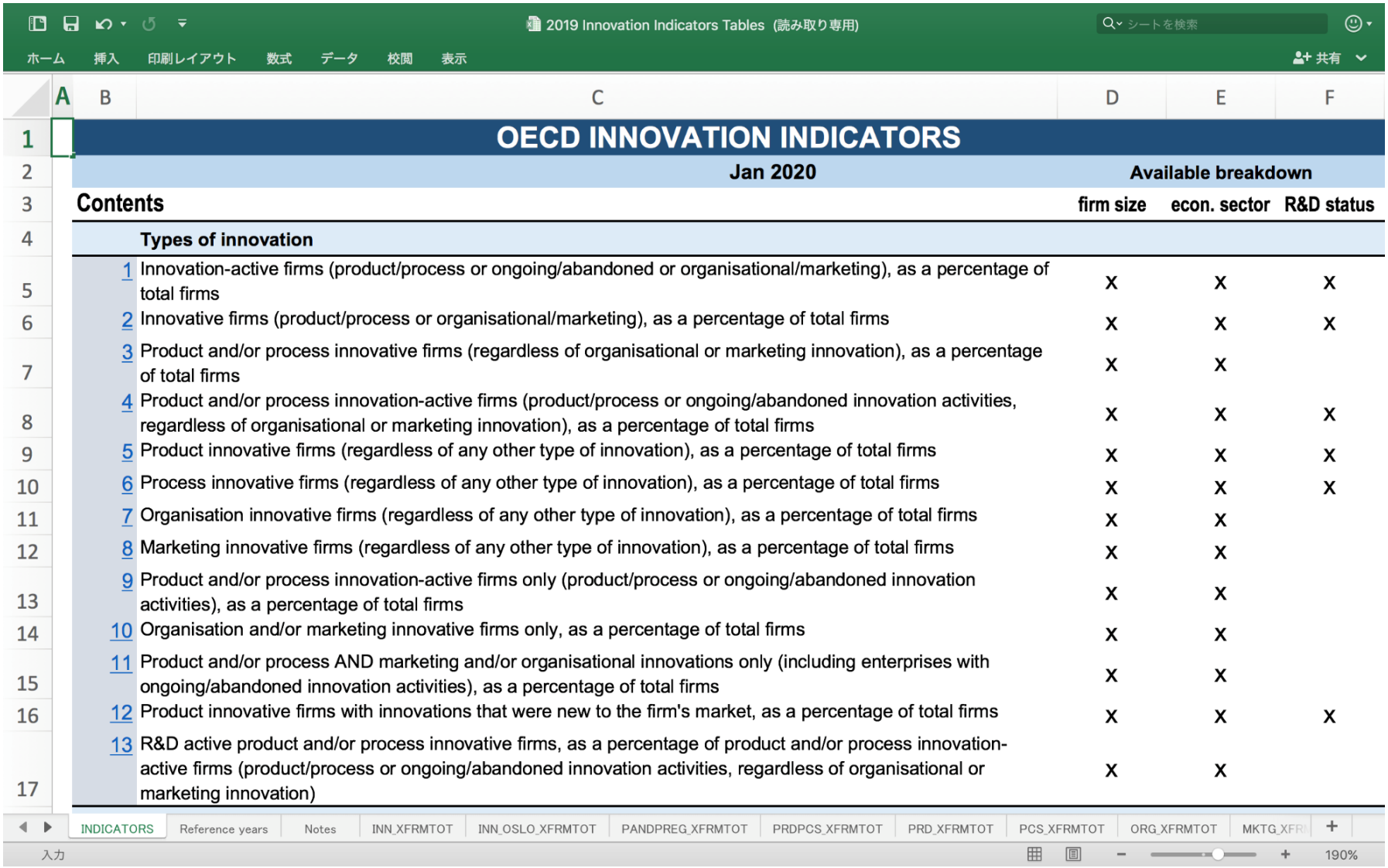
Figure 2.5 Ratios of persons who hold a doctoral degree to the total of the persons employed (2017): Distribution of proportions (%)




*Sources:* Japanese National Innovation Survey 2018 (J-NIS 2018), NISTEP, Statistical Tables 27–29.

# Japanese National Innovation Survey 2018 (J-NIS 2018) (5/5)
## Internationally comparable innovation indicators

- The results from J-NIS 2018 are also used as the data of Japan in the OECD Innovation Indicators, which consist of 36 indicators.


2019 Innovation Indicators Tables (読み取り専用)

ホーム 挿入 印刷レイアウト 数式 データ 校閲 表示

| | | Jan 2020 | Available breakdown | | |
|---|---|---|---|---|---|
| | Contents | | firm size | econ. sector | R&D status |
| | **Types of innovation** | | | | |
| 1 | Innovation-active firms (product/process or ongoing/abandoned or organisational/marketing), as a percentage of total firms | | X | X | X |
| 2 | Innovative firms (product/process or organisational/marketing), as a percentage of total firms | | X | X | X |
| 3 | Product and/or process innovative firms (regardless of organisational or marketing innovation), as a percentage of total firms | | X | X | |
| 4 | Product and/or process innovation-active firms (product/process or ongoing/abandoned innovation activities, regardless of organisational or marketing innovation), as a percentage of total firms | | X | X | X |
| 5 | Product innovative firms (regardless of any other type of innovation), as a percentage of total firms | | X | X | X |
| 6 | Process innovative firms (regardless of any other type of innovation), as a percentage of total firms | | X | X | X |
| 7 | Organisation innovative firms (regardless of any other type of innovation), as a percentage of total firms | | X | X | |
| 8 | Marketing innovative firms (regardless of any other type of innovation), as a percentage of total firms | | X | X | |
| 9 | Product and/or process innovation-active firms only (product/process or ongoing/abandoned innovation activities), as a percentage of total firms | | X | X | |
| 10 | Organisation and/or marketing innovative firms only, as a percentage of total firms | | X | X | |
| 11 | Product and/or process AND marketing and/or organisational innovations only (including enterprises with ongoing/abandoned innovation activities), as a percentage of total firms | | X | X | |
| 12 | Product innovative firms with innovations that were new to the firm's market, as a percentage of total firms | | X | X | X |
| 13 | R&D active product and/or process innovative firms, as a percentage of product and/or process innovation-active firms (product/process or ongoing/abandoned innovation activities, regardless of organisational or marketing innovation) | | X | X | |

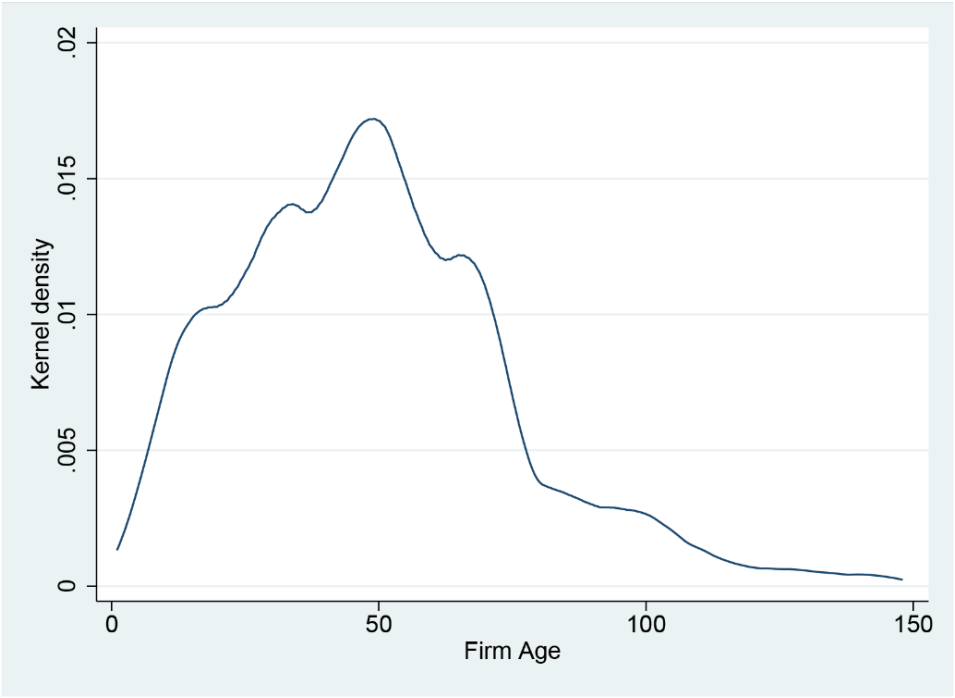
INDICATORS | Reference years | Notes | INN_XFRMTOT | INN_OSLO_XFRMTOT | PANDPREG_XFRMTOT | PRDPCS_XFRMTOT | PRD_XFRMTOT | PCS_XFRMTOT | ORG_XFRMTOT | MKTG_XFR

入力 190%

# An example of analysis using the data from J-NIS 2018
## Firm ages and innovations

- The analysis shows that there is no statistical significance in the relationship between firm ages and incidents of realising product innovations. This suggests that older firms are not inferior in realising product innovations to younger firms.

