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Statistical Analysis of National Science and Technology Programs

— Activities of National R&D Institutes and Cooperation among Government, Industry and Academia in Japan —

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by

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1. INTRODUCTION

Today, the impacts of science and technology extend over almost all areas like economy, industry, education, defense, and diplomacy. Government involvement in the research and development (R&D) is becoming active more and more, and the areas where government sustain the R&D activities are expanding. Of cause, the themes and contents of science and technology change with time. Correspondingly, the role of government in the R&D of science and technology is also subject to change with the times. To understand it, just looking back only the last twenty years is enough. In the 1970s to the 1980s, although signs of the relaxation of the Cold War appeared, the world was still in the midst of the Cold War structure. And, national science and technology programs were placed at high priority positions in each country as one of the basic policies for maintaining national prestige, security, and progress in industrial development. Therefore, each country has made efforts to promote science and technology programs with a view to enhance her own technology capability, although she has had many problems to be solved urgently. Today, the essential meaning of national science and technology programs in each country is still preserved, however, there are emerging needs to find some new approaches and to establish rules for progress in the national science and technology programs with the demise of the Cold War structure. Changes in the domestic societies also require the establishment of new approaches for national science and technology programs. Recent OECD's initiative concerning the development of international criteria for national R&D subsidies to private industry's R&D activities, rising concern over aging population, and increasing concerns about global environment as reflected in the Brazil summit are only few examples of such changes.

Irrespective of its apparent increasing importance of government involvement in science and technology, such involvement has been often viewed as having negative influences on free and fair market competition and the development of sound market economies. Behind this criticism, there has been a growing belief that efficient market economies are the only alternatives under the situation of the collapse of Communism in the former Soviet Union. In addition, growing concerns about global problems like environmental demolition and population explosion have also called for new approaches to national science and technology programs. Under these circumstances, a new vision of national science and technology programs based on the unified efforts like a collaboration among government, industry and academia has begun to attract more attention from researchers and policy makers. Such efforts, however, may bring about some controversies. For example, the political conflict over the opening of the Japanese telecommunications industry under the pressure of the "Super 301" provision of the 1988 Trade Act in the United States entails such concern of where the boundary between government R&D activity and commercial activities lies. Creating a new framework for international research cooperation must also deal with this boundary issue between governmental activity and market competition (Ref. 1).

In order to properly deal with the current problems related to science and technology policy as described above, it is mandatory to have clear understanding of the history and current status of national science and technology programs before proceeding to the analyses of the specific issues.

Here, let's review briefly the structure of science and technology promotions in Japan. Because of the scarcity of natural resources, Japan has been adopting a policy of paying much attention to develop technology since the Meiji Restoration. Nation-building on the basis of science and technology has been the central goal, and the goal has been pursued by each sector in the society with the collaboration of government, industry and academia. Economic, political and social systems have been integrated toward the establishment of its own indigenous technology system. The developments of heavy industry, chemical industry, electronics industry were accelerated by the use of the basic technologies transferred from the United States and European countries, and the technology bases accumulated through these efforts caused today's advancement of the industries such as information and biotechnology industries, etc. Many high-tech products have become to support our daily life. For instance, Japanese people now enjoy the services of geometeorological, broadcasting and communications satellites, which are a typical outcome of national science and technology programs. In sum, Japan has been able to build various technology bases and obtained today's prosperity by promoting the R&D of science and technology in national scale with the adaptation of social needs to international environment in each era.

To define the problems and to clarify the historical necessities of national programs progressed under a complex of economic, political and social systems, we need a multi-disciplinary approach that covers related disciplines such as economics, politics, sociology, natural sciences and engineering. Preliminary development of such multi-disciplinary approaches to build theoretical frameworks for this type of problems have been proposed in several concepts such as "system politics" (Ref.2), Wallerstein's "world system analysis" (Ref. 3), etc., even though none of them have still reached the stage of containing science and technology problems in that domain explicitly. By understanding national science and technology problem as a multi-disciplinary problem, we begin our study with a review of the science and technology system in Japan and then identify the characteristics of national science and technology programs by adopting the systems approach backed up with historical and empirical approaches. More specifically, we will look into national R&D organizations as core promoters of national science and technology programs and some typical cases of the programs, by making the most of statistical approaches to clarify the dynamic behavior of these programs. The purpose of this endeavor is to find some general tendencies and laws governing the science and technology activities and to present them as a clue to establish a guideline of the future national R&D programs. In addition, systematic considerations through this study will effectively work to extract essential subjects immanent in the process of national R&D activities.

The next chapter, i.e. chapter two presents a brief discussion about framework of the analysis, where the territory of this study will be clarified. And also the basic architecture of this research will be described. The framework to be presented here is essentially to intend to specify the general territory and direction of the research. More rigorous framework and its details will be discussed and set as complete form in the later stage when we will analyze each specific problem.
In chapter three, the current activities of national research organizations as implementers of national science and technology programs will be analyzed to identify the areas of essential problems common in particular national science and technology programs. Because it was conjectured that the understanding of the realities of national research institutes and research institutes of public corporations will help figure out basic characteristics in national science and technology programs. We will first review the historical outlook in the development in science

and technology infrastructure including the establishment of national research institutes and research institutes of public corporations after World War II. Then, based on a questionnaire survey and interviews, current feature of these national research organizations will be analyzed.

In chapter four, a case study of a typical national science and technology program, i.e. space program will be presented, where we stress an important aspect of national program problems, that is the cooperative activity among three sectors: government, industry and academia beyond the traditional theories of the cooperation between two sectors like industry-academia or government-industry.

Finally in chapter five, the results of the research as the first phase is summarized.

2. FRAMEWORK OF ANALYSIS

2.1 Definition of Problem

Science and technology today affect every aspects of national living. And also, it is inseparable from such major national policy areas as not only economy, industry, education and security but also politics and foreign relations. Although the influences of science and technology are diversified, the science and technology can be classified according to the content and degree of government involvement into three major categories as follows:

a. Science and technology indispensable for the nation
b. Science and technology necessary for the basis of the production in industries
c. Science and technology necessary to maintain the stationary and stable living of a civilized nation

The science and technology indispensable for the nation consist of the most advanced technologies that contribute to raise national prestige, the specific technologies that have direct implications for national security, and the technologies of which the neglection will hamper the national interest in the future. R&D of the above technologies usually need specific organizations to be in charge. Nuclear power and space technologies are typical examples of the technologies in this category.

Science and technology for the basis of the production in industries refer to the technologies that need such a large amount of money to build up as to make it unbearable by private firms only. We cannot depend on the market mechanisms for the development of these kinds of technologies. Therefore, it is necessary to give a certain government assistance for the development of such technologies. The problems related to these technologies have been discussed within the industrial policy, and recently, the specific policy area is being formed as industrial science and technology policy.

Science and technology necessary to maintain the stationary and stable living of a civilized nation are related to basic infrastructures, i.e. fundamental systems of the stable supply of foods, housing, medical services, transportation, and energy. Basic R&D of these technologies are carried out by not only national organizations but also public corporations enthusiastically.

Any modern science and technology involved by government can be classified into above three kinds of technologies. In order to bring up each of such R&D of science and technology, it is a prerequisite to establish some common fundamental infrastructures, and then specific measures will be developed well for each program. In order to clarify the scope of national science and technology programs and related problems to be discussed here, we propose a conceptual model as shown in Figure 2.1.

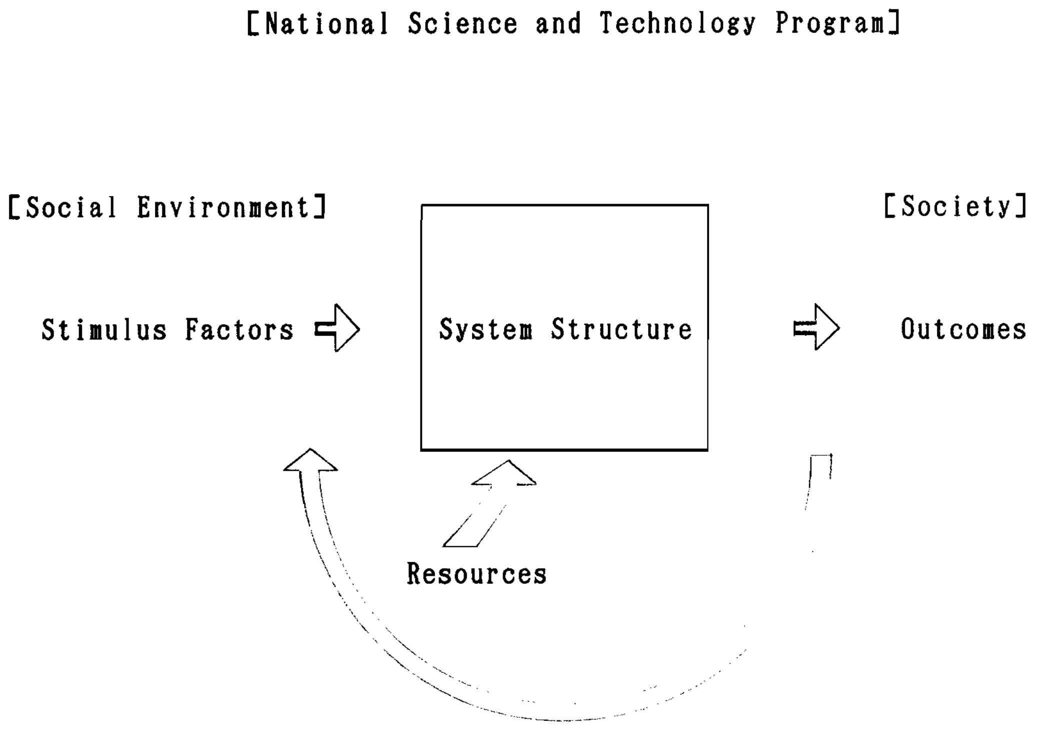


Fig. 2.1 A Conceptual Model of Dynamic System of National Science and Technology

In Figure 2.1, "stimulus factors" in "social environment" work effectively to create a certain "national science and technology program," which brings forth a "system structure" consisting of laws, acts and institutions for the implementation of the program. The system structure will then produce output or "outcomes" into our society that will in turn have impacts on the "social environment." "Resources," i.e. human resources and funds will be input to the system structure to fulfill its function well. The output of one program could be an input for the following programs. In this fashion, the implementation of national science and technology programs and the evolution of our society take an interactive process forming a spiral.

It is widely known that the military-industrial complex has been exerting certain level of contributions to the development of outstanding national science and technology programs in the United States. It is natural to suppose that Japan has had certain equivalents to such military-industrial complex in the U.S. What are the equivalents in Japan then ? Trying to answer to this question forms one of the motives for our study. If we look at the formation stage of national programs in Japan, a typical pattern is found that either the government agencies decide the research themes on their own judgement or government agencies support the university researchers who follow the advanced technologies abroad and the industry's researchers who have some bright themes in primitive stages. It can be said that the network composed of government agencies, university researchers, and industry forms the Japan's equivalents of the US military-industrial complex. As one of important members among such network, national research institutes have been established under the ministries and agencies. In fact, in creating and promoting the national programs, some council and committee were established in government agencies, and the members of the councils and committees which consist of the ones from the academia and industry were played important role. We must also not overlook the importance of the opinions of general people which were reflected into mass media and partly the opinions through political parties. Therefore, we will define all these determinants or factors influencing national science and technology programs as stimulus factors, from the point of view of macro level approach.

