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0.2 What is science, technology, and innovation (STI) policy?

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Abstract

An overview of the scope and structure of STI policies, with reference to foreign STI policies and history where appropriate. Basic science and technology statistics and indicators are also introduced.

Keywords

STI policy, Basic Act on Science and Technology, Science and Technology Basic Plan

1 Introduction

We provide a basic framework for science and technology innovation (STI) policy practice and research by elucidating the structure and components of STI policy and its relationship with other areas of policy.

2 The scope of STI policy and its relationship with other areas of policy

In discussing the concept of STI policy, it is first necessary to review how science and technology policy and science and technology innovation policy have been defined. For example, Inui Susumu (1982) defines science and technology policy as "a system of planned and systematic action policies concerning

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science and technology and the actions to be taken by the state to further them, with consideration for maintaining harmony with the environment, in order to promote various science and technology activities by government and private organizations by making full use of human and material resources, and to improve the basis of science and technology.” However, “the concept of science and technology policy was established in the 1960s and 1970s, but its content have been changeable, varying with historical background and with the times. As such, there is no clear, authoritative definition of science and technology policy. There are also few standard textbooks that clearly explain science and technology policy” (Kobayashi Shinichi, 2011). Hitotsubashi University Institute of Innovation Research (2017) devotes a chapter to overviewing STI policy.

Considering the definition proposed by the Japanese government, the following description in the Fourth Science and Technology Basic Plan (approved by the Cabinet on August 19, 2011) is worth noting further, particularly insofar as it also takes into account the development of the concept from science and technology policy to science and technology innovation policy: “‘Science and technology innovation’ is defined as ‘the creation of intellectual and cultural value based on new knowledge produced through scientific discoveries and inventions, and innovation that develops this knowledge to create economic, social, and public value’” and “in addition to science and technology policy, it is essential to include a wide range of related innovation policies and to move forward in a holistic manner. For this reason, the Fourth National Strategy positions this as ‘Science and Technology Innovation Policy’ and seeks its strong development.”

In reviewing concepts related to STI policy, Okamura Asako et al. (2013) first cite the Fourth Science and Technology Basic Plan, touching on the definition of STI proposed therein. More specifically, while science and technology innovation is narrowly defined as “innovation based on science and technology,” science and technology innovation policy is not narrowly defined as a policy for science and technology innovation (i.e., innovation based on science and technology). As in the Fourth Science and Technology Basic Plan, this paper treats science and technology innovation as “the creation of intellectual and cultural value based on new knowledge produced through scientific discoveries and inventions, and innovation that develops this knowledge to create economic, social, and public value.”

This definition has been emulated in various policy documents, including the Fifth Science and Technology Basic Plan.

In this regard, “science,” “technology,” and “innovation” are by nature distinct concepts. Given the variety of definitions, this study defines these concepts as follows:

Science: The creation of knowledge through the process of hypothesis and verification.
Technology: The means and methods used to achieve objectives.
Innovation: The transformation of society through new combinations of knowledge.

Although innovation is translated as “technological innovation” in Japan, this is misleading because innovation is not derived from science and technology alone. For example, in Chinese, the term is translated as “creativity.” The various characteristics of science, technology, and innovation policy should also be clarified. To that end, I would like to introduce a review by The Oxford Handbook of Innovation (see Figure 1, Fagerberg and Mowery, 2009).

According to The Oxford Handbook of Innovation, “science policy” is concerned with securing sufficient resources for science, allocating them wisely to various activities, using them efficiently and in a way that contribute to social welfare, with particular concern for the quality and quantity of students and researchers. “Science policy” is viewed as having diverse targets, such as national pride, cultural values, national security, and economy, with the central ministries in charge of education and research and public research organizations constituting the main players.

Similarly, “technology policy” refers to policies that focus on technology and industrial fields, and is considered to be characterized by the identification of strategic technologies and industrial fields and the promotion of specific fields. However, developed and less developed countries differ in their definition of the term “technology policy.” In developed countries, “technology policy” refers to the creation of advanced technologies, while less developed countries use the term when referring to the adoption of such technologies and their use in the market. Technology policy differs from one country to another. For instance, in the US, technology policy is developed for each field, such as national defense and energy; in contrast, Japan has an independent administrative agency with jurisdiction over “technology policy” from an industrial policy perspective.

Meanwhile, the main objective of “innovation policy” is economic growth and international competitiveness, which can be roughly divided into two categories: “laissez faire” and “innovation system.” The former focuses on frameworks rather than specific technologies or fields of industry, and includes basic research, education, intellectual property policy, entrepreneurship development, and stimulation of public interest in science and technology. In contrast, the latter is concerned with optimizing the relationships between the various parts of the innovation system. Accordingly, the content of “innovation policy” is thought to be extremely diverse; it is not limited to universities and technology, involves many economic entities, and is not confined to public sector initiatives.

STI policy partially overlaps with various policy areas, including industrial, security, and environmental policy. Chapter 2 discusses the relationships between these policy areas in greater detail.

Table 1. Relationships between science, technology, and innovation policy

Science policy

Targets: Production of scientific knowledge
Policy tools: Public grant to research, public research institute, etc.