Distribution of firm ages (year)




Logit regression results

| | Odds ratio | Robust S.E. | *p*-value |
|---|---|---|---|
| Firm age (ln) | 1.099 | 0.063 | 0.099 |
| Firm size (ln) | 1.230 | 0.028 | 0.000 |
| In-house R&D (1/0) | 12.372 | 1.012 | 0.000 |
| (N of competitors) (1/0) | | | |
| 0 | 0.487 | 0.100 | 0.000 |
| 1-4 | 1.138 | 0.109 | 0.176 |
| 5-9 | 1.177 | 0.117 | 0.100 |
| 10-14 | 1.194 | 0.136 | 0.120 |
| 15-49 | 1.427 | 0.143 | 0.001 |
| 50 or more | - | - | - |
| Constant term | 0.015 | 0.004 | 0.000 |
| Economic activities (1/0) | Yes | Yes | Yes |
| N of observations | 8,328 | | |
| Pseudo loglikelihood | -3,213 | | |
| Wald $\chi^2$ | 1,442 (*p*-value=0.000) | | |

*Source:* Translated from Ikeda, Y. and Ijichi, T. (2019) "Firm ages and innovations: Are older firms inferior to younger firms?," *STI Horizon*, vol.5, no.4, pp.26–30. https://doi.org/10.15108/stih.00197 .

# Contents

# "Survey on R&D Activities of Firms in the Private Sector"
# Implementation ratios of R&D in selected fields/objectives

This survey item is to grasp the status of implementation of "**R&D in selected fields/objectives**" by companies, that are difficult to comprehend by existing statistics in spite of these importance.

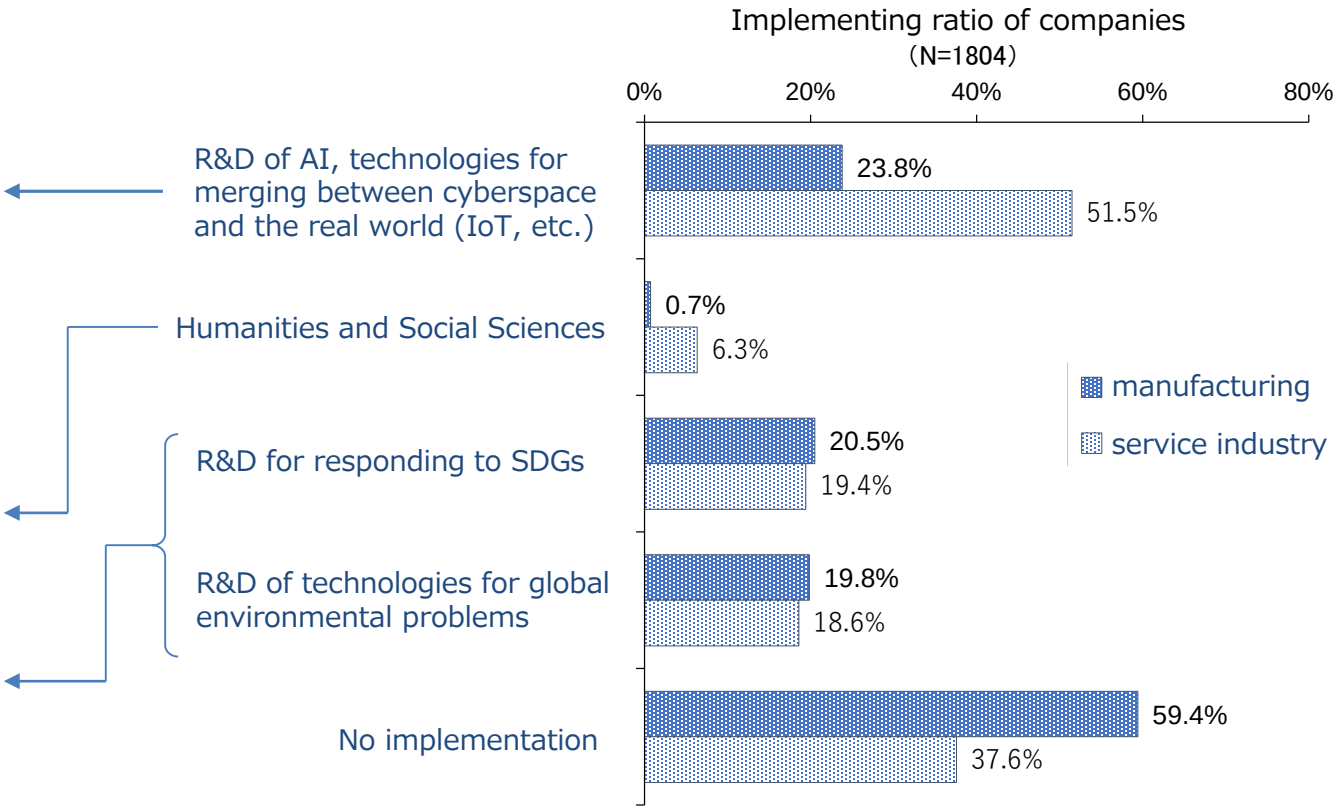
Major points:

**The implementation ratio of service industry (*) is more than twice of the ratio of manufacturing.**

(*) Industries having high ratio are Information services, Transport & postal services, Electricity, gas, heat supply & water, etc..

**The ratios are low, 0.7% for the product industry, 6.3% for the service industry.**

**The ratios of product industry and service industry are nearly the same.**




"**Technologies for merging between cyberspace and the real world**" is mentioned in the 5th Science and Technology Basic Plan as core technologies toward realizing "Society 5.0".

"**R&D for responding to SDGs**" does not mean R&D of SDGs-related contents but R&D aims to respond to SDGs itself

# "Survey on R&D Activities of Firms in the Private Sector"
# Recruiting R&D personnel by academic degree

This survey item is to look at trends of recruiting R&D personnel by academic degree.

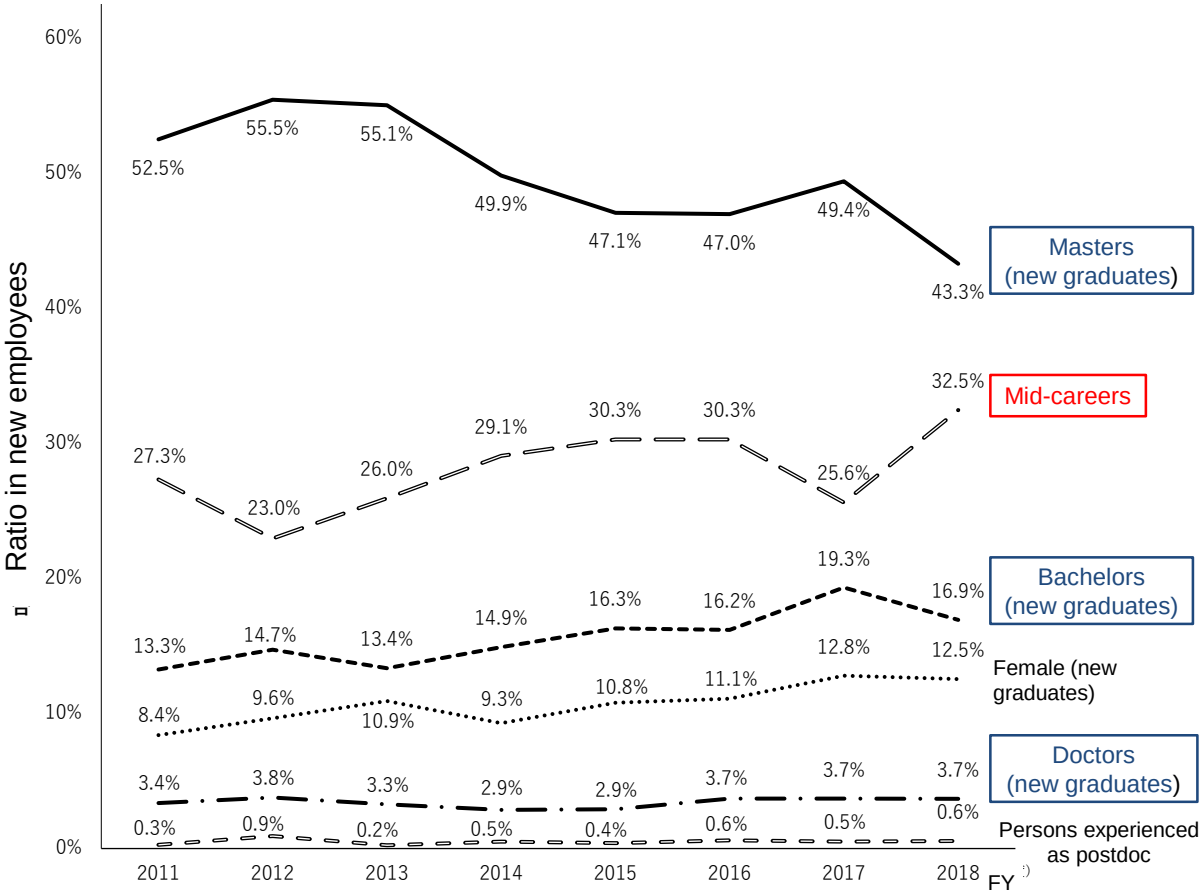
Major points:

The ratio of masters (new graduates) has been the largest in all categories but decreasing since FY2013, except FY2017.

The increase of the ratio of mid-career recruitment is a remarkable recent trend, and the ratio in FY2018 recorded the largest ever.

The ratio of bachelors (new graduates) decreased in FY2018, but it has been in increasing trend in medium-term

The ratio of doctors (new graduates) has been at a low level
⇒ Needs of the highly-skilled are not high

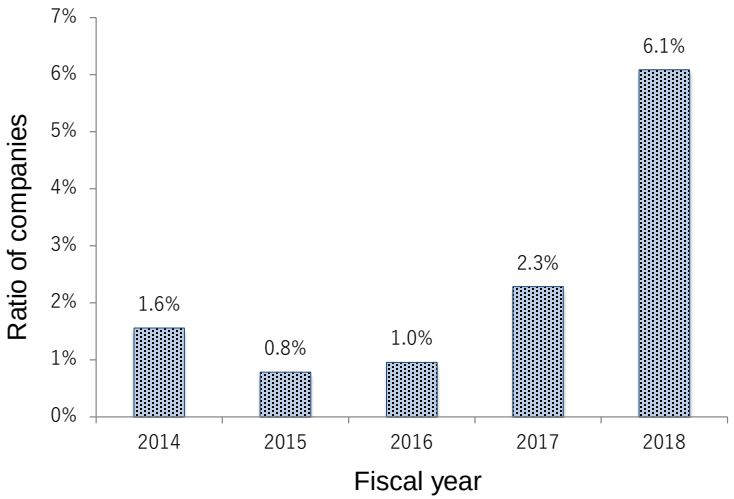



Note: The total of ratios of every academic degree does not become 100% because some companies answered only total number of recruiting R&D personnel.