For the science and technology indispensable for the nation, the environment surrounding the nation including the international tensions will form the stimulus factors, which will in turn have critical impacts on the system structure. When the effects of the stimulus factors will become too big for the system structure to perform the functions and beyond a threshold level, eventually the structure will be changed and adapted to the new situation.

For the science and technology necessary for the basis of the production in industries, the sales and trade status of the industry in domestic and foreign markets will form major stimulus factors. And they will bring about the issues of balancing between the protection of domestic industries and the market liberalization. In other words, the balance between the concerns for domestic and foreign factors becomes one of the most critical determinants.
The science and technology related to basic infrastructures necessary to maintain the stationary and stable living will cause such issues as the promotion of public enterprises to provide better services and the ways to support and control such services. And also, one of important factors comes from the physical changes in the nation and people themselves, such as the increase of aging population, etc.

National science and technology programs driven by the stimulus factors deal with and solve the problems related to the needs from the government, industry and people, respectively. When the design and implementation of such programs are well performed, these will produce the benefits leading into prosperity, evolution and more comfortable people's daily life, respectively.

On the other hand, national science and technology programs have a two dimensional structure: one dimension consists of problems related to the coherence among the national technology, the industrial technology and the technology for people's life, and another dimension consists of the problems related to a life cycle of science and technology, i.e. the stimulus factors brewed from social environment, the system structure from national science and technology programs and the outcomes. In order to take a broad view over the whole system containing above area, this study will focus on the characterization of stimulus factors, the system structure and outcomes. In other words, this problem is understood as a kind of systems identification of social structure. Figure 2.1 is the very visualization of this research framework as a conceptual model.

2.2. Procedure of Analysis

Once the characterization of the "dynamic system of national science and technology activities" shown in Fig. 2.1 is obtained and a model is developed, we will be able to get some valuable information for forecasting a response of the system, i.e. the influences to society. And also during the process of the identification, we can find some important matters for future policy making. From the point of view that this study is a type of systems identification of a time variant social system related to science and technology activities, we will proceed our discussion with laying stress on the following subjects:

(1) To extract dominant events in the history of national programs and to grasp major influence factors in the R&D process with their historical backgrounds.
(2) To perform questionnaire survey and interviews on all national R&D organizations. After that to diagnose the national systems through a statistical approach.
(3) To perform case studies of typical national programs, and to understand a system structure of the national programs.

We will accumulate the knowledge from each analysis of the specified items and then try to draw some implications for future policy making.

In next chapter, we will begin with the discussion on the current activities of national R&D institutes, based on a questionnaire survey, to serve as general background for the following individual analyses. We will then present a case study on space program to understand a cooperative pattern among government, industry and academia through the national program.

3. CURRENT ACTIVITIES OF NATIONAL R&D INSTITUTES AS CORE PROMOTERS OF NATIONAL PROGRAMS

This chapter discusses current activities of national R&D institutes as core promoters of national programs. Before this discussion, we will review a brief history of science and technology system after World War II to have a general background of basic issues related to the national organizations, i.e. answering the fundamental questions as follows:

. How have the system structure changed over time corresponding to domestic and international environments, particularly in terms of the role of government (law, institutions, organizations, etc.) ?
. What kinds of themes and subjects have been adopted as national programs ?

After that, we will analyze the current activities of national R&D institutes, which is equivalent to answer the question:

. How have the national and public research organizations acted and been managed in reality as implementers of national science and technology programs ?

Clarifying the historical events in the science and technology activities will serve as a basis for the following analysis of national organization's activities, and also for the micro level analysis of each individual program.

3.1 Brief History after World War II

The modern industries in Japan have started since the Meiji Restoration. The development of the industries has been accelerated owing to governmental involvement in the technology imports from Western developed countries, and also government promoted the science and technology activities. During the period between the late Meiji and the Taisho eras, textile, mining and pulp were the major industries. Turning to the early Showa era, military and steel industries came to assume larger magnitude, and The Korean War drove and activated Japanese economy, and textile, steel and coal industries became largest industries. Entering the high rate of growth period from 1955, the focus moved to electric appliance and automobile industries. During these periods, correspondingly national and public research organizations expanded their activities and had an important role for developing generic technologies for industries (Ref. 4). The center of these activities of national organizations is changing with time. In early days, it was to implement tests and to establish basic industrial standardization. In recent years, it shifted to consultation of industrial problems and coordination of high-technology R&D among industry's R&D organizations (Ref. 5).

Now let's review the history of restructuring of national science and technology R&D systems after World War II. Table 3.1 shows a brief history of national science and technology R&D systems (Refs. 6-9).

With the ending of World War II in 1945, the old system structures were dissolved and Japan turned to the path for non militarism. The fundamental institutions that had been built during the war period revived in the postwar years with some short intervals. For example, the Agency for Technological Advancement (Gijutsuin), which had been established for R&D of military technology in 1942, was dissolved in 1945 and came to be revived as Agency of Industrial Science and Technology (AIST; Kogyo Gijutsuin) in 1948. Presently, it belongs to the Ministry of International Trade and Industry (MITI).

In 1948, the Science Council of Japan (Nihon Gakujutsu Kaigi) was opened. Originally, the institution had been established as Japan Society for the Promotion of Science (Nihon Gakujutsu Shinkokai) in 1932, which contributed much to the expansion of the budget related to science and technology. The budget started in 1939 as Research Grant Program continue to exist until today, even though it is now called Grant-in-Aid for Scientific Research.

The system structures after World War II have their roots on the arrangements in the middle of the war and were constructed with some modification in American fashion. The year 1949 was marked by economic recession due to the Dodge Line which enforced the exchange rate to 360 yen per US dollar. The Korean War brought a special boom and the production growth in Japan. In May 1950, the Foreign Investment Law was promulgated and it boosted the technology imports. The loans from the World Bank activated the investment, especially in iron and steel sectors. The year 1956 witnessed the establishment of the Science and Technology Agency

(STA). A great deal of technological introductions had been made in the 1960s and the popularity of science and engineering disciplines increased among high school students and their parents.

In order to deal with the energy problem, the Electric Power Source Development Law was introduced in 1952, and the 1955 legislation of the Law on the Provisional Measures for the Rationalization of Coal and Mining Industries prompted the switch from coal to oil as main power source.

In 1960, Japan faced a international change with the revision of the Japan-United States Security Treaty. And in 1964, the transition of Japan to the IMF clause 8 country and GATT clause 11 country. Based on this new soil, science and technology ventured into new, large-scale programs such as nuclear and space development to catch up with the advanced technologies in Western leading countries.

The foundations for nuclear and space programs were solidly laid during the period of the 1960s and were completed by the early 1970s. As such, the 1970s were devoted to research on new material, biotechnology, and microelectronics. A renewed attention for the utilization of human resources based on the collaboration among government, industry and academia was proposed to promote new research fields. This was clearly reflected in the 6th recommendation by the Council for Science and Technology in 1977 in terms of "strengthening the organic ties among government, academia and the public."

In 1981, two leading agencies, MITI and STA, each announced ambitious schemes. MITI created the "Research and Development Project of Basic Technologies for Future Industries" and STA created "Exploratory Research for Advanced Technologies (ERATO)." The 11th recommendation of the Council for Science and Technology in November, 1984 emphasized the coordinating role of the government agencies. In 1985, the Law for the Facilitation of Research in Fundamental Technologies was enacted to establish the Japan Key Technology Center. In order to reform universities, then, the University Council was set up in 1987. The Council suggested the creation of the Graduate University for Advanced Studies and the Advanced Institutes of Science and Technology.

Now when we turn our eyes from the institutions to technologies (Table 3.2), we find that the national programs until the 1970s were mostly oriented to catching up with advanced countries in the West. In other words, they were focused on either the basic and promising programs or the ones which involve great risks in R&D such as nuclear, space, etc. And gradually, another important consideration, i.e. whether or not technological spillover effects of such programs exist has been added in the design of programs. Now, with the phase-out of catching up style of technological development, the goals of the programs have begun to include such notions as the utilization of indigenous technologies, their diffusion to other countries, and the globalization of research and development.

Currently, a major concern for the promotion of science and technology activities lies not only in assisting the research and development of current basic technologies but also in promoting interaction among different organizations and fields for exploring into new technology areas. And several institutional rearrangements are under way for this purpose.

The formation process of one of national science and technology programs will be discussed in Chapter 4, with a case study. Before doing that, it is important to understand the fundamental nature of the implementing institutions of national programs. This task is done through a questionnaire survey, of which the discussion will relate to national research organizations.

Table 3.1 The History of Science and Technology System

Year	Law and Institution	Organization	Social and Economic Events
1945			Ag.15 Unconditional Surrender
		S. 5 Dissolution of the Agency for Technological Advancement	
	S.22 GHQ expressed its policy concerning science and technology.		
			O.11 GHQ instructed the five big reforms to secure human rights.
	N.18 GHQ prohibited research and education on military technology including aeronautics. N.24 GHQ demolished Cyclotron.		
			D. 9 GHQ presented memorandum concerning the agrarian reform.
1946	(J.10 Arrival of Dr. H.C.Kelly as GHQ's Science Advisor)	J.10 Abolition of Aeronautical Research Institute, the University of Tokyo	
			F. 1 Enforcement of the First Agrarian Reform
		Ag.16 Establishment of the Japan Federation of Economic Organizations (KEIDANREN)	
			S.30 The dissolution of the Zaibatsu (Financial Clique) N. 3 Promulgation of the Japan's Constitution
1947	J.30 Far East Committee decided the prohibition of study on atomic energy.		
		F. Establishment of the Technology Section, The Ministry of Commerce and Industry	F. 1 Strong restriction of electric power consumption
			Mr.31 The Basic Education Law and the School Education Act were enacted. Ar.14 Promulgation of Antimonopoly Act (Jy.20 Enforcement) My. 3 Enforcement of the Japan's Constitution
		My.21 Establishment of National Institute of Health	
	Je. 1 Enforcement of Radio Law		
			D.18 Promulgation of Laws on Prevention of Concentration of Excessive Economic Power (Temporary law until Je.30,'49)
1948			《Era of the Cold War and the Iron Curtain》
		Mr. Reorganization of the Institute of Physical and Chemical Research (RIKEN) to a private corporation " Scientific Research Institute Inc." Ar. Establishment of Japan Electronics and Communication Machinery Association My.28 Establishment of Japan Electrical Manufacturer's Association	
	Jy.10 Promulgation of the Science Council of Japan Act Ag. 1 Promulgation of Industrial Technology Agency Establishing Law		
			D.18 GHQ indicated nine principles for stabilization of economy.
	D.20 Promulgation of the Law for Scientific Technical Administration Committee (J.20,'49, Enforcement)		

Table 3.1 The History of Science and Technology System (continued)

Year	Law and Institution	Organization	Social and Economic Events
1949		J.20 Establishment of the Science Council of Japan	
			F. 1 The U.S. sent Mr. Dodge as a special envoy to Japan.
			Ar.23 GHQ fixed the exchange rate at ¥360 to the dollar. (enforced from Ar.25)
		My.25 Establishment of the Ministry of International Trade and Industry	
	My.31 Promulgation of National School Act and the Law for establishment of the Ministry of Education (Next day,Enforcement)		
	Je. 1 Promulgation of Industrial Standardization Law (Establishment of JIS.)		
			N. 3 Hideki Yukawa received the Nobel Prize for Physics, as the first Japanese winner.
	(N.28 House of Councilors passed a resolution on promotion of science and technology.)		
1950	(Mr.11 House of Representatives passed a resolution on promotion of science and technology.)		
			My.10 Enacted the Foreign Investment Law
			Je.25 The Korean War broke out.
			Jy. 8 Establishment of the National Police Reserve Force
		D.19 Establishment of Industrial Technology Council	
1951			Ar.11 Dismissal of General MacArthur Lieutenant General Ridgeway took his place.
			My. 1 Reorganization of the electric power industry was completed. Inauguration of 9 electric power companies
			Je.21 Affiliation of Japan to ILO was approved.
			S. 8 The United States - Japan Security Treaty was signed.
		The Liberal Party established a special committee for promoting science and technology.	
1952			Ar.28 The effectuation of the Peace Treaty and The U.S.-Japan Security Treaty
	Jy.31 Promulgation and enforcement of Electric Power Source Development Law Promulgation of the Law for establishment of Resources Council (Ag.1 Enforcement)		
		Ag. 1 Establishment of Agency of Industrial Science and Technology (Dissolution of Industrial Technology Agency)	
			Ag.14 Japan became a member of IMF and World Bank.
		S.16 Establishment of Electric Power Development Co.,Ltd.	
	(D. The Liberal Party proposed the establishment of Science and Technology Agency.)		