Technology policy

Targets: Development and commercialization of technological knowledge of respective areas
Policy tools: Public support for strategic areas, inter-institutional collaboration (between research community and industry), industry sector benchmarking, etc.

Innovation policy

Targets: Overall innovation capability of the economy
Policy tools: General education system and labor training to improve~~s~~ individual skills and learning ability, improved access to information (information society), environmental regulations, company legislation, competition policy, consumer protection, etc.

Source: Fagerberg and Mowery (2009), *The Oxford Handbook of Innovation*.

3 The legal structure of the Basic Act on Science and Technology

Until the enactment of the Basic Act on Science and Technology, which was passed through a private member's bill in the Diet in 1995, there was no legal system providing general regulation of science and technology policy. Instead, such policy was provisioned by individual laws and regulations, such as the Act for Establishing the Science and Technology Agency and the Act for Promotion of Research Exchange. The basic report of the Council for Science and Technology Policy and the "Outline of Science and Technology Policy," decided by the Cabinet on the basis of the basic report, served as the comprehensive regulations guiding science and technology policy.

According to the Basic Act on Science and Technology, a Science and Technology Basic Plan is to be formulated every five years, and an annual report in the form of a white paper published each year. The Science and Technology Basic Plan stipulates targets for government R&D investment, priority fields for R&D, and priority measures. It is rare for a national plan to stipulate a multi-year investment target, especially insofar as it relates to future fiscal expenditures (another example is the Mid-Term Defense Buildup Program). For instance, the First Science and Technology Basic Plan establishes the so-called 10,000 Postdoctoral Fellows Plan, the Second and Third Plan stipulate priority fields for R&D, while the Fourth Plan lays out problem-solving science and technology. The Fifth Plan identifies policy concepts, priority fields, and measures such as fundamental capabilities and Society 5.0.

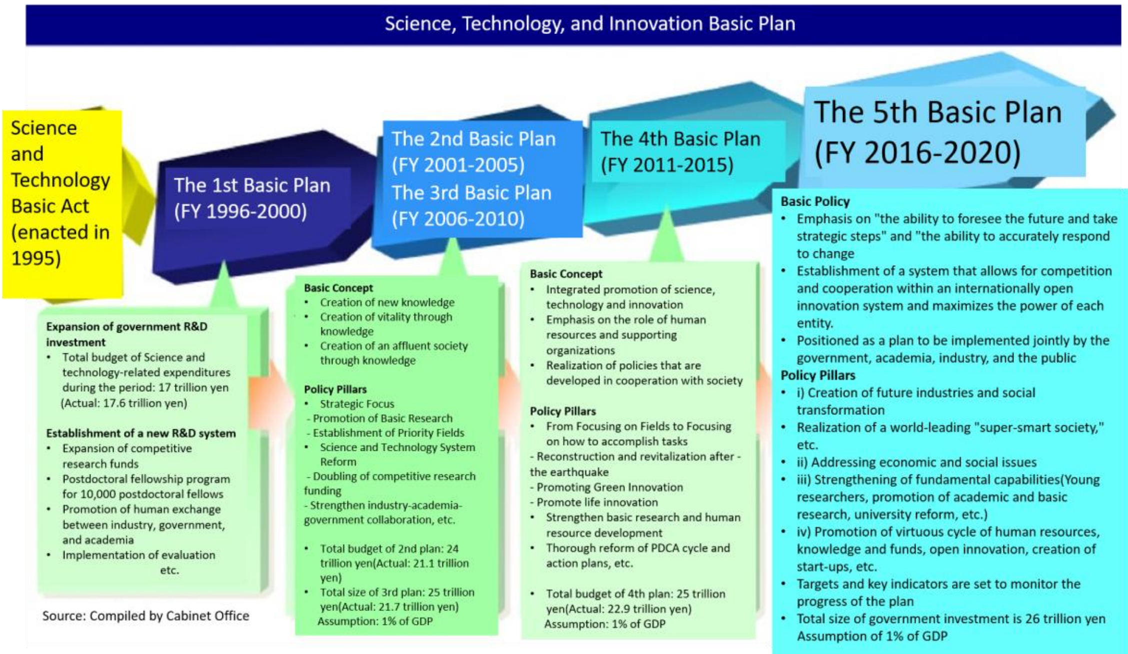


Figure 1. Evolution of the Science and Technology Basic Plan.

In addition to the Basic Act on Science and Technology and the Act on Strengthening Research and Development, the successor to the Act on Promoting Research Exchange was enacted in 2008. This act is intended to strengthen and promote R&D capabilities and output through advancing the reform of the R&D system. It also provides for the development of human resources for innovation, special provisions concerning the status of civil servants in research, and the promotion of shared facilities.

4 The STI policy implementation system

Science and technology innovation policy implementation systems vary depending on the political, economic, and social systems of each country, the structure of the research community, and the organizational design of government agencies. Nonetheless, they generally comprise the elements illustrated in Figure 2.