# Receiving supports from government programs for public procurement for R&D

The figure below and the figure in the next page show major result of this survey item

Trend of ratios of companies receive supports through public procurement for R&D




Major points:

1～2% until FY2017

↓ **increased remarkably**

6.1% in FY2018

## What is "public procurement for R&D"?

Public procurement for R&D is one of government measures to support R&D activities of business companies, but it is not R&D funding, rather "*public organizations become customers and procure goods and services of small businesses or startups*" (*) to promote innovation.

(*) Source: Cabinet Office, "Guideline to stimulate public procurement and to facilitate utilize small businesses and startups"

**Public procurement for R&D is recognized as an effective government measure broadly in the world.**

## Recent policy development in Japan

- Law to stimulate science and technology activities and innovation (Law, no.63, 2008; Amendment of law, no.94, 2018)
  - ➔ The law requires central government, local governments, public research institutes and national universities "to make efforts to enlarge business opportunities for small businesses conducting innovative R&D"
- Cabinet Office, "Guideline to stimulate public procurement and to facilitate utilize small businesses and startups" (April 1st, 2019)
- Cabinet Office, "Open Innovation Challenges" (2017, 2019)
  - ➔ A program to stimulate public procurement for small businesses or startups

# Receiving supports from government programs for public procurement for R&D

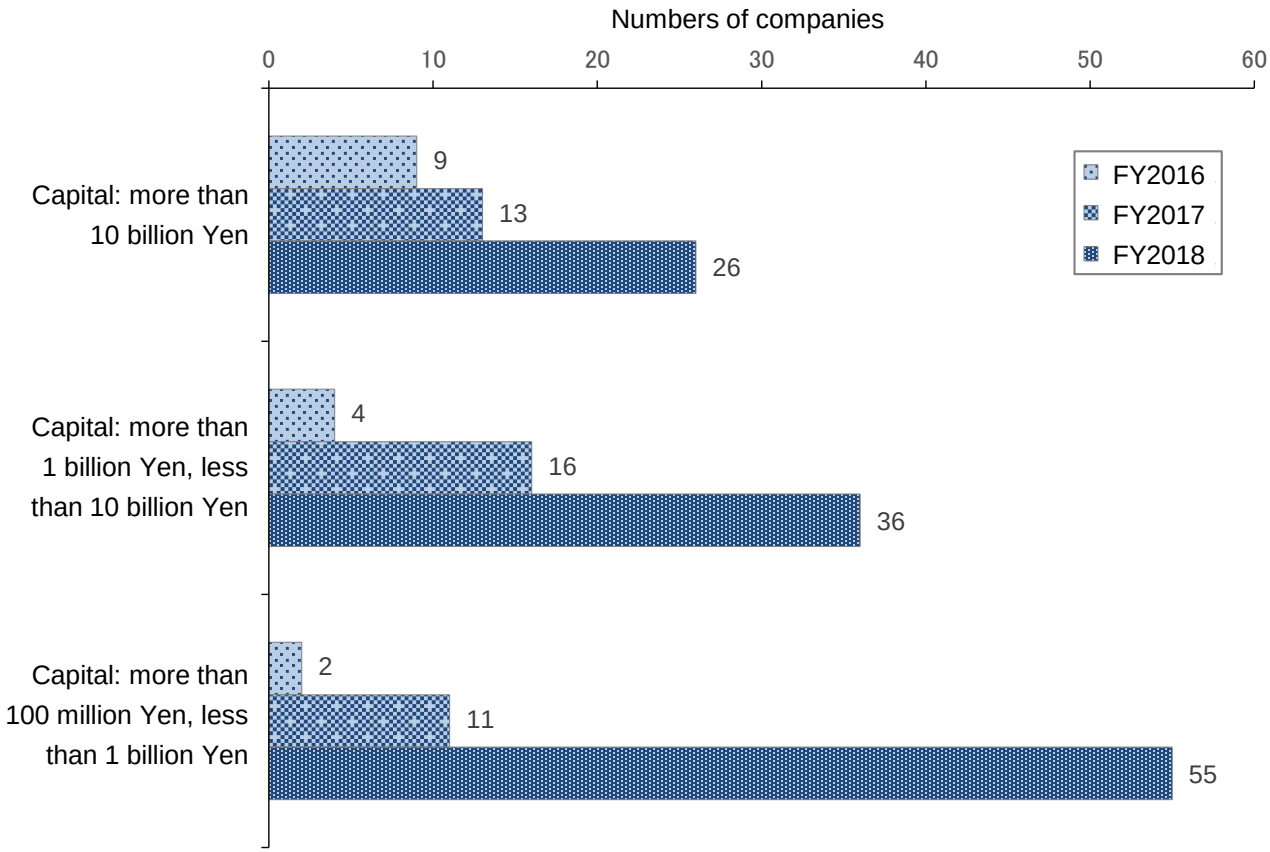
Major points:

In FY2016, the larger companies more received supports than the smaller companies.

But the tendency was reversed in FY 2018, i.e., the smaller companies more received supports than the larger companies from government through public procurement for R&D.

Since major targets of "public procurement for R&D" are small businesses and startups, the figure may reflect consequence of such government policies.

Numbers of companies receive supports through public procurement for R&D
(By capital class, FY2016-2018)



# Contents

# Japan Graduates Database (JGRAD)

JGRAD is an information infrastructure platform that NISTEP has been developing since 2014 in order to broadly understand the activities of doctoral researchers in society.

- **Over 21,000 users registered in 49 universities (May 2020)**
- **Information provided by JGRAD to registrants**
  - **Job information (provided by JREC-IN Portal)**
  - **Portal Site for Role Model Stories of Doctoral Personnel**
- **Future Improvement on usability**
  - **Access from mobile device**
  - **Automatic import of individual data from JST's "researchmap" and university database**

# Careers of Doctorate Holders

## Japan Doctoral Human Resource Profiling (JD-Pro)

The survey focuses on doctoral graduates who completed their courses in the specific year. Our goal is to grasp career paths of doctoral human resources by revealing their current status of employment and research activities.
Since 2015, our plan has been published every 3 years.
The 2nd and 3rd surveys targeted graduates in 2012 (the 2012 cohort) and graduates in 2015 (the 2015 cohort) about their current employment status.

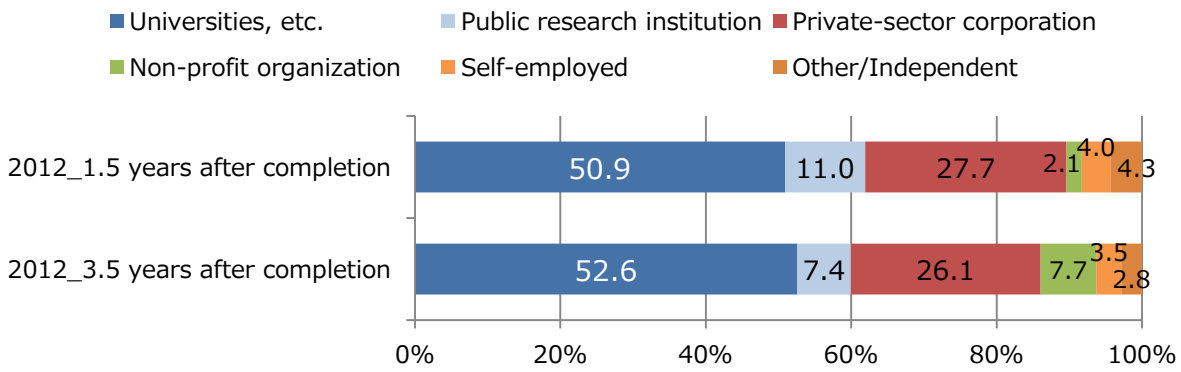
## Survey on Postdoctoral Fellows Regarding Employment and Careers in Japan

The aim of this study is analyzing young researchers' situation by understanding their employment status and career development focusing on postdoctoral fellows in universities and public research institutions.
This survey started in 2005 and conducted every year during 2004-2009, then conducted by MEXT and NISTEP every 3 years to today. It also became governmental statistical survey in 2015.
1,180 institutes cooperated for the latest survey in 2018, response rate was 100%.

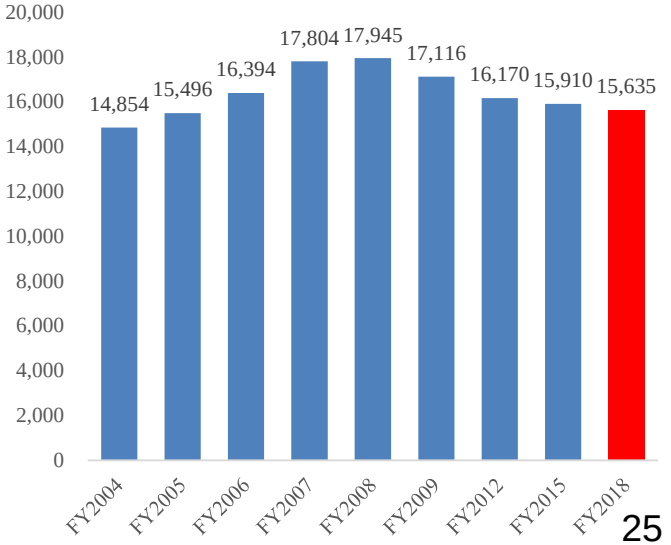
## The employment Status of Instructional Staff Members at Research Universities 11 (RU11)

The aim of this study is to clarify the employment status of instructional staff members at universities, especially those who is in the younger generation.
This survey is conducted by MEXT and NISTEP every 3 years.
Research Universities 11 cooperated in the latest survey in 2020.