Table 3.1 The History of Science and Technology System (continued)

Year	Law and Institution	Organization	Social and Economic Events
1953			Mr. The last time of commencement day of the universities under the old system of education, The first time of commencement day of new-system universities
	Ag. A plenary session of the House of Representatives passed a resolution concerning the promotion of science and technology.	Ag. 1 Establishment of Research Institute for Fundamental Physics, Kyoto University	
			O.23 General meeting of GATT approved the temporary affiliation of Japan.
1954	F. The Diet-member group submitted its Plan for establishing the Science and Technology Agency.		
			Mr.14 The Daigo-Fukuryu-Maru (Fisher-boat) suffered from radioactive fallout of H bomb testing around the Bikini atoll returned to the Yaizu harbor.
	Ar. 3 Approval of the budget for Atomic Energy Research		
	Je. The Japan Federation of Economic Organizations requested the establishment of a general administrative organ for science and technology		
		Jy. 1 Establishment of Technical Laboratory, Defense Agency	
1955		F.14 Establishment of Japan Productivity Center	
	Ar.11 Promulgation of establishing the Nuclear Energy Division at Agency of Industrial Science and Technology		
		Jy. 1 Establishment of Institute for Nuclear Study, the University of Tokyo	
		Jy.11 Establishment of National Aeronautical Laboratory	
			Ag.10 Promulgation of the Law for Emergency Measures for the rationalization of the coal mining industry
			O.25 Yawata Iron & Steel Co., Ltd. obtained a loan from World Bank.
	N.14 Signing of Agreement for cooperation between the Government of the United States of America and the Government of Japan concerning peaceful uses of nuclear energy (D.27 Effectuation)		
	N.18 The Administrative Council agreed with the establishment of Science and Technology Agency.		
		N.30 Inauguration of Atomic Energy Research Institute (Foundation)	
	D.19 Promulgation of Atomic Energy Basic Law and the Laws for establishment of Atomic Energy Commission and Atomic Energy Bureau (Next J.1 Enforcement)		
			D.23 Cabinet adopted The Five-Year Economic Development Plan.

Table 3.1 The History of Science and Technology System (continued)

Year	Law and Institution	Organization	Social and Economic Events
1956		J. 1 Establishment of Atomic Energy Commission and Atomic Energy Bureau at the Prime Minister's Office F. 4 Scientific Research Institute Inc. became a special company. Mr. 1 Establishment of Japan Atomic Industrial Forum, Inc. (JAIF)	
	Mr.31 Promulgation of the Law for establishment of Science and Technology Agency		
			Ar. 6 Atomic Energy Commission decided the site of Japan Atomic Energy Research Institute at Tokai-Mura, Ibaraki.
	My. 4 Promulgation of Japan Atomic Energy Research Institute Law, the Law for Emergency Measures for the Promotion of Nuclear Source Material Development, and Nuclear Fuel Corporation Law		
		My.19 Inauguration of Science and Technology Agency (STA) Je.15 Inauguration of Japan Atomic Energy Research Institute (JAERI) Je.25 Inauguration of Agriculture, Forestry and Fisheries Research Council Jy. 1 Inauguration of National Research Institute for Metals Ag.10 Inauguration of Nuclear Fuel Corporation (O.2,'67 Merged into Power Reactor and Nuclear Fuel Development Corporation)	
			O.15 The construction of Sakuma dam for hydroelectric power plant was completed.
	O.26 Signing of the charter of IAEA (Jy.29,'57 Effectuation)		
1957			J.29 Japan Antarctic Research Expedition Party landed in Ongul Island, and named the place as Showa.
		Ar. 1 Establishment of the Institute for Solid Physics, the University of Tokyo	
			Je.19 Japan's government announced an urgent measure for the improvement of international balance of payment.
		Je.29 Establishment of National Institute of Radiological Sciences (Jy.1 Inauguration) Ag.16 Establishment of Japan Information Center of Science and Technology	
			Ag.27 The American type reactor of Atomic Energy Research Institute at Tokai-Mura firstly generated electric power. S.20 Professor Hideo Itokawa of Tokyo University launched the first domestic rocket, successfully.
		N. 1 Establishment of Japan Atomic Power Co., Inc.	
1958		Ar. 1 The revival of Aeronautical Research Institute, the University of Tokyo	

Table 3.1 The History of Science and Technology System (continued)

Year	Law and Institution	Organization	Social and Economic Events
1958		Ar. 1 Establishment of Institute for Protein Research, Osaka University	
		Ar. 1 Establishment of Nuclear Engineering Department, Kyoto University	
	Ar.24 Promulgation of The Institute of Physical and Chemical Research Law (O.21 Enforcement)		
		My.22 Radio Communication Machinery Association renamed Electronic Industries Association of Japan	
		My.23 The Technical Laboratory of Defense Agency renamed Technical R&D Institute.	
	Je.16 Agreement for cooperation between the Government of the U.S.A. and the Government of Japan concerning peaceful uses of nuclear energy (D.5 Effectuation)		
		Jy.25 Japan External Trade Recovery Organization made a new start as a semi-governmental corporation.	
	Jy.28 MITI decided the Five Year Program for the Promotion of Electronic Industry.		
		O.21 Reorganization of Scientific Research Institute Inc. to semigovernmental corporation " The Institute of Physical and Chemical Research"	
			D.23 Completion of Tokyo Tower (the highest in the world, 333m)
1959			《Iwato-boom》
	F.20 Promulgation and enforcement of the Establishing Act for the Council for Science and Technology		
	D. 2 Recommendation No.2 of the Council for Science and Technology		
1960			J. 6 Negotiation for the revision of the United States-Japan Security Treaty came to an agreement.
		Ar. 1 Establishment of Nuclear Engineering Department, the University of Tokyo	
			Je.23 Ratification and effectuation of the New United States-Japan Security Treaty
			S. 5 Liberal Democratic Party proposed " National Income Doubling Program."
	O. 4 Recommendation No.1 of the Council for Science and Technology		
1961		Ar. 1 Establishment of Institute of Plasma Physics, Nagoya University (Joint use)	
			Ar.12 The Soviet Union recovered the manned satellite, successfully. Major Gagarin returned to the earth.
		Ar.20 Establishment of Council for Ocean Science and Technology	

Table 3.1 The History of Science and Technology System (continued)

Year	Law and Institution	Organization	Social and Economic Events
1961	My. 6 Promulgation of Research Associations for Mining and Manufacturing Technology Law (My.20 Enforcement)		
		Jy. 1 Inauguration of Research Development Corporation of Japan (JRDC)	
1962		F. 1 Establishment of National Cancer Center	
	My.10 Promulgation of the Law for the Promotion of New Industrial City Construction (Ag.1 Enforcement)		
	Jy.13 Recommendation No.3 of the Council for Science and Technology		
		S.27 Formation of Technology Research Association of Electronic Computers	
		Establishment of The Overseas Technical Cooperation Agency	
1963	Ar. 1 Creation of the system of research funds per person	Ar. 1 Establishment of National Research Center for Disaster Prevention	
		Ar. 1 National Aeronautical Laboratory renamed National Aerospace Laboratory.	
		Ar. 1 Establishment of Kagoshima Space Center, the University of Tokyo	
	Je. 8 Promulgation and enforcement of the Law for establishing Japan Nuclear Ship Development Agency		
		Ag.17 Inauguration of Japan Nuclear Ship Development Agency	
1964		Ar. 1 Inauguration of Institute of Space and Aeronautical Science, the University of Tokyo	Ar. 1 Japan moved to the IMF clause 8 country and GATT clause 11 country
			Ar.28 Japan joined OECD.
		Jy. 1 Establishment of the Space Development Promotion Group in the Science and Technology Agency	
			O. 1 The New Tokaido Line started its service.
1965			Ar. 1 Domestic airplane YS11 entered service of Tokyo-Tokushima and Tokyo-Kochi lines.
			O.21 Shinichiro Tomonaga received the Nobel Prize for Physics.
			N.10 Tokai Nuclear Power Plant began to supply electric power to the public.
	D. 1 Additional Recommendation to Recommendation No.1 of the Council for Science and Technology		
			Liberalization of car import
1966			Mr.24 Joint Committee for the Promotion of Environmental Control decided its policy concerning the regulation of car exhaust fumes.
		Ar. 1 Establishment of the National Institute for Research in Inorganic Materials	
	N. The National Research and Development Program of MITI (Large-Scale Project)		

Table 3.1 The History of Science and Technology System (continued)

Year	Law and Institution	Organization	Social and Economic Events
1967		O. 2 Inauguration of Power Reactor and Nuclear Fuel Development Corporation (PNC) (Abolition of Nuclear Fuel Corporation)	S. 5 Mutsu-shi, Aomori was selected as the site of home port of Nuclear-Powered Vessel. O.30 Fifteen UHF television broadcasting companies were granted preparatory license.
1968	F.26 Signing of New Agreement for Cooperation between the Government of the U.S. of America and the Government of Japan Concerning Peaceful Uses of Nuclear Energy (Jy.10 Effectuation) Ar. 1 Creation of Financing System for promoting technology at Japan Development Bank My. 2 Promulgation and enforcement of the Law for Establishment of the Space Activities Commission (Abolition of Space Development Council)	Je.15 Establishment of National Institute of Resources D.12 Establishment of Research Development Corporation of Japan (JRDC)	
1969	Ag. 7 Promulgation of the Law for Temporary Measures Concerning University Management (Ag.17 Enforcement) O.31 Recommendation No.4 of the Council for Science and Technology	O. 1 Establishment of National Space Development Agency of Japan (NASDA) (Abolition of Space Development Promotion Group)	Je.12 Launching of the Nuclear Ship "Mutsu" Jy.20 U.S.A.'s Apollo 11 landed on the moon, successfully.
1970		Je.10 Establishment of Tropical Agricultural Research Center O. 1 Establishment of National Grassland Research Institute	F.11 The first satellite "Ohsumi" was launched by ISAS, successfully. Mr.14 The opening of International Exposition (to S.13) Je.23 Automatic extension of the Treaty of Mutual Cooperation and Security Between Japan and the United States of America
1971	Ar.21 Recommendation No.5 of the Council for Science and Technology	Ar. 1 Establishment of National Laboratory for High Energy Physics (National Universities' Joint Use Laboratories) Jy. 1 Inauguration of the Environment Agency	

