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3.1.2 Big Science and society

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Abstract

This paper offers clues for thinking about the relationship between science, technology, and innovation and society by examining Big Science as a dimension of science, technology, and innovation. In doing so, this paper clarifies the definition of Big Science; outlines how Big Science is positioned in the history of science, technology, and innovation after the Second World War; and discusses the relationship between space policy and society, which can be considered a typical example of Big Science. As the relationship between Big Science (which includes space policy), society, and the general public becomes ever more relevant, there is a need to increase opportunities for the general public to become directly involved in the policy process.

Keywords

Big Science, history of science and technology, space policy, public commentary, deliberative poll

1 Introduction

When thinking about the relationship between scientific and technological innovation and society, we cannot neglect Big Science. In the history of science, technology, and innovation after the Second World War, Big Science has played a significant role in domestic and international society, particularly during and after the Cold War.

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This paper offers clues for thinking about the relationship between science, technology, and innovation and society by examining Big Science as a dimension of science, technology, and innovation. After defining Big Science, this paper outlines how Big Science is positioned in the history of science, technology, and innovation after the Second World War, and then discusses the relationship between space policy and society, which can be considered a typical example of Big Science.

2 What is Big Science?

According to some explanations, Big Science refers to scientific research that is carried out as a matter of national policy involving large-scale organization and management, and requiring large amounts of human resources and money, such as nuclear power and space exploration (Jido Yuji, 2018).

Three characteristics can be identified in Big Science: large scale, policy, and internationalization (Jido Yuji, 2018). In the twentieth century, science grew larger in scale; with instruments and equipment for scientific research becoming more sophisticated, more human resources and money became necessary to develop, manufacture, maintain, and operate them. In order to conduct scientific research on such a large scale, state funding became necessary. Meanwhile, as military technology and related industrial technology became important in international competition, so scientific research has become a matter of national policy, with decisions made on how much to invest in which fields and the results and their significance evaluated. In short, science has become policy. While such large-scale and policy-oriented scientific research is conducted amidst fierce international competition, the difficulty of carrying out such research drawing on the scientific and economic power of a single country necessitates international cooperation and joint research. Accordingly, science has become internationalized. In general, scientific research with the aforementioned characteristics is called Big Science.

Big Science can be classified as follows (Hironori Ayabe, 1999): If we define Big Science as a type of scientific research project that requires tens of billions of yen in investment, and in which the number of participating researchers is small compared to the size of the funds invested in the project, we can call vast scientific projects such as high-energy physics “capital-intensive big science,” while similarly vast scientific projects such as the human genome project, a human-resource intensive project, can be called “labor-intensive mass science.”

As noted, while the definition of Big Science has been elaborated upon to some extent, it is not necessarily fixed. Indeed, while Big Science is the commonly used term, as in the explanation above, it can be used to refer to both Big Science and Mass Science, which have slightly different meanings. Therefore, in this paper, I take a broad view of the definition of Big Science, and discuss it in terms of science, technology, and innovation policies and plans that are large-scale in terms of human resources, costs, organization, and management, and undertaken by a single country or through international cooperation.

3 A history of postwar science and technology and Big Science

How is Big Science positioned in the history of scientific and technological innovation following the Second World War? In his book, International Competitiveness in Science and Technology (2006), Shigeru Nakayama, a historian of science, attempted to provide an overall picture of the history of postwar science and technology, which he classified into periods of time according to the ideologies of the world, the US, and Japan (Table 1). In this respect, he explained ideology as a kind of "zeitgeist," in which certain values are perceived as shared values during a particular era.

Table 1: Postwar history of science and technology (world, US, and Japanese time periods)

Period (e.g. of history)	Representative Scientific Technologies	Ideology (Global)	Ideology (US)	Ideology (Japan)	Supporter
1st period (1945-1957) Postwar Demilitarization and the Cold War: Cold war science	Atomic energy ←the beginning of big Science	Basic science	Basic science	Post-war democracy	US : Military Japan : Academic
2nd period (1957-1960s) Post-Sputnik: Science and Technology Boom and High Economic Growth	Universe ←Period of the heyday of big science	Basic science	Basic science	Science and technology	US : Academic Japan : Industry
3rd period (1970s) Scientific Criticism and Ecology: Nature and Environment protection	Ecology	Ecology	Ecology	Ecology	Citizen and academic
4th period (1980s) U.S. Stagnation and Japan's Rise: U.S.-Japan Economic and Technological Friction	Computer, Internet ←Period of the resurgence in big science	Information-oriented society	Competitive power	Japan as No.1	Government and industry
5th period (Since 1990) Post-cold war and privatization: Earth and Environmental Sciences	Biotechnology	Privatization	Globalization	Competitive power	Government and industry

Source: Created by the author with reference to Shigeru Nakayama (2006), *International Competitiveness in Science and Technology*, Asahi Shimbunsha, pp. 3–13.