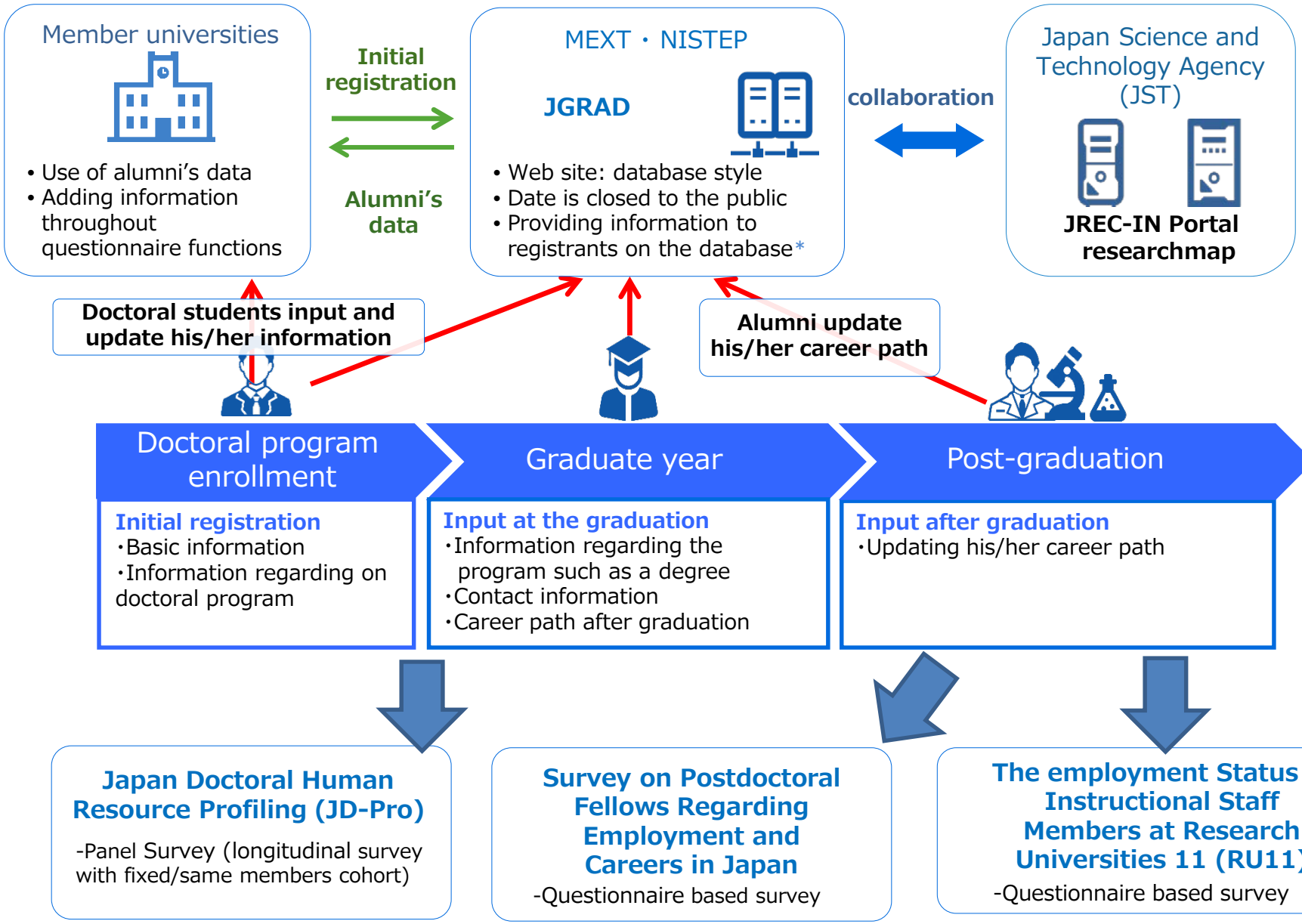
**An Example of Survey Items:**
**Status of Employment by organizations (2012 cohort)**




**An Example of Survey Items: The number of Post Doctoral Fellows**



# Careers of Doctorate Holders



# Public Attitudes to Science and Technology (S&T)

The 5th Science and Technology Basic Plan (2016-2020) of Japan stipulates that Science, Technology, and Innovation has to get understanding, trust, and support from the society in order to meet social expectations, thus the Japanese government is addressing themselves to communicate and collaborate with various stakeholders in the society.

Spreading new S&T into the society, it is necessary to get public comprehension and acceptance. In this sense, it is required to grasp public attitudes (trust, expectation, anxiety, etc.) to S&T. In the recent survey, not only public attitudes to S&T, but also natural disasters were investigated.

The survey resulted in public attitudes to S&T as follows:

【Survey Method】 Survey on the Internet

1) Total number of respondents (N)= 3,000 since 2016. (especially in March 2020, N = 1,500)
2) Target age of respondents: 15-69 years old
3) Number of sample was made equal according to each age group (15-69)

## ○ Temporal Change of Public Attitudes to Science and Technology

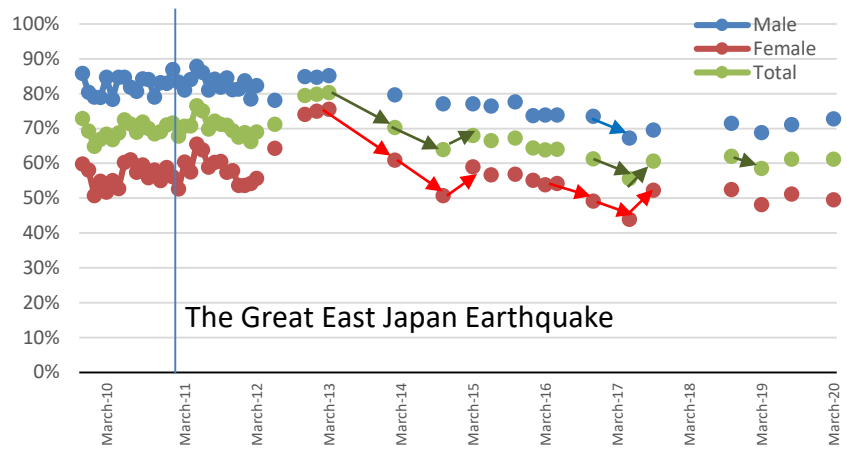



**Fig.1 Public Interest in Science and Technology**

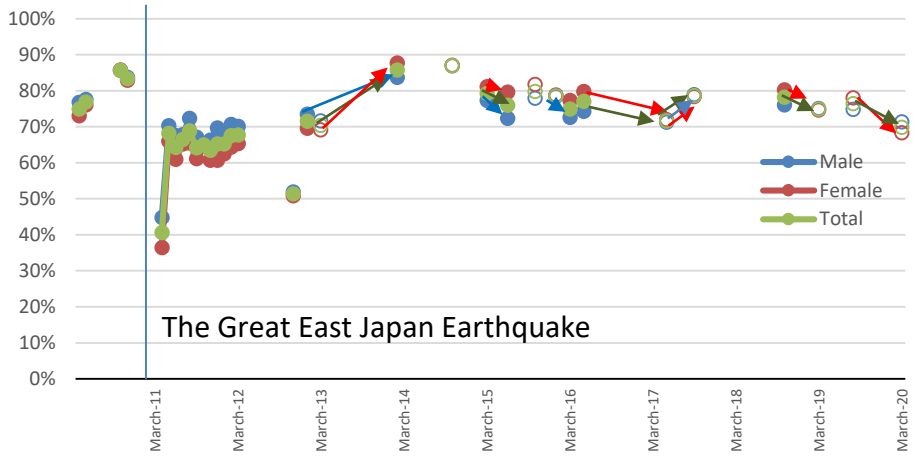



**Fig.2 Reliability of Scientists**

ce March 13 means statistical significant change.