Table 3.1 The History of Science and Technology System (continued)

Year	Law and Institution	Organization	Social and Economic Events
1971		Jy. 1 Reorganization of Council for Ocean Science and Technology to Council for Ocean Development O. 1 Establishment of Japan Marine Science and Technology Center (JAMSTEC)	
1972		My.10 Establishment of Tsukuba Space Center, NASDA	Je. 1 Promulgation of Revision of the Road Traffic Act (Initiation of the symbol mark of a beginning driver)
1973	O.17 Recommendation No.1 of the Council for Ocean Development	J. 1 Establishment of Fruit Tree Research Station and Vegetables Research Station	O. 6 The fourth Middle East War broke out. O.23 Leo Esaki received the Nobel Prize for Physics. D.22 Promulgation and enforcement of the Law for rationalization of demand and supply of oil, and the Law for Emergency Measures for stabilizing national life
1974		Mr.15 Establishment of the National Institute for Environmental Studies	Ag.24 Fishermen opposed to the departure of the Nuclear Ship "Mutsu." O. 8 Former Prime Minister Eisaku Satoh received the Nobel Prize for Peace.
1975		Ar.22 Establishment of Institute for Molecular Science (National Universities' Joint Research Organization)	O.16 The total number of farming families fell below five million (The Ministry of Agriculture and Forestry announced).
1976	Jy.30 Advisory Committee on Atomic Energy Administration submitted the final report of "Opinion on Strengthening the Atomic Energy Administrative System."	J.16 Establishment of Nuclear Safety Bureau, STA Mr.10 Inauguration of Technology Research Association of Ultra Large Scale Integration (ULSI) (until Mr.,1980) O.29 Establishment of the Earthquake Prediction Promotion Headquarters at the Cabinet	
1977		My. 2 Establishment of National Center for Biological Sciences (National Universities' Joint Research Organization) My. 2 Establishment of National Institute for Basic Biology My. 2 Establishment of National Institute for Physiological Sciences	

Table 3.1 The History of Science and Technology System (continued)

Year	Law and Institution	Organization	Social and Economic Events
1977	My.25 Recommendation No.6 of the Council for Science and Technology		
			D.24 The first stage common examination for entrance to National and Public Universities and Colleges was performed tentatively.
1978		F.27 Establishment of Tsukuba Center for Institutes, STA	
		Jy. 5 Ministry of Agriculture and Forestry renamed Ministry of Agriculture, Forestry and Fisheries.	
	Jy.28 Recommendation No.7 of the Council for Science and Technology		
		O. 4 Establishment of Nuclear Safety Commission	
			Japanese Word Processor was developed (Toshiba JW-10).
1979		J.29 Earth Observation Center of NASDA began its operation.	
		Mr. 1 Establishment of Training Laboratory, National Research Institute of Fisheries Engineering	
		Mr.26 Establishment of the Council for the Promotion of the International Exposition, Tsukuba, 1985	
	Ag. 9 Recommendation No.8 of the Council for Science and Technology		
1980			《Nation-Building on the Basis of Science and Technology Doctrine appeared.》
		Mr.15 Establishment of the Japan Association for the International Exposition Tsukuba, 1985	
	My.28 Signing of Japan-China Agreement on Cooperation in Research and Development in Science and Technology		
		Je.17 Establishment of Joint Committee of Ministries concerning Ocean Development	
		O.17 Establishment of Council of Ministries concerning Science and Technology	
1981			Mr.16 First meeting of the Second Provisional Commission for Administrative Reform
	Ar. 1 Establishment of Special Coordination Funds for Promoting Science and Technology		
		Ar.14 Establishment of The Institute of Space and Astronautical Science (ISAS) of the Ministry of Education (Abolition of ISAS of the University of Tokyo)	
		Ar.14 Establishment of Okazaki National Research Institutes	
	Jy. 6 Recommendation No.9 of the Council for Science and Technology		
	O. 1 Inauguration of Exploratory Research for Advanced Technology (ERATO)		

Table 3.1 The History of Science and Technology System (continued)

Year	Law and Institution	Organization	Social and Economic Events
1981			O.19 Kenichi Fukui received the Nobel Prize for Chemistry.
		D. 1 Establishment of Agriculture Research Center	
	Inauguration of Research and Development Project of Basic Technologies for Future Industries		
1982	Inauguration of Fifth Generation Computer Project	Ar.14 Establishment of Institute for New Generation Computer Technology (ICOT)	
1983		Mr.14 Establishment of Committee on Policy Matters at the Council for Science and Technology	
	My.16 The Promotion Act for accelerating the development of high-tech industry integrated region (the Law of Technopolis Project) (Jy.15 Enforcement)		
		D. 1 Establishment of National Institute of Agrobiological Resources	
1984			《Strong tendency to basic research》
	Ar.24 Recommendation No.10 of the Council for Science and Technology		
	N.27 Recommendation No.11 of the Council for Science and Technology		
1985			F.15 Japan Communications Satellite Co.,Inc. (JC-SAT) was established.
			Mr.17 The Tsukuba Expo '85 was opened to the public (to S.16).
	Ar. Enforcement of Telecommunication Business Law		
		O. 1 Establishment of The Japan Key Technology Center	
	D. 3 Recommendation No.12 of the Council for Science and Technology		
1986		Ar. 5 Establishment of the National Center for Science Information System.	
	My.20 Approval of The Law for Facilitating Governmental Research Exchange (N.19 Enforcement)		
		O. 1 Establishment of Bio-oriented Technology Research Advancement Institution	
	O. The Institute of Physical and Chemical Research initiated International Frontier Research System.		
1987			Ar. 1 National universities started chairs sponsored by business enterprises.
	Ag.28 Recommendation No.13 of the Council for Science and Technology		
	Ag.28 Recommendation No.14 of the Council for Science and Technology		

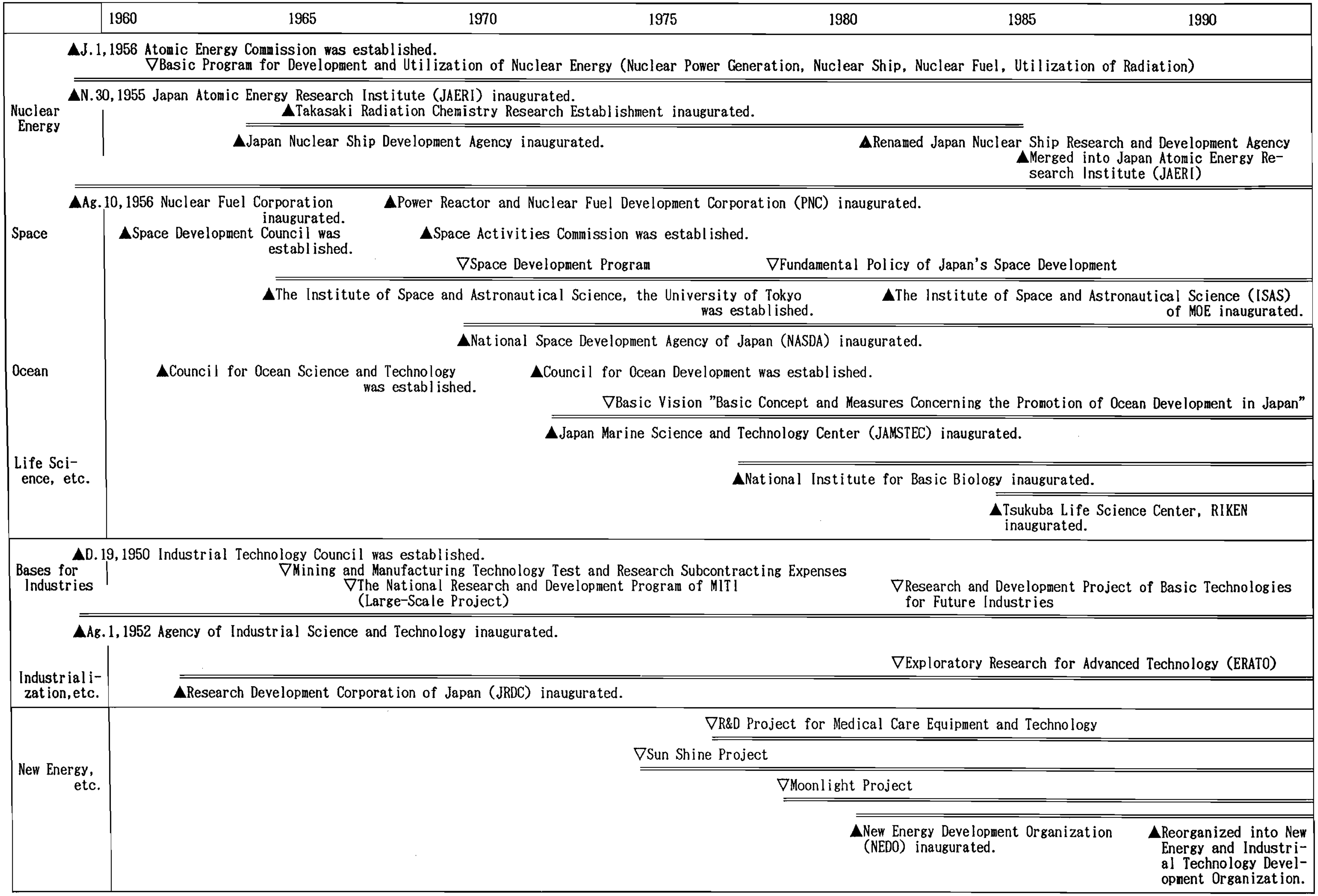
Table 3.1 The History of Science and Technology System (continued)

Year	Law and Institution	Organization	Social and Economic Events
1987	Negotiation of revision of Agreement between the Government of Japan and the Government of the United States of America on Cooperation in Research and Development in Science and Technology		
	Establishment of University Council		
			O.12 Susumu Tonegawa received the Nobel Prize for Physiology and Medicine.
1988		F. Establishment of Tsukuba Center, Inc.	
	My. STA initiated Multi-core Project for Super-conductive Material.		
	Je.20 Effectuation of a New Agreement between the Government of Japan and the Government of the United States of America on Cooperation in Research and Development in Science and Technology		
		Jy. 1 Establishment of National Institute of Science and Technology Policy (Abolition of National Institute of Resources)	
			Ag.23 U.S.A. passed the comprehensive trade bill including the Super 301 provision.
		O. 1 Establishment of The Graduate University for Advanced Studies	
		O. 1 Reorganization of New Energy Development Organization (NEDO) into New Energy and Industrial Technology Development Organization (NEDO)	
			N. 4 Nine companies in Japan received partly DOD's order for SDI (DOD, U.S. announced).
	STA established Fellowship Program.		
1989	Mr.14 Recommendation No.15 of the Council for Science and Technology		
			S. 4 Japan-United States Structural Impediments Initiative started.
			S. 4 The number of collaborative research between Industry and University increased ten times within six years.(Survey of MOE)
		O. Establishment of International Human Frontier Science Program Organization (HFSPO)	
	D. 5 Recommendation No.16 of the Council for Science and Technology		
1990	Je.22 Recommendation No.17 of the Council for Science and Technology		
		O. 1 Establishment of Japan Advanced Institute of Science and Technology, Hokuriku	
1991		O. 1 Establishment of Japan Advanced Institute of Science and Technology, Nara	

Table 3.1 The History of Science and Technology System (continued)

Year	Law and Institution	Organization	Social and Economic Events
1992	J.24 Recommendation No.18 of the Council for Science and Technology		Je. 3 United Nation Conference on Environment and Development (the Earth Summit) (to Je.14) Ag.28 World Space Congress (to S.5)

Table 3.2 Major Fields and Themes of R&D of National Science and Technology Programs



Nuclear Energy

▲J.1,1956 Atomic Energy Commission was established.