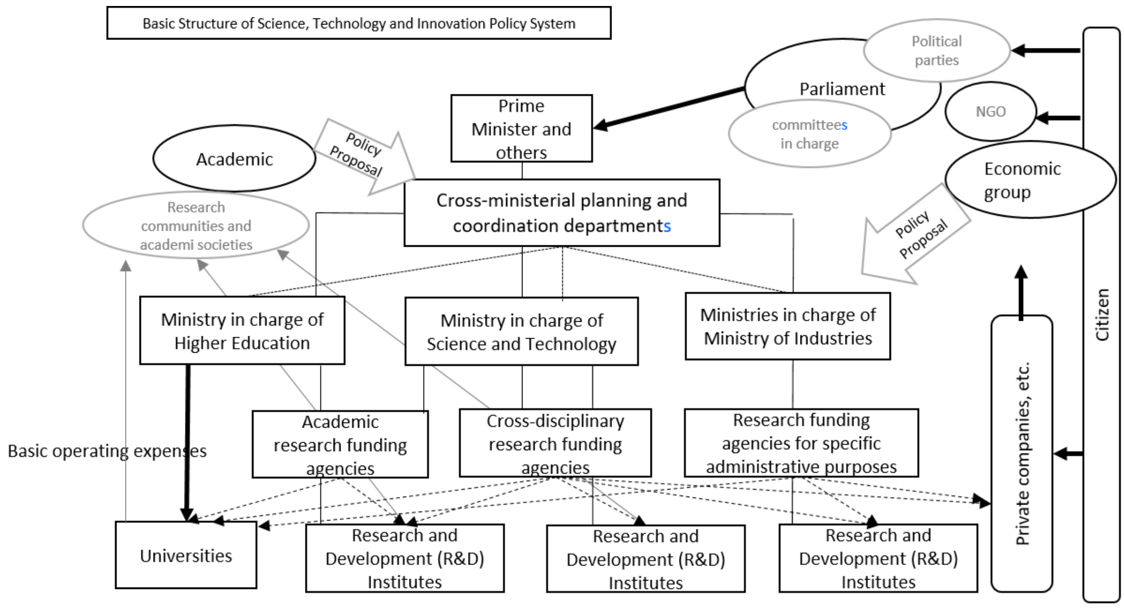


Figure 2. Basic structure of science and technology innovation policy systems.
Source: Created by the author.

4.1 Cross-agency planning and coordination departments

- Examples of establishing priority R&D areas by setting R&D investment targets as part of strategic policy for government as a whole include the Science and Technology Basic Plan (Japan, South Korea) and American Competitiveness Initiative (US).
- Examples of cross-agency resource allocation include the Memorandum on Administration Research and Development Budget Priorities (OMB-OSTP MoU) (US), and the Resource Allocation Policy and so-called SABC Assessment (Japan).

4.2 Ministry in charge of higher education

The Ministry in charge of higher education is the authority responsible for universities and other institutions of higher education. Developed countries generally do not take an interventionist administrative approach in consideration for the autonomy of universities. Such ministries play an important role as the institutional foundation for research through university licensing and subsidies for operating expenses. Examples include the Ministry of Education, Culture, Sports, Science and Technology (former Ministry of Education) in Japan, the Department for Education in the UK, and the Ministry of Education and Research in Germany.

4.3 Ministry in charge of science and technology

Ministry in charge of science and technology is responsible for cross-ministerial programs and large-scale research projects related to science and technology (e.g., space development, ocean development).

While some such agencies operate independently (e.g., China, and formerly in South Korea and Japan), most are part of the ministry in charge of higher education (e.g., Japan, Germany, and Korea) or industrial policy (e.g., the UK).

4.4 Ministries in charge of industry

Ministries in charge of industry are responsible for promoting research and development for various administrative purposes, such as industrial promotion. They are directly linked to the promotion of industries and agriculture, medicine, telecommunications, and energy, and have connections to the private sector. There are various combinations depending on the industrial situation of each country.

4.5 Funding agencies

There are a variety of funding agencies, ranging from basic research to mission-oriented research and development, human resource development, and support for domestic and international researcher exchange. Such agencies vary from country to country, their different missions requiring appropriate systems of evaluation. The organizational structure of Japan is such that the Japan Society for the Promotion of Science (JSPS), Japan Science and Technology Agency (JST), New Energy and Industrial Technology Development Organization (NEDO), and others carry out everything from academic research to mission-oriented research and development. The Japan Agency for Medical Research and Development (AMED) was established to conduct integrated research and development in the medical field, with initiatives ranging from basic research to clinical and practical applications, as well environmental improvement and providing grants.

4.6 Institutions for higher education

Institutions for higher education play the largest role in research in all countries. They also play a role in human resource development through graduate schools and post-doctoral programs. There is a trend toward reducing general funding for universities (e.g., provision of subsidies for operating expenses in Japan), with the weighting of competitive funding (i.e., multi-funding) and contracted research from various research funding bodies increasing.