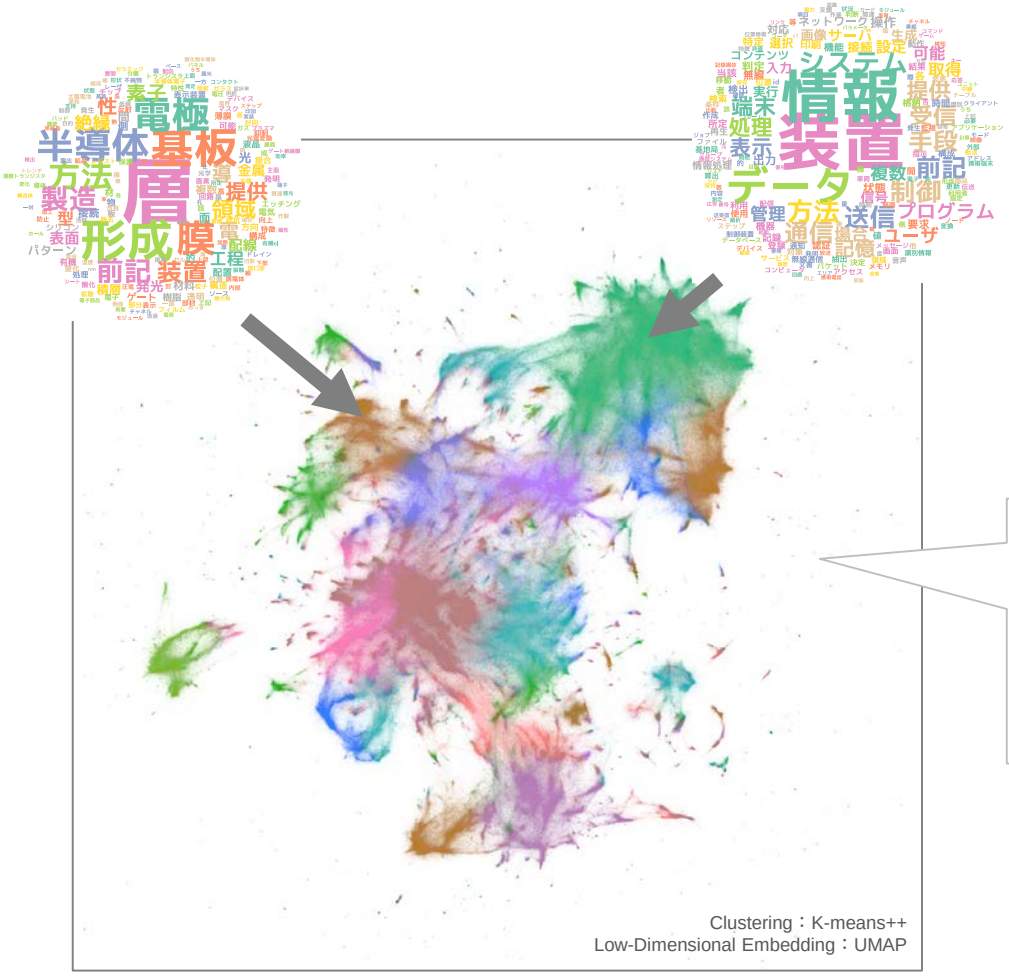
# Contents

# Patent analysis: characteristics of university-launched ventures, universities, companies, etc.

1. Mapping of approximately all of 4 million published patents gazettes by content similarity

← Analyze trends as a whole, beyond simple disciplinary classification

Development of a new scale of distance (similarity) between individual patents and a new classification axis that can detect interdisciplinary issues and grasp the relationship between fields.




**Overall picture and content characteristics of the patent space**

**Technical points:**

・With existing methods*1, it took several weeks to calculate the data, which was nearly 300TB.

・Calculated in units of several days, with about 6GB of data.

*1 Younge, K. A. and Kuhn, J. M.: Patent-to-Patent Similarity, SSRN (2016)

**Analytical point:.**

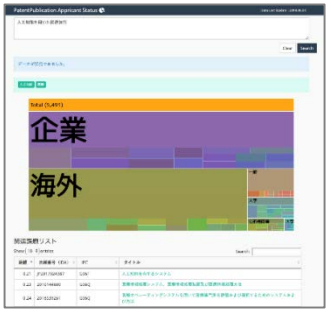
Defining the "distance" between patents based on the meaning*2, "how similar" is expressed numerically.

*2 Similarity calculation using Word Embedding

Each point is individually patented (about 4 million patents) (300 dimensions are reduced to 2 dimensions).

Color is the result of 16 classifications of nearby objects in 300 dimensional space.

Each classification was visualized with frequent words and characterized.




The information system for analysis and visualization has been constructed and is being utilized.

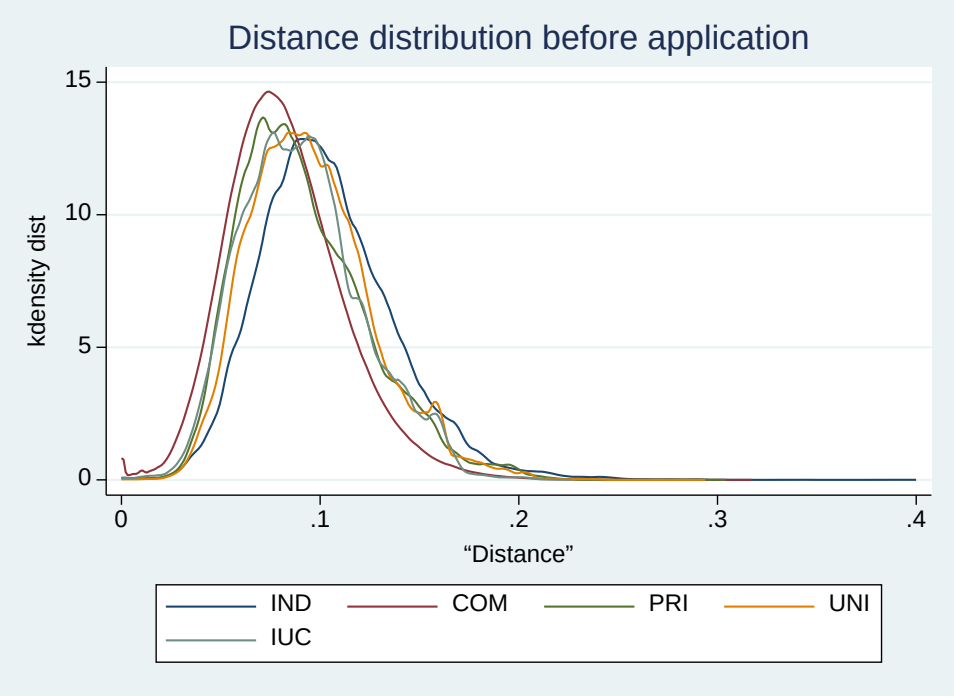
Tabulate and drill down by applicant type after a fuzzy search

Motohashi, et.al. : A method of extracting content information from patent documents and comparison of their characteristics by applicant type by using the vector space model of distributed expressions, NISTEP, DISCUSSION PAPER No.175, 2019

# Patent analysis: characteristics of university-launched ventures, universities, companies, etc.

2. Analysis of application trends and characteristics for each type of organization.

Conducted analysis using new scales and classification axes




**Distribution of distance from 200 patents in the vicinity within 5 years before filing, by applicant type**

**Point1：**
Companies file in areas where there are already many similar patents

**Point2：**
Individuals file in areas where there aren't many similar patents.

**Point3：**
Universities, public institutions, and industry-university cooperation patents are between individuals and companies.

It is not an area where there are no exact similarities, nor an area where subtle differences claim novelty

Relatively speaking, universities have taken the path of pioneering its own field
Industry-academia cooperation is a little more different than companies.

Since this method can have been used for any kind of documents,
we are considering and developing it into a mixed analysis of papers & patents and a mixed analysis of patents in other countries.

Motohashi, et.al. : A method of extracting content information from patent documents and comparison of their characteristics by applicant type by using the vector space model of distributed expressions, NISTEP, DISCUSSION PAPER No.175, 2019

# Contents

# Historical Development of NISTEP Foresight

**1970-80's** — Catch-up process
- Bottom-up decision making
- Consensus among sectors

**1990's** — Transition phase
- Moderate link of foresight surveys to comprehensive S&T policy

**2000-** — Prioritization
- Top-down decision making/prioritization
- Link S&T policy to foresight surveys

**2010-** — Shift to problem-solving, backcasting approach

**2015-** — Integration of S&T policy and innovation policy

**S&T BASIC PLANS**

- 1995 Basic Act on S&T
- 1996-2000 The 1st S&T Basic Plan
- 2001-2005 The 2nd S&T Basic Plan
- 2006-2010 The 3rd S&T Basic Plan
- Innovation 25
- 2011-2015 The 4th S&T Basic Plan
- Japan Vision2020
- 2016-2020 The 5th S&T Basic Plan

**NISTEP Foresight**

1971-1997
The 1st– 6th Technology Foresight
Delphi

Technology Development centered Seeds type

2001 The 7th Technology Foresight
Delphi Needs analysis

2005 The 8th S&T Foresight
Delphi Scenario
Emerging technologies
Needs analysis

Shift to Needs driven type

2010 The 9th S&T Foresight
Delphi Scenario
Future of regions

2015 The 10th S&T Foresight
Future vision Scenario
Delphi

Shift to Problem-solving type

2017- The 11th S&T Foresight
Horizon Scanning Future vision
Delphi Scenario

Social vision Development type

Contribution to the next S&T Basic Plan

# Overview of the 11th Foresight

- This survey has been conducted on a five-year basis since 1971 with the purpose of providing fundamental information for science and technology innovation policymaking, beginning with the next Science and Technology Basic Plan. This is the 11th survey.
- This survey envisions the future of science and technology and the future of society; it then merges these two to envision the future of society in relation to scientific and technological developments.
- The target year is 2040 (the scope of the survey itself is inclusive of 2050).
- This survey proactively uses ICT, such as AI-related technologies, for the collection and analysis of information (natural language processing, etc.).

**Identifying trends in science, technology, and society (horizon-scanning)**

## Future of society (visioning)

Vision Workshop (approx. 100 participants), Regional Workshops (6 locations + Central Workshop and Academic Collaboration Workshop; approx. 340 participants in total), International Workshop (14 countries, approx. 60 participants)

Four values and 50 visions of the future

Humanity | Inclusion | Sustain-ability | Curiosity

### Visions of the future of society brought about by the development of science and technology (scenarios)

**Intangible-individual**

A society of coexistence, rethinking what it means to be human and recognizing diversity

What about people's thoughts?

**Intangible-social**

A flexible society in which the real and the virtual are harmonized

What about the virtual world?