▽Basic Program for Development and Utilization of Nuclear Energy (Nuclear Power Generation, Nuclear Ship, Nuclear Fuel, Utilization of Radiation)

▲N.30,1955 Japan Atomic Energy Research Institute (JAERI) inaugurated.

▲Takasaki Radiation Chemistry Research Establishment inaugurated.

▲Japan Nuclear Ship Development Agency inaugurated.

▲Renamed Japan Nuclear Ship Research and Development Agency

▲Merged into Japan Atomic Energy Research Institute (JAERI)

▲Ag.10,1956 Nuclear Fuel Corporation inaugurated.

▲Power Reactor and Nuclear Fuel Development Corporation (PNC) inaugurated.

Space

▲Space Development Council was established.

▲Space Activities Commission was established.

▽Space Development Program

▽Fundamental Policy of Japan's Space Development

▲The Institute of Space and Astronautical Science, the University of Tokyo was established.

▲The Institute of Space and Astronautical Science (ISAS) of MOE inaugurated.

▲National Space Development Agency of Japan (NASDA) inaugurated.

Ocean

▲Council for Ocean Science and Technology was established.

▲Council for Ocean Development was established.

▽Basic Vision "Basic Concept and Measures Concerning the Promotion of Ocean Development in Japan"

▲Japan Marine Science and Technology Center (JAMSTEC) inaugurated.

Life Science, etc.

▲National Institute for Basic Biology inaugurated.

▲Tsukuba Life Science Center, RIKEN inaugurated.

Bases for Industries

▲D.19,1950 Industrial Technology Council was established.

▽Mining and Manufacturing Technology Test and Research Subcontracting Expenses

▽The National Research and Development Program of MITI (Large-Scale Project)

▽Research and Development Project of Basic Technologies for Future Industries

Industrialization, etc.

▲Ag.1,1952 Agency of Industrial Science and Technology inaugurated.

▽Exploratory Research for Advanced Technology (ERATO)

▲Research Development Corporation of Japan (JRDC) inaugurated.

New Energy, etc.

▽R&D Project for Medical Care Equipment and Technology

▽Sun Shine Project

▽Moonlight Project

▲New Energy Development Organization (NEDO) inaugurated.

▲Reorganized into New Energy and Industrial Technology Development Organization.

3.2 An Analysis of Current Activities of National R&D Institutes

In this section, we will clarify the activities of national and public research organizations by examining the questionnaire survey data. Questionnaires were sent out to the national and public research organizations, and the returned questionnaires were analyzed as follows:[1]

3.2.1. The Outline of the Questionnaire

The questionnaire survey was administered to find out the activities of public research organizations and research management there. Questionnaires were sent to 111 research organizations including: 92 national research institutes, 11 research institutes of public corporations and 8 space-related research organizations.

The outline of the questionnaire was as follows:

I. The Determinants of Research Activities

  a. Research philosophy and research mission
  b. Responsible government agencies' basic research guidelines
  c. Stakeholders
  d. The influences of new science and technology developments

II. Domains of Research Activities

  a. Original research areas
  b. New research areas
  c. Diversity of research areas
  d. The reasons for diversifying research areas
  e. The methods of research activities

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[1] A computer program, Statistical Analysis System (SAS), was used for this analysis.

III. Management of Research Activities

  a. Formulation of research themes
  b. Methods of problem solving
  c. Evaluation of research themes
  d. Duration time of research themes
  e. Methods of terminating research themes

IV. Major Research Facilities and Equipments

V. Organization

  a. Director
  b. Advisory Committee
  c. Number of researchers
  d. Organization
  e. Training of researchers
  f. Discretionary researches
  g. Use of external researchers

VI. Research Outcomes

  a. Contribution to journals
  b. Publications
  c. Patents registered and applied
  d. Impacts of research outcomes

The questionnaire was sent out in February, 1992, and 65 organizations out of 111 responded: 53 national research institutes, 7 research institutes of public corporations and 5 space-related research organizations. In what follows, then, we shall analyze the responses.

3.2.2 Typologies of Public Research Organizations

Public research organizations have various roles including the role of implementing national science and technology programs. We shall summarize their diverse features in terms of several key functions. In doing so, we paid attentions to the expressed relative importance of the research philosophy and research mission. For example, the following aspects were asked as the research philosophy and research mission:

- Contribution to the development of basic science

- Contribution to the problem solving occurring in the supervising agencies
- Contribution to the creation of knowledge needed for administration at the supervising agencies
- Participation to the related national projects
- Pursuit of research themes that are not studied by private research laboratories
- Nurturing research skill and knowledge
- Creation and diffusion of important information and knowledge
- Establishment of standards
- Contribution to regional development
- Helping researchers maximize their creativity
- Contribution to the development of generic technologies for the related industries

The data on these questions were analyzed using the factor analysis technique. In doing this, each answer was coded with the following scale:

1 = Very low (small)
2 = Relatively low (small)
3 = Medium
4 = Relatively high (large)
5 = Very high (large)

Here there is one technical problem that the respondents might have had bias in answering the questions. For example, some respondents tend to give high scores to many question items while others do not. In order to eliminate such biases, the average score of each respondent was calculated. The deviations from the average score for each item were then calculated, and they were used for factor analysis. The result of such analysis produced four major factors. Table 3.3 shows the factor loadings and eigen values for each factor.

Table 3.3 Factors of Research Philosophy of Public Research Organizations

Factors Research Philosophy	Factor 1 Administration Assistance-Basic Science Orientation	Factor 2 Application-Publicness Orientation	Factor 3 Technology Transfer-Basic Science Oriented	Factor 4 Regional Economy-Basic Science Oriented
Contribution to the Development of Basic Sciences	-0.37	-0.25	-0.31	-0.63
Contribution to the Problems-Solving occuring in the relationships with the Supervising Agencies	0.68	-0.12	-0.19	0.34
Contribution to the Creation of Knowledge needed for administration at the Supervising Agencies	0.86	-0.10	0.08	-0.20
Participation to the Related National Projects	-0.57	-0.20	0.05	-0.03
Pursuit of Research Themes that are not studied by Private Research Institutions	0.02	-0.69	0.13	-0.11
Nurturing Research Staff of the Given Research Area	-0.04	0.80	-0.22	0.08
Creation and Diffusion of Important Information and Knowledge	0.26	0.57	0.40	-0.35
Establishment of Standards	0.05	-0.11	0.88	-0.03
Contribution to Regional Development	-0.10	0.02	0.01	0.80
Helping Researchers Maximize Their Creativity	-0.64	0.02	-0.32	-0.08
Contribution to the Development of Basic Research for the Related Industries	0.01	0.14	-0.60	-0.12
Eigen Value	2.17	1.60	1.59	1.50

The figures in this table represent factor loading.

Factor 1 is regarded to express the following aspect: The higher the score is, the higher the orientation to public administration assistance; and the lower the score is, the higher the orientation to basic science.

Factor 2 is also regarded to express the following aspect: the higher the score is, the higher the orientation to application; and the lower the score is, the higher the orientation to publicness.

As to Factor 3, the higher the score is, the higher the orientation to technological transfer; and the lower the score is, the higher the orientation to basic technology research.

As to Factor 4, the higher the score is, the higher the orientation to regional development; and the lower the score is, the higher the orientation to basic science research.

The above four factors were considered to show the four distinct features of research philosophy and research mission. Of them, however, we would like to focus on two factors: Factor 1 (public administration assistance oriented vs. basic science oriented) and Factor 2 (application oriented vs. publicness oriented). A major reason for such selection is that this combination seems to be more informative than the other combination of factors such as Factor 1 - Factor 3 or Factor 1 - Factor 4. With the combination of Factor 1 and Factor 2, we can come up with four typologies of public research organizations.

First, we shall call the research institute that are oriented to basic science and publicness as the "Scientific Knowledge Creation" (SKC) type. The SKC type organizations perform public functions which cannot be done by private institutions for the creation of scientific knowledge.

Second, the research organizations which bent to basic science but are application oriented are called the "Science Application" (SA) type. Even though these organizations do create scientific knowledge, they are much more involved in the application of such knowledge.

Third, the research organizations that show orientations to public administration assistance and publicness are referred to as the "Public Knowledge Creation" (PKC) type. These organizations are expected to create knowledge which helps related industries or users solve problems or improve situations.

Fourth, the research organizations which are oriented to public administration assistance and application are called as the "Policy Promotion" (PP) type. These organizations will create knowledge which will help the related government agencies implement administrative operation.

These four types of public research organizations are depicted in Table 3.4.

Table 3.4 Typologies of Public Research Organizations

	Publicness Orientation	Application Orientation
Basic Science Orientation	Scientific Knowledge Creation (SKC) type	Science Application (SA) type
Administrative Assistance Orientation	Public Knowledge Creation (PKC) type	Policy Promotion (PP) type

The research organizations which responded to the questionnaire were then classified to any of the above four types. The classification was done using their score on Factor 1 and Factor 2. With respect to Factor 1, the positive score means the administrative assistance type, and the negative score, the basic science type. With respect to Factor 2, the positive score indicates the application orientation type, and the negative score, the publicness type. By doing so, each organization was supposed to belong to one of the four cells of Table 3.4.

Many of the SKC type organizations are found in the Ministry of International Trade and Industry (MITI) and the Environmental Agency. The SA type organizations are mostly those of medicine, MITI, and research institutes of public corporations. The PKC type organizations mostly belong to the Ministry of Agriculture, Forestry and Fisheries. Most of the PP type organizations belong to the Ministry of Agriculture, Forestry and Fisheries and the Space-related research institutes.

The above effort of specifying typologies of public research organizations was based on the espoused research philosophy and research mission. In reality, however, there can exist a gap between the espoused research mission and the real contribution. In order to examine this gap, we have asked the respondents to answer the degree of real contribution to each aspect of research activity. We then produced weighted averages based on factor loading score shown in Table 3.3, which were then used to determine the degree of real contribution concerning the public administration assistance - basic science and the application - publicness scales. We used these two scale scores to determine whether respondent organization is above or below the average value for the two aspects of contribution. Based on these classification concerning espoused research mission and real contribution, we made a cross tabulation shown in Table 3.5.

Table 3.5 shows that, among 13 organizations classified as the SKC type in terms of research philosophy, 3 were bent to the SA type, 2 to the PKC type and 1 to the PP type in terms of real contribution. Of 17 firms that are labelled as the SA type in terms of research philosophy, the ones that are science application oriented in real contribution were 7; 3 of them proved to be oriented to the PP type.