4.7 Research and development institutions

Research and development institutions conduct cross-disciplinary R&D (e.g., RIKEN in Japan and Max Planck in Germany) and those that specialize in specific research fields (e.g., the National Institute for Materials Science and JAEA in Japan; and NASA in the US, although this organization has the characteristics of a government agency). Consolidation is currently underway for administrative and financial reasons. In some countries, these institutions are established under a Research Council (e.g., the UK) or Academy (e.g., Russia)

4.8 Other

Other bodies include academies and academic societies, economic organizations, and non-profit private corporations (e.g., the Wellcome Trust in the UK, Bill Gates Foundation in the US, and the Nobel Foundation). Figures 3 and 4 illustrate the system for the promotion of science and technology innovation policy and policy communities in Japan and the US and UK, respectively; for further detail, refer to the Japan Science and Technology Agency, Center for Research and Development Strategy (JST/CRDS, 2017).

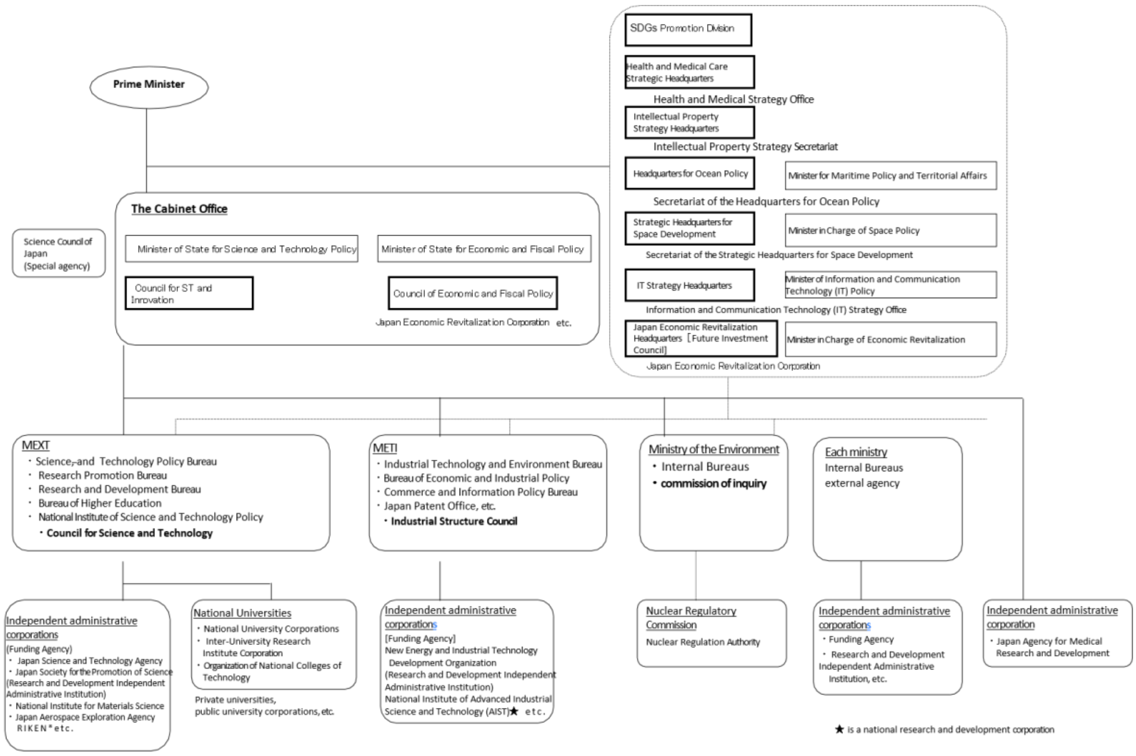
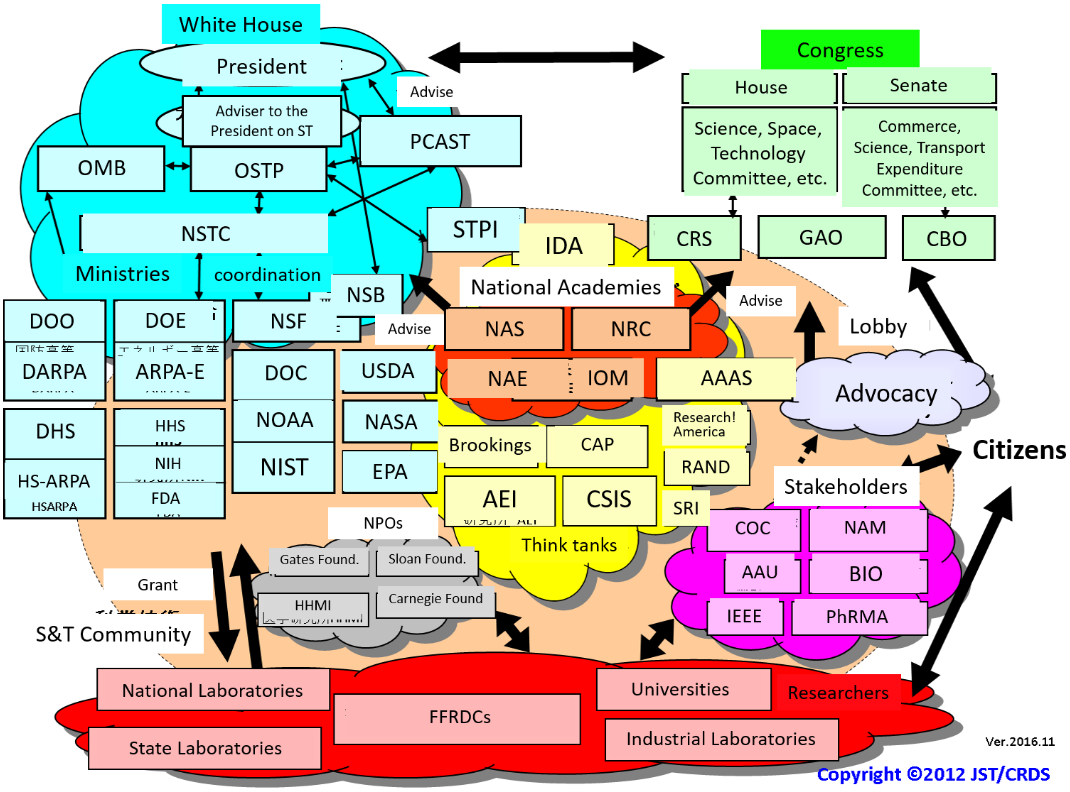