**Flexible society brought about by reviving and rethinking humanity**

**Tangible-individual**

A society that enhances *individuality* through fusing maintenance/recovery of human functions with digital assistance

What about human functions?

**Tangible-social**

A society in which personal customization and general optimization coexist, allowing individuals to have their own unique lifestyles

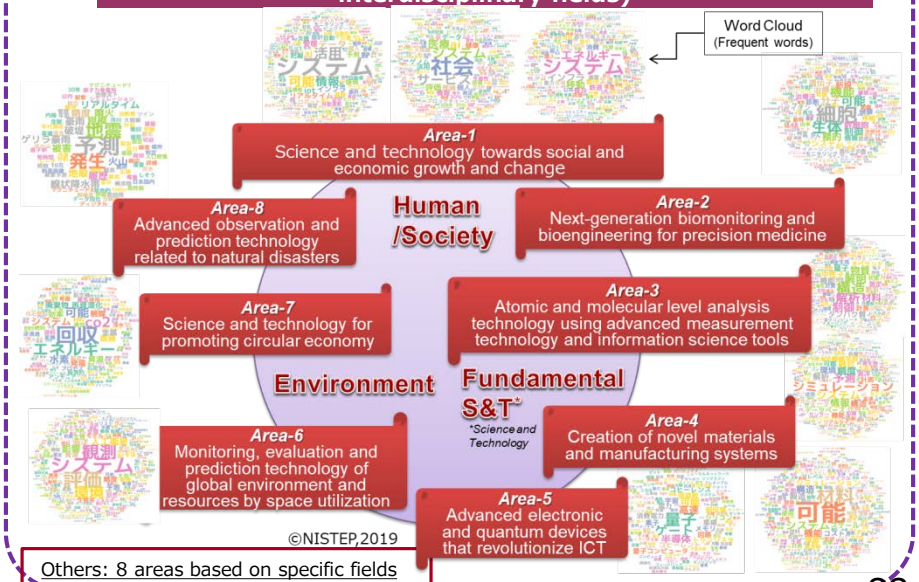
What about society and the environment?

## Future of Science and Technology (Delphi survey )

- Questionnaires given to experts (approx. 5,300 experts from the NISTEP Experts Network, JST, Research Map, etc.)
- Experts judge from various fields (total of 79 members of the S&T Foresight Committee and its subcommittees in respective fields)

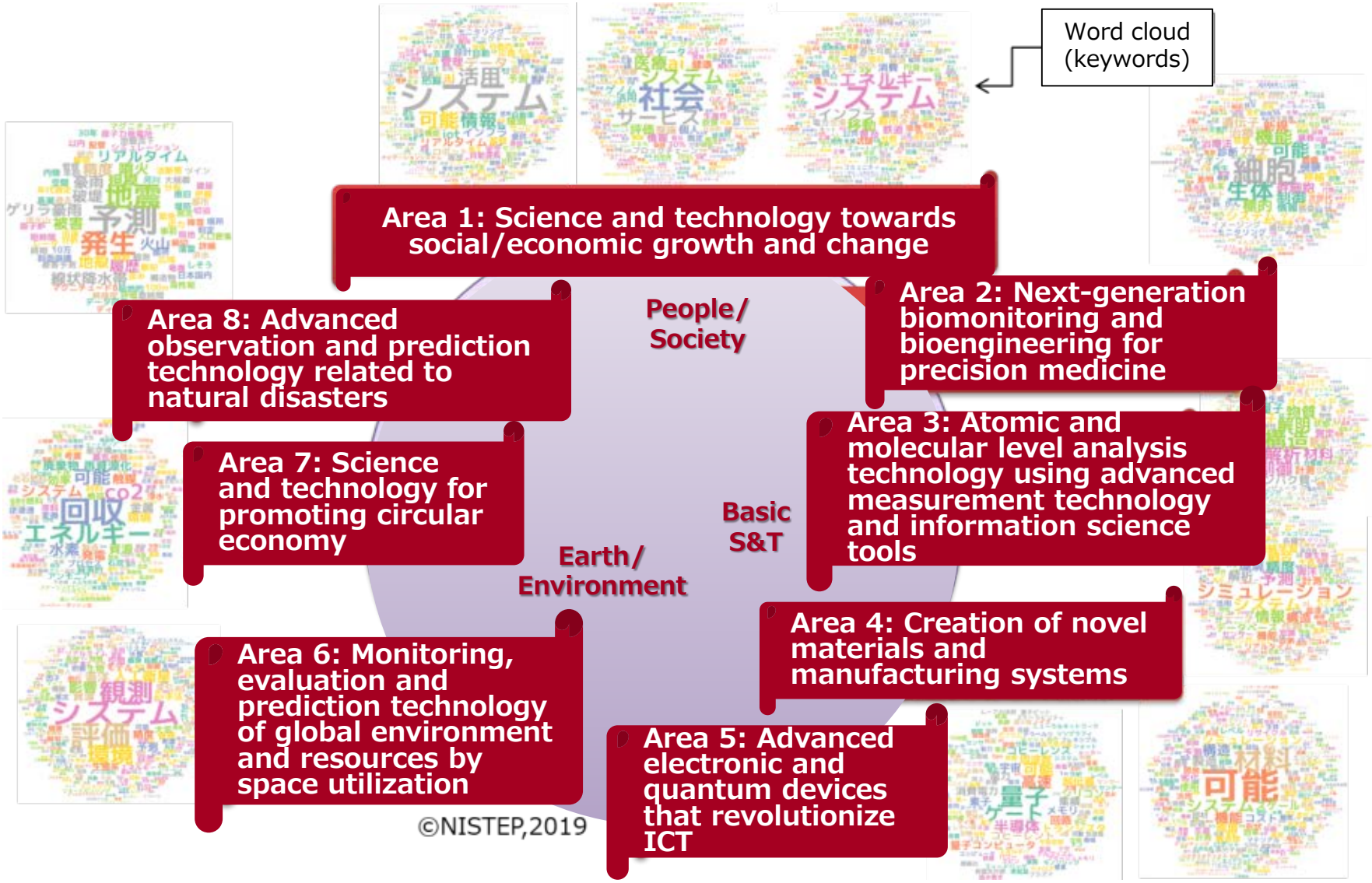
702 S&T topics (7 fields/59 sections)

### Close-up areas of science and technology for the future (8 areas with high potential of multidisciplinary and interdisciplinary fields)




Others: 8 areas based on specific fields

# Close-up areas of S&T for the future



# Future society brought by S&T development

## Society of coexistence, rethinking what it means to be human and recognizing diversity

| (Example of S&T) | (S&T topics*) | (Social visions) |
|---|---|---|
| Neuro-function imaging | Imaging technologies capable of measuring brain function noninvasively at a cellular level. (2030/2035) | Society in which we can be human |
| Experience-transmission media | Recording personal experiences not only sensory information but also the psychological state at the time as a vivid skin sensation, and being able to edit, transmit, experience and share that media (2030/2033) | Diverse society |
| Multilingual/ nonlinguistic navigation | Navigation system that provides information to allow elderly and visually impaired people to move around freely and with confidence (2025/2028) | Society of coexistence |

Share emotions and experiences, promote mutual understanding and co-exist with mutual respect.

Intangible-individual

## Flexible society in which the real and the virtual harmonize

| (Example of S&T) | (S&T topics*) | (Social visions) |
|---|---|---|
| Robots and human-machine interfaces | Body sharing technology where anyone can freely manipulate a part of the movement or the whole body of a remote person or a robot, and work in cooperation with the lender of the body and surrounding people (2030/2033) | Multi-dimensional society |
| Information extraction | Natural language processing technology capable of extracting desired information from atypical sentences and conversations (2026/2029) | Data sharing society |
| Real-time monitoring | Technology to prevent unauthorized access into control systems such as important infrastructure, vehicle control, and personal IoT devices/ services (2028/2029) | Healthy humans/healthy earth |

Learn to use the virtual space and real space, through the accumulation, sharing, and utilization of Big data

Intangible-social

## Flexible society brought about by reviving and rethinking humanity

Tangible-individual

Society that enhances individuality through fusing the maintenance/ recovery of human functions with digital assistance

| (Example of S&T) | (S&T topics*) | (Social visions) |
|---|---|---|
| Biocompatibility | Biomimetic materials for human senses, to supplement in case of loss, and to enhance senses in order to achieve a superhuman level (2032/2036) | Society with extended physical functions |
| Symptom control | Methods for breaking the vicious circle by elucidating the interaction between the autonomic nervous system, mental stress, depression, and lifestyle diseases(2030/2034) | Society with physical and mental stability |
| AI use | A system that automatically archives tacit knowledge through measurement and modeling of the skills of a craftsperson (skilled experts, etc.) (2026/2029) | Master society |

## Society that enhances individuality through fusing the maintenance/recovery of human functions with digital assistance

Tangible-social

Achieve proper placement and recycling of resources while satisfying individual desires, and respond flexibly in case of emergency

| (Example of S&T) | (S&T topics*) | (Social visions) |
|---|---|---|
| Monitoring/ sensing | System that ascertains damage in real-time and conducts expansion prediction during large-scale earthquake disasters using IoT equipment ( 2026/2028) | Prepared society |
| Energy systems | Long-term hydrogen storage technology that can be supplied on a large scale both economically and stably (2032/2034) | Optimized society |
| Individuali-zation | Additive manufacturing (3D printing) technology with productivity equivalent to that of conventional mass production technology (2027/2030) | Customized society |