Table 3.5 The Relationship between Research Philosophy and Real Contribution

Typology based on Real Contribution Typology based on research Philosophy	Scientific Knowledge Creation (SKC) type	Science Application (SA) type	Public Knowledge Creation (PKC) type	Policy Promotion (PP) type
Scientific Knowledge Creation (SKC) type	7	3	2	1
Science Application (SA) type	7	7	0	3
Public Knowledge Creation (PKC) type	1	1	11	2
Policy Promotion (PP) type	0	1	5	7

The numbers in this table denote the numbers of laboratories.

χ^2=39.841

It is possible that the content and methods of research activities and research management are determined by the content of the organization's research philosophy and at the same time by the real contribution. Here we suppose that the content of research philosophy affect the content and methods of research activities and research management. Based on this recognition, we will examine the research activities, research management (formulation of research themes, evaluation of research themes, etc.), organization, and research outcomes by typology based on research philosophy of public research organization.

3.2.3 The Determinations of Research Activities

3.2.3.1 The Existence of the Research Guidelines in the Responsible Government Agency

The respondents were asked whether the basic research guidelines and long-term plans of the responsible government agency have any impact on their research activities. The responses are reported in Table 3.6. Most of the PP-type and PKC-type organizations recognized the existence of such guidelines or long-term plans, while some of SKC-type and SA-type organizations responded negatively. These latter organizations are interpreted to have higher degrees of autonomy in planning and implementing research activities.

Table 3.6 The Relationships between Government Guidelines and Research Planning

Basic Guidelines and Long-term Plans	Scientific Knowledge Creation (SKC) type	Science Application (SA) type	Public Knowledge Creation (PKC) type	Policy Promotion (PP) type
Exist	8	13	14	11
Dosen't Exist	4	4	1	2

The numbers in this table denote the numbers of laboratories.

χ^2=3.378

* $p<0.10$ ** $p<0.05$ *** $p<0.01$

Nevertheless several SKC-type research organizations responded that they take the responsible agency's guidelines into consideration in formulating their research plans. In this case, the used guidelines are mostly long-term ones such as the MITI's visions of the 1990s and the recommendation by the Council for Science and Technology. The guidelines used by the SA-type research organizations include the Nuclear Development Utilization Long-term Plan, Maritime Development Promotion Plan, Anti-Cancer 10-Year Comprehensive Strategy, Construction Technology Research and Development Long-term Vision, etc. On the other hand, PKC-type research organizations refer to relatively concrete guidelines such as the Agriculture and Fishery Research Basic Goals and the Fishery Industry Research Goals. The guidelines which the PP-type research organizations use consist of the Agriculture and Fishery Research Basic Goals, the Forestry Industry Research

Goals, and the Basic Guidelines of Space Development.

3.2.3.2 The Stakeholders

The social groups or organizations that could be influenced by the research activities of the public research organizations in question are supposed to attempt to exert some influence on such research activities. The responsible government agencies must be the ones that are most closely connected with, but they are excluded from this analysis. In order to find out the relationships, the respondents were asked to name three entities (social group, organization, and social stratum) which they believe to be mostly affected by their research activities. The respondents were also asked to describe what kind of actions the entities are taking to influence the respondents.

First, the stakeholders of the SKC-type research organizations included the following: (1) the New Energy and Industrial Technology Development Organization, the Regional Environment Industry Technology Research Organization; (2) large and small / medium private corporations, and (3) local public test / research institutions. From the first group came the request for collaborative research and transfer of research outcomes. The second group asked for collaborative research, transfer of specific technologies, and the placement of trainee researchers. The third group asked for placement of trainee researchers and the sponsored research for specific technologies.

Second, the SA-type research organizations proved to become involved in; (1) academic associations such as the medical association and the polymer association; (2) the industry associations such as these in chemical, agricultural-machinery, and petrochemical industries; and (3) the public test / research organizations. The academic associations show the expectation for the development of specific technologies and the request for becoming the committee members for their associations. The industry associations have the requests or suggestion for specific technology development, collaborative research and the construction of the data base. The public test / research institutions have the requests for the solution of highly professional problems, transfer of research outcomes, technology education, and the placement of trainee researchers.

Third, the PKC-type research organizations listed: (1) users of the related technologies such as farmers, fishery firms, and NTT; (2) the industry associations including the gauge industry, agricultural unions, fishery unions, food processors, and construction industry; and (3) the local public organizations. The first group asked for the development of technology for stable production, the request for the evaluation of methods for product improvement, the request for becoming part-time directors, and the temporary transfer of researchers. The industry associations asked for the technologies for quality and productivity improvements, sponsored research, and collaborative research.

Fourth, the PP-type research organizations referred to: (1) the industry associations such as the beverage and material industries, (2) industrial corporations such as the agricultural and machinery manufacturers, and (3) the test institutions of local governments. The industry associations asked for transfer of research outcomes and the solution for technical problems, while private corporations suggested collaborative research. The local test institutions demanded transfer of research outcomes, collaborative research, and symposia.

3.2.4 Domain Setting of Research Activities

Each organization attempts to expand its current domain of activity by adapting to the changes in the external environment. When it comes to the public research organizations, their domain of activity is basically framed by the law on their establishment. Therefore, the top management of the public research organization attempts to enhance its strength within the given framework.

3.2.4.1 The Commonality between New Research Area and Current Major Research Area

When a public research organization plans to expand its domain of activity, it is bound to consider the commonality between the new, planned activities and the ongoing major activities. The content of commonality pursued, however, could be different depending on the research mission of the organization. In order to examine this aspect, we asked the respondents to select two new research area in the past 10 years and evaluate the degree of commonality with the existing research area in a 5 point scale:

1 = Very low commonality
2 = Relatively low commonality
3 = Medium
4 = Relatively high commonality
5 = Very high commonality

The average score of these point scores of commonality with major research areas by each type of research organizations are shown in Table 3.7.

Table 3.7 Commonality between New Research Area and Current Major Research Area by Each Type

Content of Commonality	Scientific Knowledge Creation (SKC) type	Science Application (SA)type	Public Knowledge Creation (PKC) type	Policy Promotion (PP) type	F-value
Commonality of the Basic Research Area	4.0	4.1	4.1	4.7	1.20
Commonality in Applications Research Area	3.4	3.9	4.3	4.7	5.60***
Commonality in Terms of Meeting the Administrative Needs	3.2	3.7	4.3	4.7	3.90**
Commonality of Stakeholders	2.8	3.1	3.5	3.9	2.04
Commonality in the Method of Research Activities	3.9	3.3	3.8	4.6	3.48**

The figures in this table denote the level of commonality.
* p<0.10 ** p<0.05 *** p<0.01

For the SKC-type research organizations, the meaningful commonality was found in two aspects: the commonality of the basic research area and the commonality in the method of research activities. In comparison, the PP-type research organizations tend to have the commonality in virtually all aspects between existing and new research areas. In other words, the PP-type research organizations appear to expand the areas of research to the field that has a close association with the current one. Particularly, they paid much attentions to whether the new research area involve a high degree of commonality with the current research area in terms of the content of meeting the public administration needs.

3.2.4.2 Reasons for Diversifying Research Areas

The reasons for diversifying the areas of research were found to be:

- Compounding of current areas of research and related research areas
- To cope with the expansion of the supervising agency's responsibility
- Replacement of existing knowledge base with new scientific knowledge
- Researchers' proposal of innovative research
- Government encouragement to commit basic research with the national budget assistance
- The need to join collaborative research which the government provides financial assistance
- Collaborative research with industries

The respondents were asked to rate the degree of impact of these reasons in a 3 point scaling:

1 = No relationship
2 = Weak relationship
3 = Strong relationship

The result of analysis is presented in Table 3.8. According to this, the SKC-type research organizations tend to state the compounding of research areas with related research areas as the reason for diversifying research areas. On the other hand, the PKC-type and PP-type research organizations name the expansion of the supervising agencies' responsibility as the most important reason for diversifying research areas.

Table 3.8 Reasons for Diversifying Research Areas by Each Type

Reasons for Research Diversification	Scientific Knowledge Creation (SKC) type	Science Application (SA)type	Public Knowledge Creation (PKC) type	Policy Promotion (PP)type	F-Value
Compounding of Current Areas of Research and Related Research Areas	2.46	2.38	2.36	2.45	0.09
To Cope with the Expansion of the Supervising Agency's Responsibility	2.38	1.80	2.14	2.72	4.04**
Replacement of Existing Research with New Scientific Knowledge	2.15	2.60	1.93	2.27	1.95
Researchers' Proposal of Innovative Research	2.54	2.69	2.50	2.00	2.45*
Government Encourage-ment to Expand Current Research	2.69	2.25	2.21	2.64	1.86
The Need to Join Collaborative Research which the Government Provides Financial Assistance	2.54	2.31	2.50	2.19	0.59
Collaborative Research with Industries	2.00	1.75	1.65	1.36	1.68

The figures in this table denote the evaluation scores.

* p<0.10 ** p<0.05 *** p<0.01

3.2.4.3 Methods of implementing research activities

The research organizations do research using a variety of methods of implementing research activities. In this study, the respondents were asked to indicate the number of projects by each method of implementing research activity. Table 3.9 shows the average number of projects by each method for each type of research organization. According to this analysis, international collaborative research projects and inter-university projects are positively used by the SKC-type and the SA-type research organizations. In comparison, the PP-type and the PKC-type research organizations tend to focus on routine research. In the government-promoted research projects, all types of research organizations participate aggressively. The SA-type research organizations also appear to have more sponsored research projects which are carried out jointly with research institute of public corporations.

Table 3.9 Methods of Implementing Research Activities by Each Type

Methods of Implementing Research Activity	Scientific Knowledge Creation (SKC) type	Science Application (SA)type	Public Knowledge Creation (PKC)type	Policy Promotion (PP)type	F-Value
Participation to Government Sponsored Research Project	11.6	8.4	17.2	19.8	0.85
Sponsored Research (from other institution)	0.2	6.2	1.7	7.7	2.48*
Collaborative Research with Research Institution of Public Corporation	1.7	5.4	1.0	3.0	0.92
Collaborative Research with University	1.6	9.1	1.8	1.7	1.27
International Collaboration	2.7	4.1	0.7	1.3	1.81
Large-scale Project (Academia-Government-Industry)	2.3	0.8	0.4	1.0	1.47
Routine Research	31.6	42.6	45.9	115.1	1.04
Special/Specified Research (basic and/ or leading area)	13.7	8.6	4.9	8.4	1.55

The figures in this table denote the average number of projects.

$* \ p<0.10 \quad ** \ p<0.05 \quad *** \ p<0.01$

3.2.5 Research Management

3.2.5.1 Formulation of Research Themes

It is presumable that research organizations decide on research themes in various ways: in response to formal requests, according to informal suggestions, or using systematic surveys. In order to determine this issue, we asked the respondents to scale the importance of various patterns as follows:

1 = Very little
2 = Relatively little
3 = Medium
4 = Relatively large
5 = Very large

Table 3.10 summarizes the findings. The PP-type research organizations show a strong tendency to decide research themes according to the laws on establishment or execution. To the contrary, the SKC-type organizations use researchers' suggestions and the survey data as the basis for research theme formulation.

Table 3.10 Methods of Formulation of Research Themes

Formulation of Research Themes	Scientific Knowledge Creation (SKC)type	Science Application (SA)type	Public Knowledge Creation (PKC)type	Policy Promotion (PP)type	F-Value
[In Response to Official Requests]					
Laws on Establishment or Execution	2.92	2.65	3.50	4.00	2.61*
Council's Recommendation	2.77	2.50	2.71	3.00	0.31
[According to Informal Suggestions]					
Researchers' Suggestions	4.23	4.41	4.14	3.42	2.45*
Requests of Related Institutions	3.62	3.47	3.71	3.58	0.13
[Using Systematic Surveys]					
According to Scientific Data	3.62	3.00	2.93	2.83	1.58
According to Needs Data	3.23	3.06	3.14	3.42	0.40

The figures in this table denote the evaluation scores.