Figure 3. Japan's administrative structure for STI policy.
Source: Japan Science and Technology Agency, Center for Research and Development Strategy



(JST/CRDS, 2017)

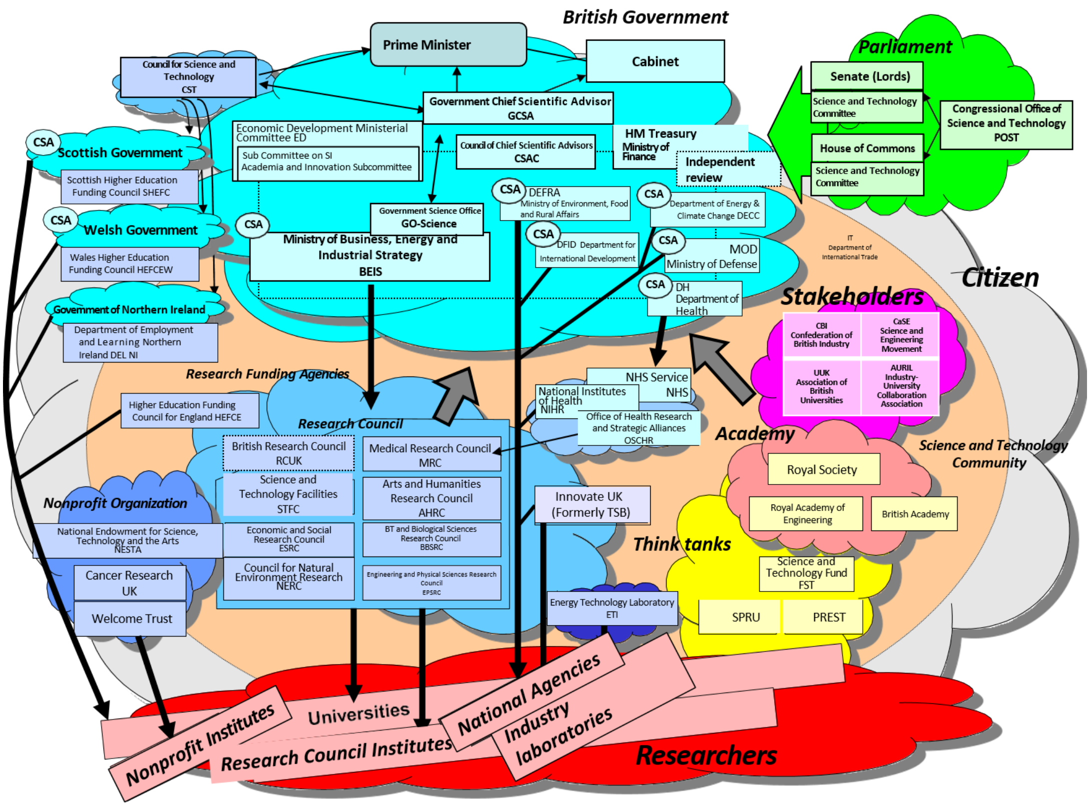


Figure 4. Science and technology policy communities in the US and UK.
Source: Japan Science and Technology Agency, Center for Research and Development Strategy (JST/CRDS, 2017)

5 Basic indicators

Japan is one of world's leading countries in terms of the ratio of research expenditure to GDP. In respect to the share of research expenses paid for by the government, the share is relatively low at around 20% compared to the average of approximately 30% in major European countries and the US. This reflects the high R&D ambitions of the Japanese private sector.