The history of postwar science and technology can be divided into five periods. The first period spanned the era of postwar demilitarization and the Cold War from 1945 to 1957. The Cold War began during this period. In the US, wartime military research funds were redirected to basic science, while Japan, a postwar democracy, focused on market-oriented science and technology for economic recovery. Big Science can be said to have started a little before this period. The Manhattan Project was a national project launched in the United States in September 1942, that is, during the Second World War, with the aim of developing and manufacturing an atomic bomb, which was successfully tested in July 1945. An estimated USD 2 billion and more than 120,000 people were invested in the project at the time. As the Cold War with the Soviet Union (USSR) became entrenched, the US continued to advance the research and development of nuclear energy (i.e., atomic bombs, followed by hydrogen bombs), which was promoted as the Big Science of the Cold War era.

The second period spanned the post-Sputnik era from 1957 to the 1960s. This period began with the so-called "Sputnik Shock" experienced by the US and the rest of the world when the Soviet Union successfully launched the first artificial satellite, Sputnik 1, in October 1957. Space became the center of science and technology. Keenly aware of the importance of science and technology, the US formalized and advanced the Apollo Project in May 1961, with the aim of achieving the first manned landing on the moon, which eventually took place in July 1969. A total of USD 25 billion and 400,000 people are estimated to have been invested in the Apollo program at the time. In Japan, during the science and technology boom and the rapid economic growth of the postwar period, Big Science was at its height.

The third period comprised the 1970s, a time of scientific criticism and ecology (e.g., ecology, environmental protection). This period was very much a reaction to the second period. At the end of the 1960s, amidst the Vietnam War, environmental destruction, and pollution, criticism of the supremacy of science and technology emerged and citizen movements for the protection of the natural environment and other issues flourished. In this context, Big Science came under scrutiny for budget cuts and project downsizing, and thus came to be advanced through international cooperation. In the space field, the Space Shuttle Program—the successor to the Apollo program—was carried out in cooperation with Europe and Canada, although the United States was responsible for the major part of the program. In July 1975, amidst the easing of tensions in the Cold War between the US and the Soviet Union, the Apollo-Soyuz project was conducted, in which a US Apollo spacecraft and a Soviet Union Soyuz spacecraft docked in low Earth orbit. In the nuclear energy field, the US tightened regulations on nuclear power plants in response to environmental issues, while in Europe, the development of the Joint European Torus (JET), a large experimental nuclear fusion device, made great strides through international cooperation. As such, Big Science survived thanks to international cooperation (Yasushi Sato, 2014b).

The fourth period spanned the 1980s, a time of stagnation in the United States and the rise of Japan. In terms of science and technology, this was the period of the microelectronics revolution, when computers and, finally, the Internet appeared, giving birth to the information society. Japan reached the pinnacle of its production science and technology, giving rise to an ideology of competitiveness with the United States and resulting in intense economic and technological friction between the two countries. Marked by fierce confrontation, the US-Soviet relationship in the first half of the 1980s became known as the New Cold War. In the latter half of the decade, efforts were made to improve relations and tensions eased. During this period, two international Big Science projects were launched. The first of these projects was a space station program, which evolved into today's International Space Station (ISS) program. The US announced the start of the program in January 1984, and invited Western countries to participate, with an intergovernmental agreement eventually signed between the US, Europe, Japan, and Canada in September 1988. The second initiative was the International Thermonuclear Experimental Reactor (ITER) project, which continues to this day. The agreement was reached at a US-Soviet summit meeting held in Geneva in November 1985, and conceptual design began in 1988 with the participation of Europe and Japan. The space station project was pursued as US-Soviet competition, while the International Thermonuclear Experimental Reactor project was pursued as US-Soviet cooperation (Yasushi Sato, 2014b).