* $p<0.10$ ** $p<0.05$ *** $p<0.01$

3.2.5.2 Pre-evaluation of Research Themes

As the next step, the respondents were asked to rank the following items as the criteria of a pre-evaluation of research themes:

- Contribution to basic sciences
- Contribution to the public administration needs
- Size of demand

- Technological feasibility
- Relevance to national projects
- Research cost
- Contribution to the nurturing of researchers.

These items were asked to be scaled:

1 = Do not consider
2 = Consider to some extent
3 = Consider importantly.

As suggested in Table 3.11, the PP-type and PKC-type research organizations tend to emphasize contribution to the public administration needs, while the SKC-type and the SA-type research organizations take contribution to basic sciences seriously.

Table 3.11 Pre-evaluation Criteria of Research Themes

Pre-evaluation Criteria	Scientific Knowledge Creation (SKC)type	Science Application (SA)type	Public Knowledge Creation (PKC)type	Policy Promotion (PP)type	F-Value
Contribution to Basic Sciences	2.54	2.44	2.00	2.19	1.59
Contribution to the Meeting of Administrative Needs	2.38	2.25	2.67	2.83	3.73**
Size of Demand	2.25	2.44	2.38	2.58	0.69
Technological Feasibility	2.54	2.50	2.46	2.33	0.29
Relevance to National Projects	2.31	2.50	2.25	2.42	0.47
Research Cost	1.92	2.13	2.00	2.17	0.34
Contribution to the Nurturing of Researchers	1.85	2.19	2.23	2.33	1.89

The figures in this table denote the evaluation scores.
* p<0.10 ** p<0.05 *** p<0.01

3.2.5.3 Other Research Evaluation Criteria

In addition to the considerations as suggested above, the respondents were asked to describe any other evaluation criteria in an open-end question. The SKC-type research organizations referred to:

- Originality
- Initiative
- Innovativeness
- Social spill-over effects.

The SA-type research organizations then listed:

- Improvement of development equipment
- Publication of superior articles
- Patent, etc.

For the PKC-type research organizations, important criteria are:

- Coherence with the supervising agency's research plans
- Improvement of researchers' potential.

Finally, the PP-type research organizations point to:

- Coherence with the capability of test facilities
- Evaluation of the supervising agency.

3.2.5.4 Methods of Terminating Research Themes

The respondents were also asked to describe the methods of terminating the research themes. The SKC-type research organizations mention as follows:

- Examine the degrees of contribution to science and technology
- Terminate one as the research progresses into another project
- Researchers' own decision with the advice of management
- According to the external evaluation.

The SA-type research organizations list:

- When the planned goal was achieved
- When the continuation of the project is not expected to achieve the goal
- When researchers were not available.

The PKC-type research organizations then point to:

- When the planned goal was achieved
- When the planned duration was expired
- When the influences of periodical job rotation is severe.

Finally, the PP-type research organizations point to:

- According to job rotation in the case of routine projects
- Research projects mostly have fixed duration.

3.2.6 Organization

3.2.6.1 Director

The fact that the director has been promoted within the research organization itself or has been invited from other organization has important meanings. First, it may indicate the level of autonomy of the organization. Internal promotion may mean a higher level of autonomy. On the other hand, when the director was invited from an outside organization, it may mean that the organization had to deal with a high level of uncertainty in the external environment. The result of the analysis is shown in Table 3.12.

It was found that the PKC-type and PP-type have more outside figures as director, probably they perceive the uncertainty more intensively. It also means that these organizations have lower degree of autonomy.

Table 3.12 Research Directors' Backgrounds

Backgrounds of Research Directors	Scientific Knowledge Creation (SKC)type	Science Application (SA)type	Public Knowledge Creation (PKC)type	Policy Promotion (PP)type
Promoted within Inside	9	13	8	5
Invited from Outside	4	4	7	8

The numbers in this table denote the numbers of institutions.

$\chi^2=5.19$

* $p<0.10$ ** $p<0.05$ *** $p<0.01$

3.2.6.2 The Number of Researchers

The respondents were asked to indicate the numbers of researchers, managing staff and support staff. The averages of these categories by each type are shown in Table 3.13.

It was found that the SKC-type research organizations have relatively fewer managing and support staff. On the other hand, these organizations have more researchers per organization, reflecting that they are oriented to basic research. The SA-type organizations have relatively more managing and support staff, probably because they are focused on applications of science and technology.

Table 3.13 Composition of Research Staff

Categories	Scientific Knowledge Creation (SKC)type	Science Application (SA)type	Public Knowledge Creation (PKC)type	Policy Promotion (PP)type	F-Value
Research Management Staff	23.3	32.3	23.8	17.4	0.62
Researchers	141.2	119.1	96.7	79.2	0.99
Research Support Staff	8.8	23.8	29.1	24.4	1.32

The numbers in this table denote the numbers of each staff.
* $p<0.10$ ** $p<0.05$ *** $p<0.01$

3.2.6.3 Nurturing of Researchers

The respondents were asked to answer whether they have the practices of discretionary research and whether or not sending researcher to domestic or foreign educational institutions. A 3 point scaling was used as follows:

1 = No such practice
2 = Case by case
3 = Have the practice

As suggested in Table 3.14, there is no remarkable difference among four types of organizations on this aspect. But the case-by-case adoption of discretionary research is relatively frequently found among the SKC-type and the SA-type organizations, while no institutionalized practice was found among the PKC-type and the PP-type organizations. About a half of the entire respondents appear to have the practice of sending researchers to domestic or foreign research institutions except for the PP-type.

Table 3.14 Researcher Nurturing Systems

Contents of Programs	Scientific Knowledge Creation (SKC)type	Science Application (SA)type	Public Knowledge Creation (PKC)type	Policy Promotion (PP)type	F-Value
Discretionary Research	2.08	2.06	1.77	1.50	1.60
Studies at Domestic Institutions	2.46	2.47	2.50	2.17	0.60
Studies at Foreign Institutions	2.62	2.59	2.36	2.17	1.02

The figures in this table denote the evaluation scores.

* $p<0.10$ ** $p<0.05$ *** $p<0.01$

3.2.7 Research Outcomes

3.2.7.1 Publications on Academic Journals

The respondents were asked to give the number of Japanese and English research papers published on academic journals. The result of the analysis is shown in Table 3.15. When it comes to Japanese articles, the four types of organizations show less differentials in number. On the other hand, more English papers are found to be published by the SKC-type and the SA-type research organizations.

Table 3.15 Research Publication

Number of Papers	Scientific Knowledge Creation (SKC)type	Science Applica-tion (SA)type	Public Knowledge Creation (PKC)type	Policy Promotion (PP)type	F-Value
Japanese Papers	128	159	86	124	0.37
English Papers	77	99	32	22	1.86

The numbers in this table denote the number of papers.
* p<0.10 ** p<0.05 *** p<0.01

3.2.7.2 Patents Registered and Applied

The respondents were asked to give the statistics of the patents registered and applied domestically and overseas. The average numbers by each type are shown in Table 3.16. It is found that the SKC-type and the SA-type organizations are more active in creating patents, both domestically and overseas. As far as the PKC-type and the PP-type are concerned, the numbers of patent registered and applied remain comparatively low.

Table 3.16 Patents Applied and Registered

Status	Scientific Knowledge Creation (SKC)type	Science Application (SA)type	Public Knowledge Creation (PKC)type	Policy Promotion (PP)type	F-Value
Domestic Application	211	174	60	18	3.47**
Domestic Registration	187	118	16	14	3.34**
Overseas Application	25	30	6	1	1.77
Overseas Registration	37	21	4	0	2.60*

The numbers in this table denote the numbers of patents applied and registered.

* $p<0.10$ ** $p<0.05$ *** $p<0.01$

3.2.7.3 Impacts of Research Outcomes

The research outcomes may have various impacts in various ways. The respondents were asked to scale the following potential impacts:

- Influence on the supervising government agencies
- Improvement of technical standards of industries and firms
- Contribution to basic research
- Contribution to regional economy
- Influence on private research organizations' activity.

A 5 point scaling method was used:

1 = Very weak
2 = Relatively weak
3 = Medium
4 = Relatively strong
5 = Very strong

The results of analysis are suggested in Table 3.17. Both PKC-type and PP-type organizations responded that their research outcomes have strong influences on the government agencies. On the other hand, the SKC-type and the SA-type organizations claimed their contribution to basic research and to the regional economy as major impacts of their research outcomes. These two types of organizations are also found to affect private research organizations to a remarkable extent.

Table 3.17 Influences of Research Outcomes

Content of Influences	Scientific Knowledge Creation (SKC)type	Science Application (SA)type	Public Knowledge Creation (PKC)type	Policy Promotion (PP)type	F-Value
Influence on the Supervising Government Agency	3.31	4.00	4.71	4.23	5.30***
Contribution to the Improvement of Technical Standards of Industry and Firms	3.77	3.94	4.00	4.08	0.20
Contribution to Basic Research	3.85	3.88	3.14	3.07	2.32*
Contribution to Regional Economy	3.15	3.24	2.43	2.54	1.70
Influence on Private Research Organizations' Activity	3.38	3.65	3.14	2.85	1.88
Contribution to Social Needs	3.77	4.06	4.14	4.23	0.79

The figures in this table denote the evaluation scores.

* $p<0.10$ ** $p<0.05$ *** $p<0.01$

3.2.8 Summary and Meaning of the Typologies of Public Research Organizations

We have discussed the characteristics of research activities by distinguishing four different types of public research organizations.

It was found that the "Scientific Knowledge Creation (SKC)-type research organizations" mostly belong to MITI or Environment Agency and perform basic research which cannot be done by private research organizations. These organizations pay much attention to the commonalities between existing and new research areas in terms of affinity with certain field of science and technology and the methods of implementing research activities as the criteria of expansion. As to the guidelines of the supervising agencies, long-term visions are used as criteria, but they usually have a high degree of autonomy. For the formulation of research themes, these research organizations often resort to researcher's suggestions and market and science and technology survey data. For pre-evaluation criteria of research theme, they focus on contribution to basic research, originality, initiative, innovativeness and contribution to the society. Most of directors for this type of research organizations are promoted internally. These organizations have relatively more researcher, fewer managing or support staff, because they focus on basic research. In terms of both journal publication in Japanese and English and patent applications and acquisition, these organizations excel others. The major impacts of their research outcome are found in the area of contribution to basic research.

"The Science Application (SA)-type research organizations" mostly belong to the agencies related to medicine, MITI, and research institute of public corporations. With the orientation to both basic research and application of research, these organizations focus on applications of scientific knowledge. They take the commonalities between existing and new research areas in terms of basic research and applied research as the criteria of expansion. They refer to the long-term plans of the supervising agencies, and thus have a high degree of autonomy. In selecting research themes, these organizations listen to what their researchers suggest. In evaluating research, these organizations emphasize the size of demand, relevance to national projects, the level of improvement in the development of equipment, and patent applications as important criteria. In journal publication and patent application, these organizations mark high scores. Their research outcomes turn out to have impact on basic research, thus affecting the technological levels of industry and firms.