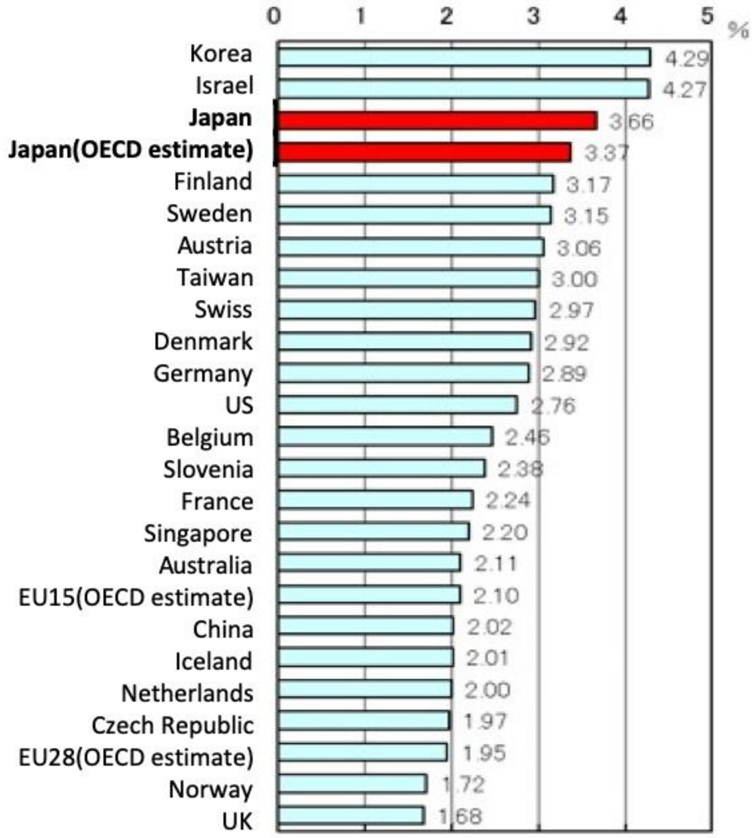


Figure 5. Total R&D expenditure in each country/region as a percentage of the GDP (2014).
Science and Technology Indicators 2017

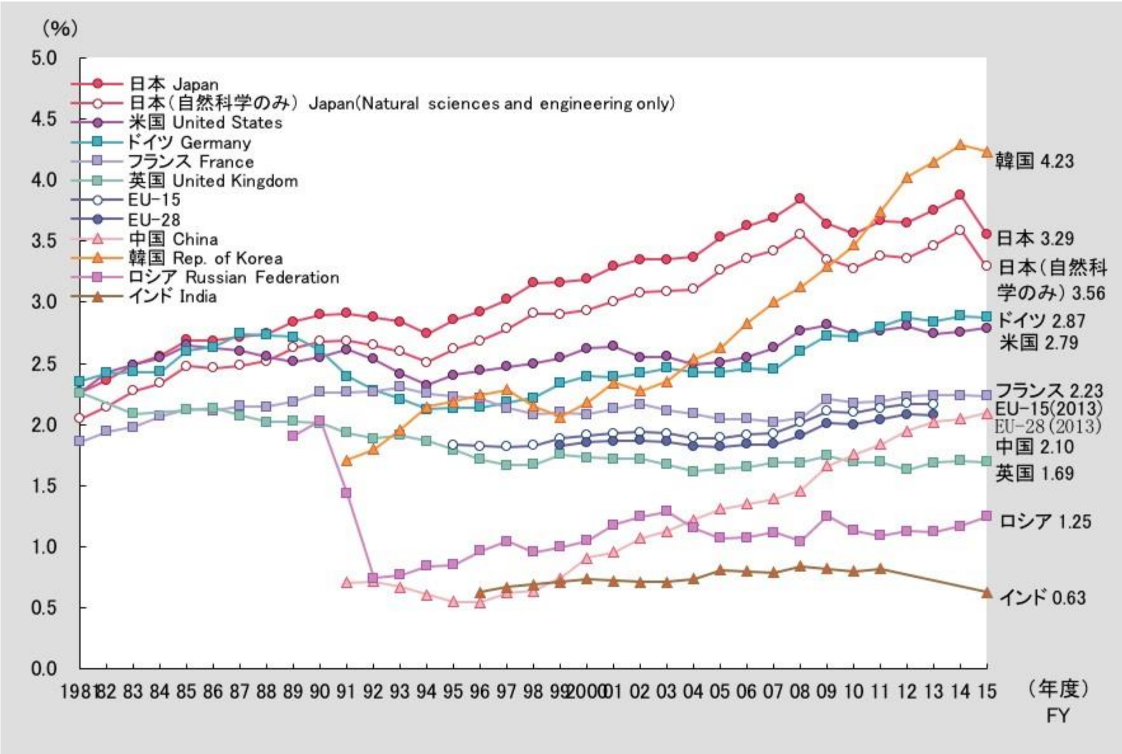


Figure 6. Trends in the ratio of research expenditure to GDP in major countries.
Source: Science and Technology Handbook (2017)