## Society in which personal customization and general optimization coexist, allowing individuals have unique lifestyles

scientific/technological realization

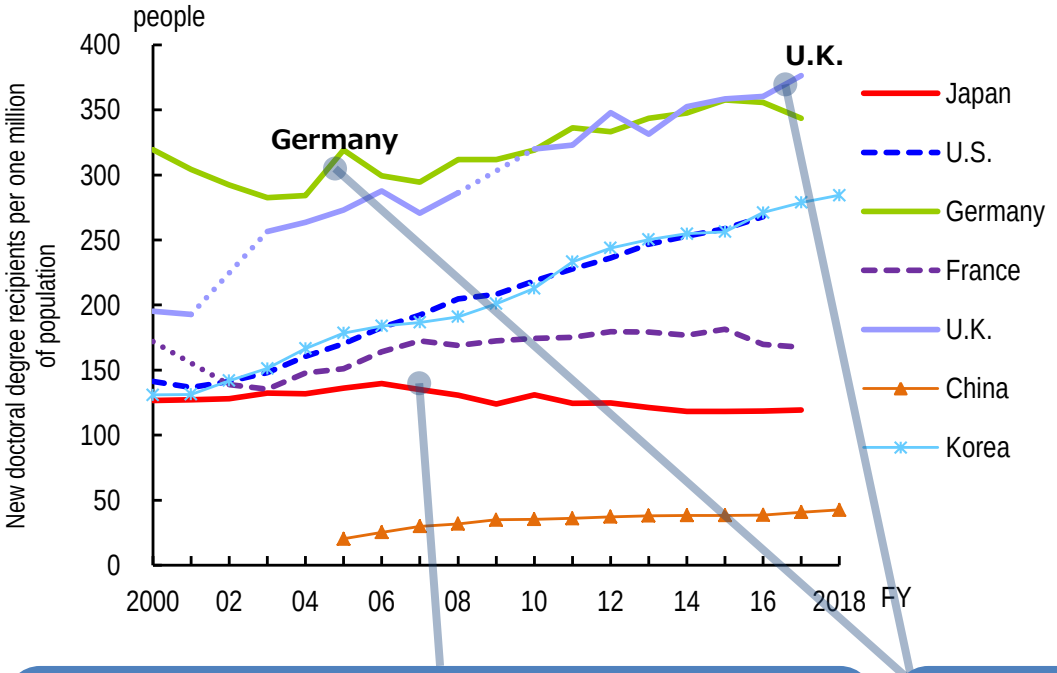
*Delphi topics

social realization

# Contents

# New doctoral degree recipients per one million of population

- **Among the major countries, Japan is the only country that shows a decline in the number of new doctoral degree recipients per million population.**




| | FY | New doctoral degree recipients per one million of population |
|---|---|---|
| Japan | 2017 | 119.3 |
| U.S. | 2016 | 267.8 |
| Germany | 2017 | 343.6 |
| France | 2017 | 167.6 |
| U.K. | 2017 | 376.3 |
| China | 2018 | 42.5 |
| Korea | 2018 | 284.3 |

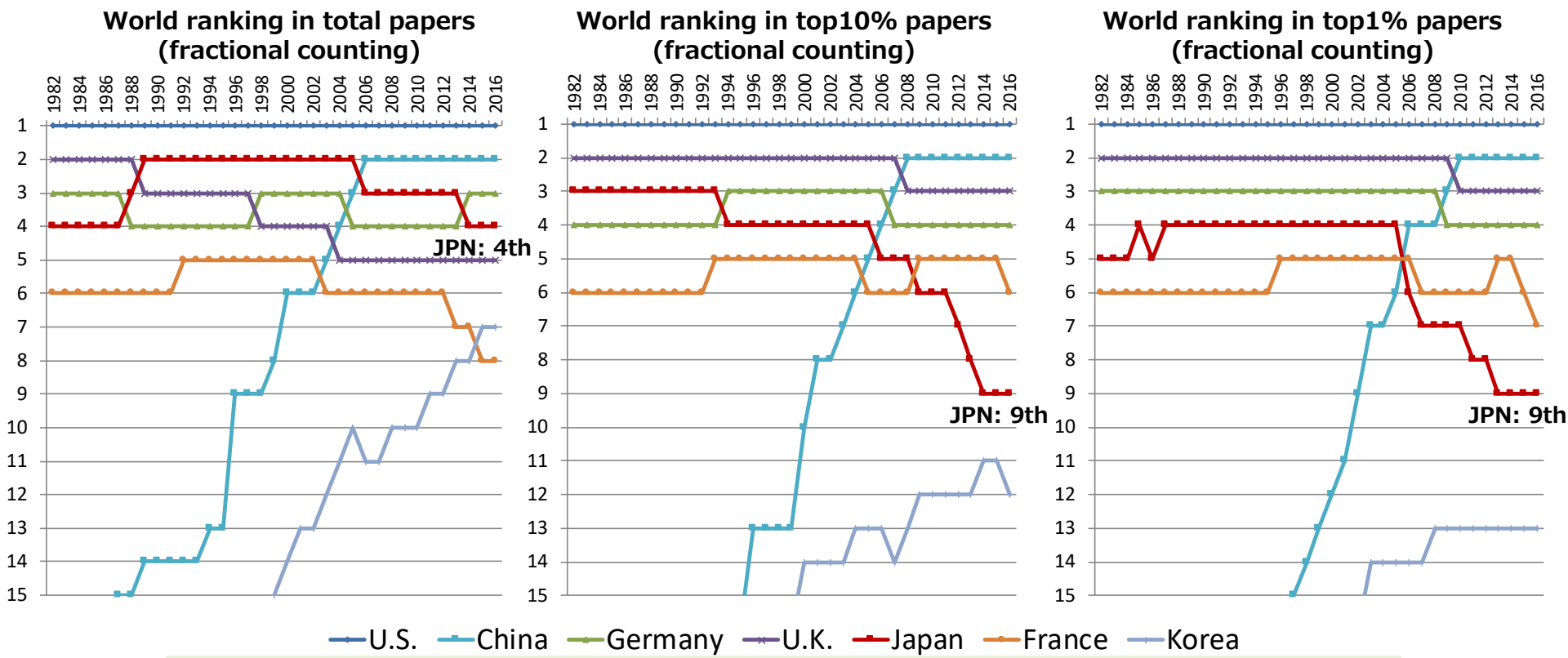
- **In FY2000, the figures of the United States and Korea were roughly the same as that of Japan.**
- **The United States and Korea show steady growth and the figures reach nearly double of Japan in the most recent data.**

- **Germany has consistently ranked number one among the major countries since FY 2000.**
- **The United Kingdom caught up with the Germany around FY 2010, and thereafter both countries have remained at the same level.**

Note: The number of new 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 degrees") from the figures for "Doctor's degrees" stated in the "Digest of Education Statistics."

# Changes in the world ranking of the number of papers and of highly cited papers in major countries

- Japan's rank in the number of total papers and highly cited papers (top 10% and top 1%) has declined since the mid-2000s.
- In fractional counting, Japan is in the 4th position in the total papers and is in the 9th positions in the top10% and top1% papers. Japan maintains its positions in recent 2 – 3 years.




In the fractional count method, a paper co-authored by Japanese institution A and U.S. institution B is counted as 1/2 for Japan and the as 1/2 for the U.S..

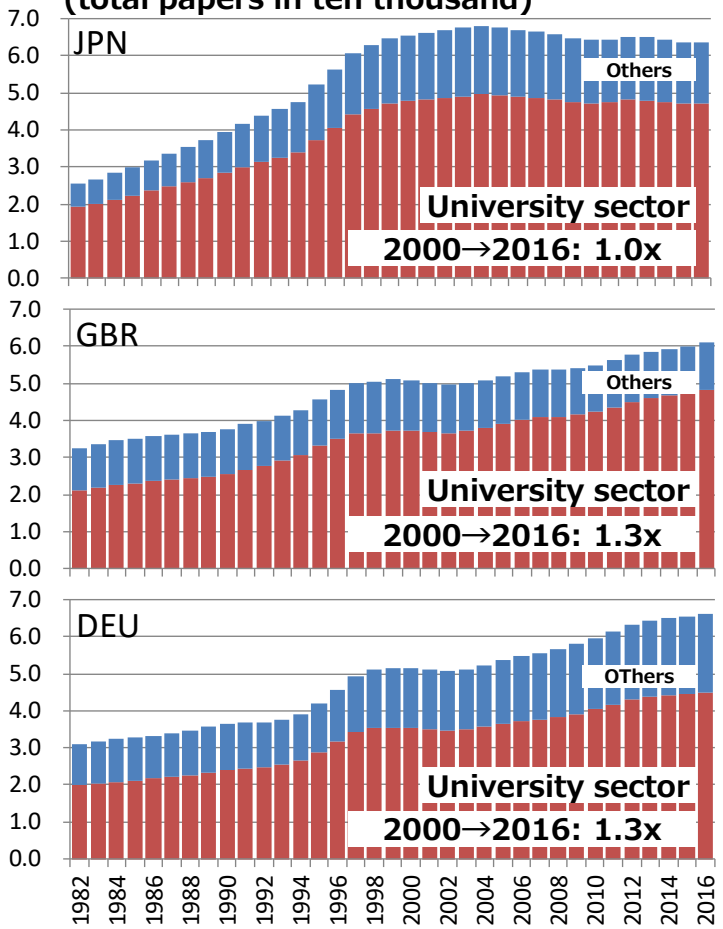
Note: Article and Review were analyzed by the fractional count method. A 3-year moving average is shown where 2016 means the world ranking based on the 2015 – 2017 average. Top 10% (Top 1%) papers represent papers which are within top 10% (1%) in the citation counts (as of the end of 2018) in each field (22 ESI fields) and in each year.

Compiled by National Institute of Science and Technology Policy, based on Web of Science XML (SCIE, End of 2018 Version) by Clarivate Analytics.