The fifth and final period comprised the post-Cold War period and privatization of science and technology from the 1990s, when global environmental science was actively advanced as a replacement for Cold War science. The collapse of the Cold War structure triggered talk of privatization and globalization. In Japan, while there was talk of an ideology of competitiveness against the United States, science and technology entered the biotechnology age. Following the end of the Cold War, the Space Station program, pursued since the 1980s by the US, Europe, and Japan, became the International Space Station (ISS) program with the addition of Russia in September 1993. Module launches began in 1998, and construction was completed in 2011. It remains in operation to this day. Engineering design for the International Thermonuclear Experimental Reactor (ITER) Project was carried out between 1992 and 1998. Although various problems arose, such as a proposal to scale down the project and the withdrawal of the US, the ITER International Fusion Energy Organization was established in October 2007, and construction is currently underway.

In the postwar history of science and technology outlined above, Big Science began with the research and development of nuclear energy from the Second World War-era Manhattan Project up to the 1950s, and reached its zenith as space research and development in the 1960s following the so-called Sputnik Shock. Around the end of the Cold War in the 1980s and 1990s, international cooperation in nuclear power and space overcame budget reductions and project downsizing amidst scientific criticism and environmental protection concerns in the 1970s, resulting in development that continues to this day.

4 Space policy and society

Finally, I would like to discuss the relationship between space policy and society, which can be considered a typical example of Big Science. In this paper, “space policy” is defined as the goals, plans, and outcomes that a nation or government should pursue with regard to space (including the moon and other celestial bodies) or space activities (e.g., research, development, and utilization of space), including as its outcomes space law and space science and technology. I use “space policy” instead of “space program” as an example of Big Science because, when we consider the relationship between the state, government, and society, space policy includes not only the planning of rockets and satellites, but their policy processes and related legal systems and organizations. Accordingly, space policy offers a broad and comprehensive view of space and space activities.

This paper also addresses space policy because it has not been sufficiently studied, especially in Japan, compared to nuclear policy, which is considered another typical example of Big Science. Although it lags behind the US and Europe, Japan has gradually undertaken space policy research, which studies space policy, since the 2000s. Prior to doing so, space policy had been studied as the history of space development in the field of the history of science and technology, and as space law in the field of international law. Indeed, it has been less than twenty years since Japan began studying space policy in international politics, national security theory, public policy theory, and political diplomacy history. Space policy research is concerned with the interaction between politics and space (i.e., activities concerning spaces); its analytical methods are mainly historical and theoretical, and it remains in a developmental stage in Japan.

What are the characteristics of space policy? First, in comparison with other science, technology, and innovation policies, foreign diplomacy and national security policy aspects are particularly significant to space policy. This is because space is a “place” together with land, sea, air, and cyberspace, which lies outside the domain of states, and because space science and technology such as rockets and satellites are truly dual-use technologies. Second, in terms of space policy's relationship with society and the general public, there has been less direct damage compared to nuclear power and the environment. Moreover, Japan's space-related budget is about JPY 340 billion (FY2017), which is 0.3% of the total government budget of about JPY 100 trillion, the highest proportion it has ever been. As a result of these characteristics of space policy, the general public is rarely requested a clear decision for or against a policy with a deadline, something further reflected in the fact that few deliberative polls on space have been conducted in Japan.

However, Japan is currently experiencing a major transition in its space policy. More specifically, the Space Basic Act was enacted in May 2008, the Space Development Strategy Headquarters and the Minister of State for Space Affairs were established within the Cabinet, and the first Space Basic Plan was formulated in June 2009. The current Third Space Basic Plan was formulated in January 2015, and includes three primary goals: (1) to ensure security in space; (2) to promote the utilization of space in the civilian sector; and (3) to maintain and strengthen industrial, scientific, and technological infrastructure. At the same time, the system for advancing space policy has been improved, with the establishment of the Secretariat for the Strategic Promotion of Space Development (i.e., control tower) and the Space Policy Committee (i.e., deliberative body) within the Cabinet Office, and the Japan Aerospace Exploration Agency (JAXA) positioned as the core implementing agency for the government's overall plans for space development and utilization.