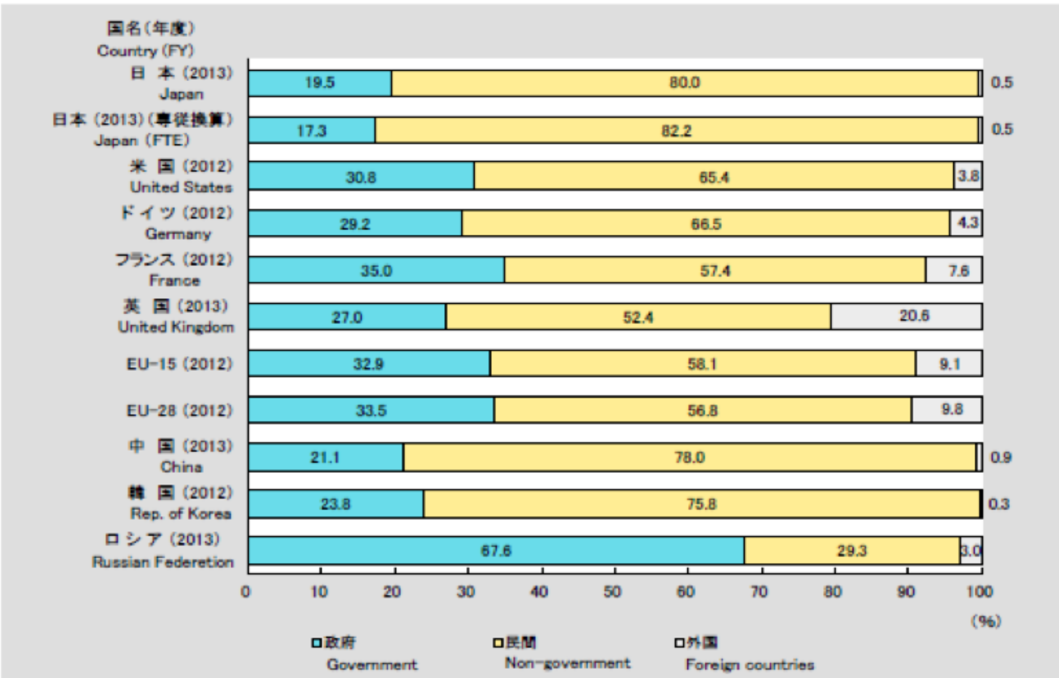


Figure 7. Research funding ratios by organization.
Source: Science and Technology Handbook (2017 edition)

Looking at trends in the government's science and technology-related budget, the government achieved the target value set out in the first Science and Technology Basic Plan, but not those of the subsequent plans. The structure of the budget shows almost no increase from the initial budget, while the impact of supplementary budgets has been significant. Supplemental budgets generally focus on facility costs to support economic expansion, and in some respects become a burden in subsequent years due to factors such as securing maintenance costs.

Public funds consist of basic expenses such as subsidies for university management, competitive funds such as subsidies for scientific and technological research, and expenses for specific projects, with basic expenses making up the largest share. Amidst constrained national finances, the basic expenses paid to universities and research institutes have been decreasing, and dependence on competitive funds has been relatively high in recent years. Competitive funds are generally time-limited, so that postdoctoral fellows and fixed-term researchers are hired, while the number of so-called tenured positions without a fixed-term is reduced. Some have raised concerns that this may have a long-term negative impact on Japan's basic research capabilities (e.g., the Fifth Science and Technology Basic Plan).

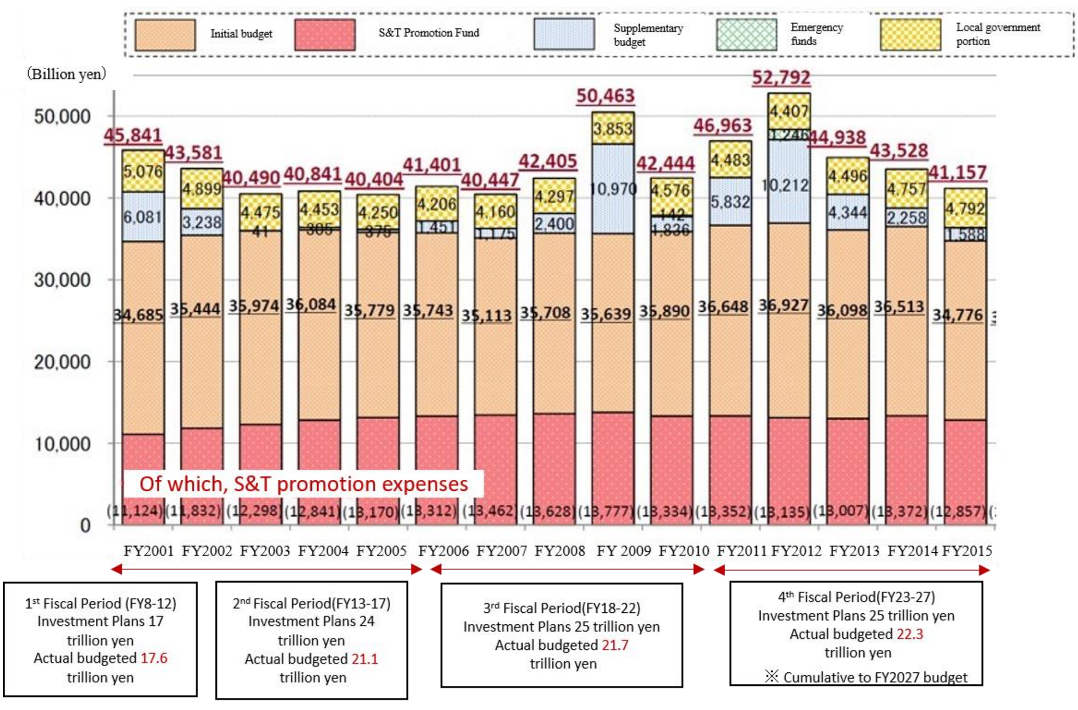


Figure 8. Trends in science and technology expenditure. Source: Produced by the Ministry of Education, Culture, Sports, Science and Technology based on materials created by the Cabinet Office