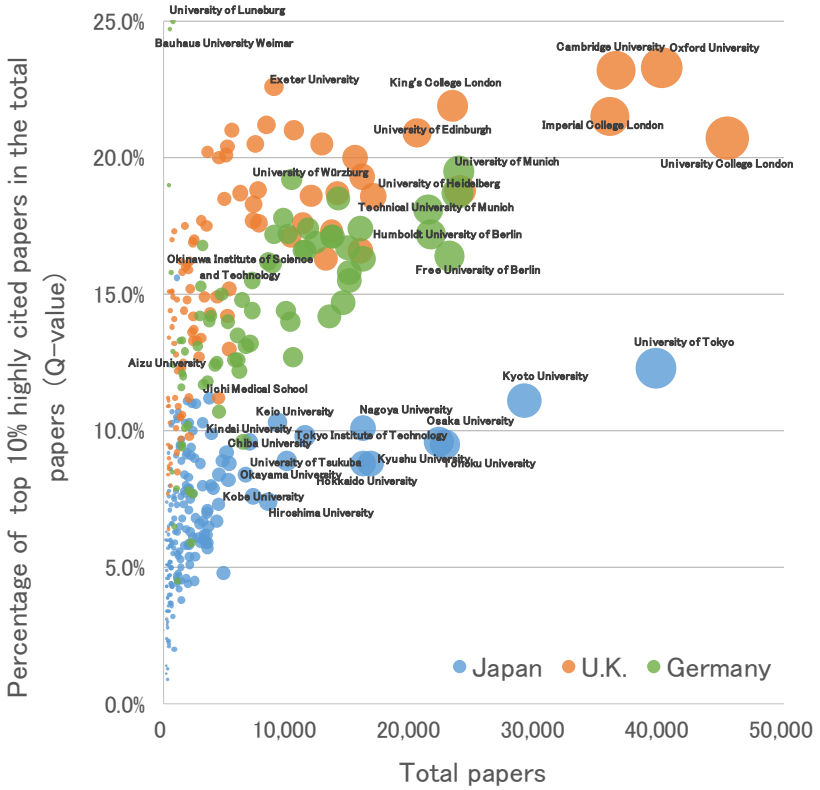
# Trends of scientific papers from the university sector in Japan, the U.K., and Germany

- The university sector plays a major role in the production of scientific knowledge.
- After 2000: The number of Japanese papers stagnated, while the number of papers from the U.K. and Germany increased.
- Proportion of highly cited papers: the U.K. is high, followed by Germany and Japan

**Trends of Japan, the U.K., and Germany (total papers in ten thousand)**




**Percentage of the top 10% highly cited papers in the total papers (Q-value)**



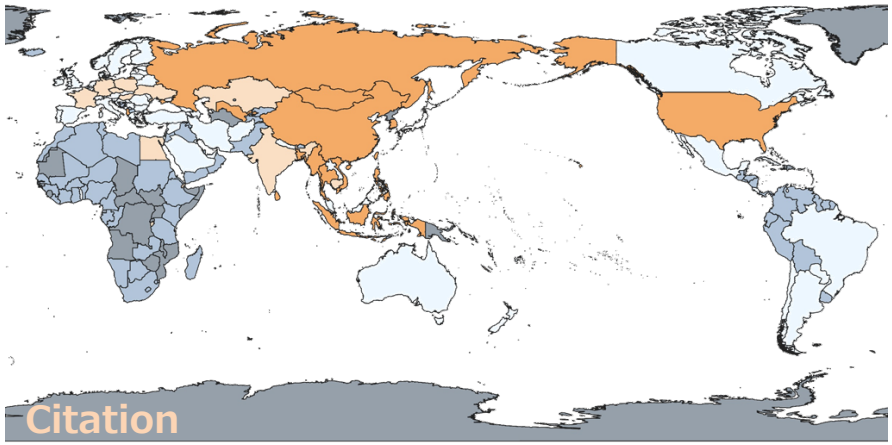

Note1: Article and review were analyzed. The time series in the number of papers are calculated by the fractional count method, and the percentage of the top 10% highly cited papers in the total papers (Q-value) is calculated by the whole count method.
Note2: The Q-value was analyzed for papers with 100 or fewer authors.

Compiled by National Institute of Science and Technology Policy, based on Web of Science XML (SCIE, End of 2018 Version) by Clarivate Analytics.

# Analysis of international research activities of Japan from the perspective of citation and co-authorship of papers

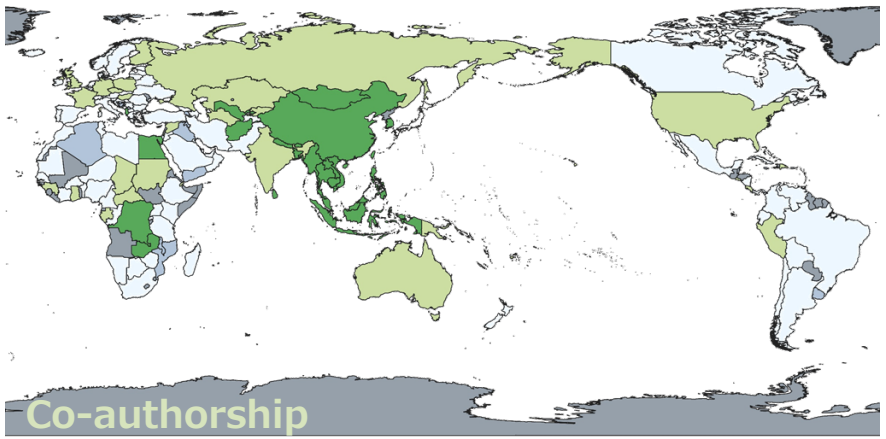
**In terms of citation and co-authorship of papers:**

- **The United States, China, Korea, Russia, and India have strong ties to Japan among countries/regions with large research scale.**
- **Asian countries, especially ASEAN countries have strong ties to Japan among countries/regions with high growth potential.**




Geographical distribution of countries/regions by degree of citation to Japanese papers.

The dark orange indicates country/region where the percentage of citations to Japanese papers is 4.0% or higher in the country/region.




Geographical distribution of countries/regions by degree of co-authorship of Japanese papers.

The dark green indicates country/region where the percentage of co-authorship with Japan is 6.0% or higher in the country/region.

Compiled by National Institute of Science and Technology Policy, based on Scopus custom data (2017 Version) by Elsevier B.V..

# NISTEP Expert Survey on Japanese S&T and Innovation System

- **NISTEP expert survey on Japanese S&T and innovation system (NISTEP TEITEN survey) aims to track the status of S&T and innovation system in Japan through the survey to Japanese experts and researchers in universities, public research institutions, and private firms.**
- **The survey asks for respondents' recognitions on the status of the S&T and innovation system, such as diversity in basic research and usability of research funds, which is usually difficult to measure through the R&D statistics.**

**(Respondents) A fixed cohort (approx. 2,700 respondents)**

**(Duration) Five years (FY2016 to FY2020), the same questionnaire is sent annually to the respondents + in-depth questions for specific issues**

**(How to answer)**

- **Subjective evaluations of respondents**
- **Zero-to-six scale, rankings, free answers**
- **Respondents can refer his/her evaluation in the previous round**
- **Respondents are required to provide the reasons why he/she altered the evaluation**

A kind of TANKAN survey (the Bank of Japan) of S&T and innovation system

# Questions that get higher evaluations compared to the first year (FY2016)

- **"Improving the working environment for female researchers" "establishment of venture companies" "Fostering human resources with entrepreneurship" etc.**

| Rank | Question item | Change in the index |
|---|---|---|
| 1 | Environmental improvement for female researchers (Supports according to life stage) | 0.07 |
| 2 | Status of knowledge transfer and creation of new value through establishment of start-up companies and their business development | 0.06 |
| 3 | Development of entrepreneurial human resources at universities | 0.06 |
| 4 | Education that provides undergraduate students with awareness and motivation for social issues and research | 0.05 |
| 5 | Devising a HR system (Recruitment, Promotion, etc.) for female researchers to play an active role | 0.04 |
| 6 | Creating an environment that provides young researchers with opportunities to be independent and active | 0.04 |
| 7 | Efforts for organization-level collaboration among industry, academia, and government | 0.02 |

※Index: Values that conversed a 6-point question (Select from "insufficient" to "sufficient") to a 0 ~ 10-point value.

# Questions that get lower evaluations compared to the first year (FY2016)

- **3 questions on "outstanding international achievement" "diversity of basic research" and "Is it leading to innovation?". This is followed by the question of "research infrastructure".**

| Rank | Question item | Change in the index |
|---|---|---|
| 1 | Has our country's basic research produced outstanding results internationally? | -1.14 |
| 2 | Is diversity of basic research secured as a source of innovation? | -0.76 |
| 3 | Is our country's R&D results sufficiently conducive to innovation? | -0.74 |
| 4 | Facilities and equipment for creative and advanced R&D and human resource development | -0.62 |
| 5 | Status of intellectual infrastructure and research information infrastructure in Japan | -0.58 |
| 6 | Do academic research meet contemporary needs (Challenge, integrity, fusion and internationality)? | -0.57 |
| 7 | State of support for outstanding research by the government in accordance with the stage of development | -0.57 |
| 8 | Are students with desirable abilities aiming for the doctoral program? | -0.56 |
| 9 | Do the funding agencies (JST, AMED, NEDO, etc.) perform its function according to its role? | -0.54 |
| 10 | State of government budgets in science and technology considering current situation of Japan | -0.53 |

※Index: Values that conversed a 6-point question (Select from "insufficient" to "sufficient") to a 0 ~ 10-point value.