In November 2016, the Space Activities Act was passed to promote private rocket launches and satellite operations, while the Satellite Remote Sensing Act was passed to regulate the use and management of satellite imagery. Japan will soon have to address what to do about its space policy with regard to space exploration in terms of whether to continue its participation in the International Space Station (ISS) program after 2024. Japan has been involved with this project since the 1980s, primarily with the aim of strengthening the US-Japan alliance.

As noted, the relationship between space policy and society and the general public has been strengthening over the past decade with the expanding use of space science and technology. However, there remain few opportunities for the general public to be directly involved in space policy. The public's direct involvement in Japan's current space policy process is limited to public comments that are solicited when the text of the Space Basic Plan and its process chart are formulated and revised. Thus far, public comments have been sought on the text of First Space Policy Basic Plan (decided in June 2009), the text of the second plan (decided in January 2013), the text and process chart of the third plan (decided in January 2015), the process chart of the third plan (revised in December 2015), and the process chart of the third plan (revised in December 2017). For the main text, a total of 550–1510 comments were received, collected over periods of one to three weeks, with 309–660 contributors. Despite the comparatively short collection period, approximated 500 people make submissions on each occasion, with contributors ranging from experts to stakeholders to the general public.

A public comment workshop has also been trialed as a study on public comments concerning the Space Basic Plan (M. Ito, T. Minamoto, A. Nakayama, K. Ebina, K. Mizumachi, K. Kano, and N. Akiya, 2014). The public comment system—that is, the soliciting of public opinion—is considered to be an innovative method of administrative participation. In general, there are two types: legally obligatory type, in which the period of solicitation is, in principle, thirty or more days from the date of public announcement; and the voluntary type. The Space Policy Basic Plan employs the latter approach. The disadvantages of public comments include not knowing that such a thing exists, small numbers of opinions, collected opinions not being reflective (i.e., 20–30 percent reflection rate), overly short solicitation periods, and specialization (i.e., difficulty in understanding and submitting opinions). A new approach was trialed in an attempt to involve citizens in the policymaking process by (1) planning and holding a workshop related to public comment, (2) providing information to the participants and exchanging opinions, (3) submitting opinions on behalf of the organizer, and (4) sharing responses to the submitted opinions in a public comment workshop for the draft of the Second Space Basic Plan (solicitation period of twenty days in December 2012).

Overall, while there are still issues to be addressed, public comments on the Space Basic Plan can be said to have achieved a certain level of success in terms of the number of opinions and participants (e.g., experts, stakeholders, and the general public). The most recent public comment workshop on the process chart of the third plan (revised in December 2017) set a month-long solicitation period, and is expected to become an established part of the space policy process as it continues to be implemented. Nonetheless, as space policy is increasingly connected to society and the general public, efforts should be made to increase opportunities for the general public to be directly involved in the space policy process while taking into account the specialized and specific nature of space policy.

5 Conclusion

This paper has considered the relationship between science, technology, and innovation and society by examining Big Science and space policy as a dimension of science, technology and innovation. Conclusions regarding Big Science in Japan can be summarized as follows. There is insufficient research on Big Science as part of science, technology, and innovation policy in Japan. Although there may be records and analysis of Big Science as part of science, technology, and innovation plans, these first need to be re-examined as individual and specific science, technology, and innovation policies. Next, it is necessary to compare and validate nuclear policies with other nuclear policies, and space policies with other space policies. Finally, science, technology, and innovation policies, such as nuclear power and space, need to be compared and validated against one another. Big Science refers to science, technology, and innovation programs that are large-scale in terms of human resources, costs, organization, and management, and is undertaken by a single country or through international cooperation. It has strong relationships with society and is highly significant as part of both domestic and foreign policy. As such, there is a need to advance Big Science research as part of science, technology, and innovation policy.

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- STiPS Osaka University, “Science and technology and public policy B” (1 credit, Winter semester)
- STiPS Interdisciplinary Collaboration Project, “Construction of a policy planning support system for examining social issues in new science and technology” (STiPS Osaka University, 2016–2018)
- SciREX Priority Research Project (Joint Implementation Project), “Research on the history, current state, and future vision of the Japan Aerospace Exploration Agency (JAXA): Focusing on the relationship between the government and the private sector” (Lead Researcher: Hirotaka Watanabe, Osaka University, 2019–2020)

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