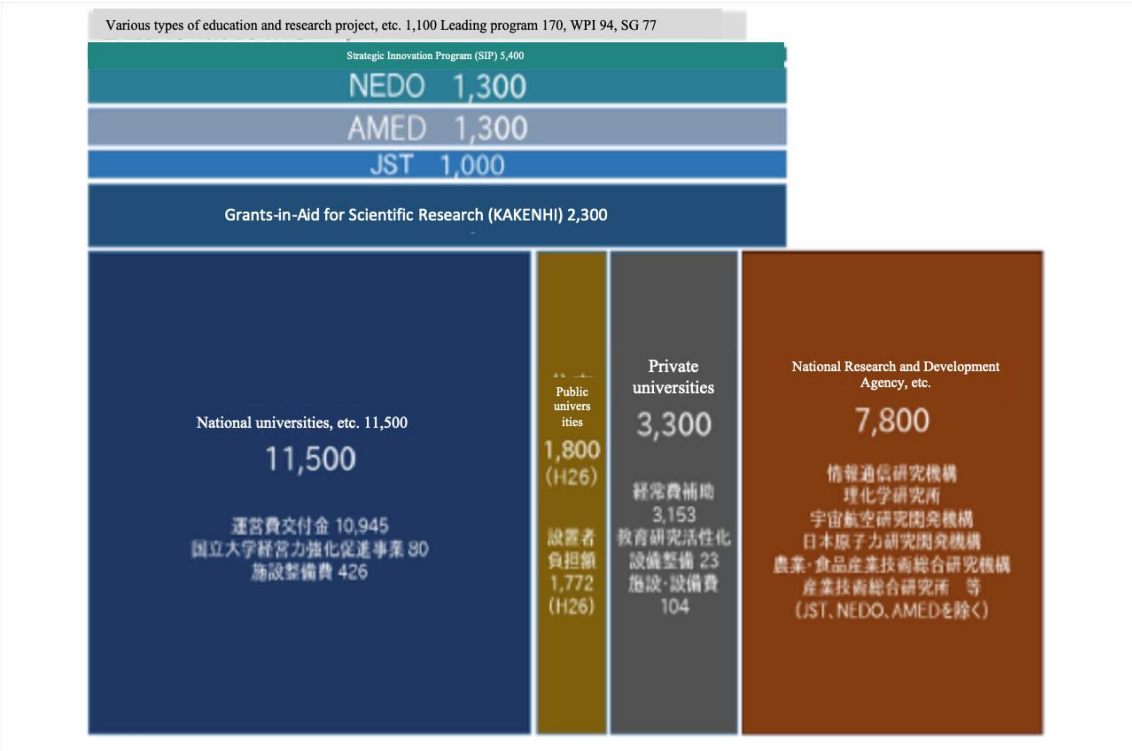


Figure 9. An overview of public funding support for universities and independent administrative institutions in Japan
Source: Strategic Proposal: Research Funding System Reforms Required in the Fifth Science and Technology Basic Plan Period: The Current State of Related Policy Measures and Future Directions to Strengthen Research Capability (Center for Research and Development Strategy, March 2016)

Figure 10. Feelings of stagnation surrounding basic research (1/2).

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Related data sources

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- The *Science and Technology Handbook* (Science and Technology Policy Bureau, Ministry of Education, Culture, Sports, Science and Technology) is published annually and available via the Ministry of Education, Culture, Sports, Science and Technology website.
- Science and Technology Indicators (National Institute of Science and Technology Policy), available via the website of the National Institute of Science and Technology Policy.
- The "Science and Technology White Paper" (Ministry of Education, Culture, Sports, Science and Technology) is published annually, and is available from the Ministry of Education, Culture, Sports, Science and Technology website.
- Research and Development Bird's-eye View Report series (Japan Science and Technology Agency, Center for Research and Development Strategies (JST/CRDS), which is published annually and is available from the JST/CRDS website.
- "Science and Technology Research Survey" (Statistics Bureau, Ministry of Internal Affairs and Communications). Basic government statistics are available from e-Stat (the general portal for government statistics).

International Sources

- OECD Science, Technology and Industry Outlook provides an annual review of STI trends.
- OECD Science, Technology and Industry Scoreboard is a comparative analysis of STI trends.
- OECD Main Science and Technology Indicators (MSTI) provides data analysis of basic science and technology indicators.
- OECD/World Bank: Innovation Policy Platform (IPP) is an integrated website on innovation policy.

All are available from the OECD Library

Related organizations

- NISTEP, JST/CRDS, RIETI, etc.

Information on related course subjects and related research projects

- All items