Most of the "Public Knowledge Creation (PKC)-type organizations" belong to the Ministry of Agriculture, Forestry and Fisheries. They have much contribution in solving problems the users have in such industrial areas. In expanding research, they emphasize the commonalities in terms of the needs of the supervising agencies' administrative needs. These institutions also refer to concrete policies such as the research guidelines established by the supervising agencies in planning their research. In deciding on research themes, they take the laws regarding establishment and execution and the recommendations by the councils into consideration seriously. Major evaluation criteria for the research themes appear to be contribution to the needs of supervising agencies and coherence with their own research plans. Journal publications are mostly in Japanese, and English articles are relatively few. The impacts of research outcomes are mostly found in the areas of the influence on the governing agencies and technological improvement of industry and firms.

Finally, "the Policy Promotion (PP)-type research organizations," which mostly belong to the Ministry of Agriculture, Forestry and Fisheries and the space agency, create and apply knowledge for the administration of the governing agencies. In expanding research, the neighboring areas of existing research is considered to be one of candidates. Concrete policies and targets are used as guidelines for research planning. In selecting research themes, the laws on installation and execution and the recommendations of administrative councils are referred to as criteria. Major evaluation criteria include contribution to the needs of governing agencies and the size of demand. Most directors for these organizations are invited from outside, and the portions of support staff are larger. Journal publications are focused on Japanese articles, and the numbers of patents registered or applied are relatively low. The impacts of these organizations are mostly found in the areas of the influence on the governing agencies and the technological improvement of industry and firms.

The characterizations of national research organizations we have done so far will form a basis of the understanding and investigation of national science and technology programs.

REFERENCES OF SECTION 3.2

Muto, Eiichi and Yukihiro Hirano, *Kokuritsu Shiken Kenkyu Kikan to Kiso Kenkyu [National Research Organizations and their Basic Research] NISTEP REPORT,* No.20, 1991.

Drucker, Peter F., *Managing the Non-Profit Organization,* New York: Harper Collins, 1990.

Nonaka, Ikujiro, "Kososhiki no Gijutsu Kakushin Senryaku - Kokutetsu to Denden Kosha no Jirei no Ichikosatsu [Technological Innovation Strategy of Public Organization - A Case Study of Japan National Railway and NTT]," *Business Review* (Japanese), Vol. 29, No.3, 1981.

Thompson, James D., *Organizations in Action,* New York: McGraw-Hill, 1987.

Hirota, Toshiro, "Nihon Kigyo to America Kigyo no Gijutsu Kaihatsu [Technological Development of Japanese and American Companies]," *Shogaku Ronshu [The Business Review of Kansai University]* (Kansai University), Vol. 30, No.6, 1986.

4. EVOLUTION OF NATIONAL PROGRAMS AMONG GOVERNMENT, INDUSTRY AND ACADEMIA

In the previous chapter, we have analyzed the results of questionnaire survey to identify the current activities of national and public institutes, which are the core promoters of national science and technology programs. For the implementation of national science and technology programs, however, business firms and academic organizations are also important players. National science and technology programs are often initiated by the government agencies, which are then many times joined by firms and universities. Therefore, an analysis on the aspect of government-industry-academia cooperative relationships is one of the substantive approaches for the deep understanding of the nature of national science and technology programs. In this chapter, we shall begin to analyze this problem by examining such relationships in the space program as one of the typical national programs.

4.1 General Outlook

Regarding the interaction among government, industry and academia, there exist many studies on the cooperative relationships between industry and academia, or between government and industry. In this section, we will briefly review them.

The studies on the relationships between industry and academia were performed actively in the 1960s and the 1970s, which were presented in various manner. In rather old time, it was supposed that the scientific research was performed exclusively in academia. Recently, the center of the research has moved to industry. Modern science was industrialized, and the research in academia is highly influenced by that tendency. As to the collaboration between those who follow "the pursuit of private interests" and those who seek "the pursuit of public knowledge," there have been two perspectives. One was deeply concerned about whether academism could be maintained in the face of many problems such as the confidential nature of proprietary knowledge and intellectual property rights. On the other hand, the other take a positive attitude toward the transfer of knowledge from academia to industry by expecting sufficient funding from industry. Today, the relationships between industry and academia are becoming deeper, as both sides become less reluctant to commit such collaboration.

For example, the industry increasingly needs to commit basic research, and the academia more and more needs research funds.

On the other hand, as to the business-government relationships in Japan, there has been much concern, particularly by the United States, that they are characterized by some exclusive network relationships, a notion opposite to the free market system. A typical example of the workings of such concern was the opening of the Japanese satellite market, which the U.S. government sought for intensively.

National science and technology programs thus have important implications, since they inevitably involve the collaborations among government, industry and academia. This tripartite relationship have existed more or less since the government had ever involved in science and technology programs. However, a trend-setting note came with the Recommendation No.5 of the Council for Science and Technology in 1971. In that recommendation, the Council emphasized that it needs to mobilize all research capabilities and for such purpose it also needs to link universities, national research laboratories and private research institutions. The Recommendation No.6 of the Council in 1977 then stressed the importance of "strengthening the organic links among government, academia and industry in research and development," and after that time, the necessity of collaboration among industry, academia and government was frequently appealed to the public in order to promote the growth of economy.

Recently, government's coordinating efforts in R&D of advanced science and technology have become salient. The background for this tendency is the increasing fusion among different disciplines and areas of research. This "borderless" phenomenon includes not only different disciplines and technologies but also systems, organizations and even nations. Cooperative activities emerge not only from searching for new intellectual frontiers between researchers of different fields but also from aiming at effective utilization of researchers' potentials. Restructuring of various systems has already begun, and this effort is now advancing to other levels including the globalization of the government-industry-academia relationship. Therefore, the role of government has also reached to the central importance in this relationship.

In order to dissolve the current policy problems which come from above phenomena, some lessons should be drawn from case studies with historical insights. In this study, we will analyze the mechanisms of cooperation among the three sectors in several national programs, in order, in the stress of the role of government, i.e. from a point of view of optimization of public benefits. Here, we firstly take Japanese space program.

4.2 A Case of Space Program

In this section, we will deal with the Japanese space program as a representative case of the national science and technology programs. The case study will lay emphasis on the expansion of the relationship among academia, government and industry[1] in terms of systems, i.e. laws, institutions and organizations.

First of all, we will review the historical formation process of the space R&D system, which will be followed with macro data on the academia-government-industry relationships. A preliminary analysis of the collaborative structure will then performed.

4.2.1 Brief History of Space Institution

A brief history of the evolutionary process of institutes and organizations of space R&D in Japan is shown in Table 4.1 (Refs. 10-12). The early setting of space research in the world was the missile research after World War II against the backdrop of the US-Soviet competition and the applications of the R&D to the research on geometeorological survey. On such background of international tendency, the Institute of Industrial Science of the University of Tokyo began to research on the rocket technology using a small rocket called the "pencil rocket" in 1955. In 1957, the world was shocked by the Sputnik launched by the Soviet Union, and three years later, in 1960, the Space Development Council (SDC) was created in Japan.

The Japanese business community responded to the government initiative by installing the Special Committee on the Peaceful Unitization of Space (SCPUS) in the Federation of Economic Organizations (Keidanren) in June, 1961 as a link between industry and government. In 1963, the National Aeronautical Laboratory of STA was revamped to the National Aerospace Laboratory. In academia, the rocket research division of the University of Tokyo's Institute of Industrial Science was combined with the University's Aeronautical Laboratory to form the Institute of Space and Aeronautical Science (ISAS) in 1964. In government, the Space Development Promotion Group was installed in STA. Active reconstruc-

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[1] We adopt this order of three sectors in the case of space program, because Japanese space R&D have progressed from academia, through government, to industry.

tion of all these institutions came from a strong tendency to promote science and technology beyond the results obtained by contributing to the International Geophysical Year (IGY) during 1957 to 1958.

In December 1967, SDC finally compiled its eight years research into its 4th Recommendation titled "On the Basic Guideline of the Long-Term Plan and System of Space Development." The Guideline emphasized, among other things, the need to establish an organization which can unite the space research efforts of government, industry and academia as a national force. Upon receiving this Recommendation, the government wrote "the Law for Establishment of the Space Activities Commission (SAC)" in 1968, which then followed by the announcement of the "National Space Development Agency (NASDA) Law" in 1969. And, SAC replaced SDC with a view "to facilitate the comprehensive and planned promotion and democratic management of national policies on space development." NASDA was then installed to promote space development for application purposes, with the abolition of the Space Development Promotion Group. Now activities of both ISAS and NASDA came under the jurisdiction of SAC. In the business sector, Keidanren's SCPUS was dissolved to develop into the Space Development Promotion Council (SDPC) in 1968. These organizations now consist the backbone of the government-industry-academia cooperations in space development.

During the national space development system had been arranged, ISAS's endeavors to launch satellites had failed four times before they successfully launched a satellite on the L4S-5 rocket on February 11, 1970. This Japan's first satellite was named "Ohsumi," and Japan became the 4th country in the world which has the technological capability of launching satellite.

The first satellite in the application fields was Engineering Test Satellite-I (ETS-1; nicknamed "Kiku") that was launched by NASDA on September 9, 1975. Prior to this success of launching ETS-1, due to the pressure by increasing demands from various government offices, there was a deep dilemma to go through the deadlock of delayed development by indigenous technology. A major force which overcame this difficulty was a drastic policy shift from domestic development to importation of technologies from the United States, which was documented in the 1970 review of space policy (See Ref. 6, pp.297-300). This policy change was based on a prospect that pursuing less uncertain method of importing technology would be better for launching larger payloads in the future. On the other hand, the experiences of the University of Tokyo so far had also contributed to develop the fundamentals in the application fields, especially Tanegashima launch facilities and ETS-1. In this fashion, the progress of the projects was very smooth.

Since then, Japan has risen fast as a power in the field of space development. As of November, 1992, the total number of satellites launched by ISAS, NASDA and private enterprises are 56, which consists of ISAS for scientific purposes 21, NASDA for applications 31 and private firms for communications 4 (Figure 4.1). Presently, Japan is on the third place after the former Soviet Union and the United States. One major characteristic of space development in Japan is the dominance of applications satellites compared to engineering test satellites which have larger proportions in the US and the former Soviet Union. This partly comes from the fact that Japan imported the basic technologies for space.

Technology development can be measured in terms of the number of papers published by the authors in each sector. Figure 4.2 indicates one of these data in all fields of space science and technology (Source: Proceedings of The Space Sciences and Technology Conference, Japan Society for Aeronautical and Space Sciences). A clear trend found in the figure is a rapid growth of the number of papers submitted by the researchers of private firms. The trend has risen rapidly since the early 1980s with 1981 and 1987 as two stepping stones. This trend is contrasted with the slow growth of those by government and university research institutions. The background for this rapid growth of space research in the private sector is understood from the sponsored research from NASDA. In other words, its tendency partly depends on the NASDA's policy and activities. NASDA, in its early times, aimed not only at importing the basic technologies for satellite and rockets but also at elaborating them to suit the Japanese needs. The success of launching ETS-II in 1977 indicated that the basic technologies for the geostationary satellite were mastered. With this success as a turning point, NASDA shifted its space program's orientation towards new advanced target. Along with this new plan, the functions of Tsukuba Space Center were expanded as one of the major R&D centers along this line. In terms of research, new emphasis was now given to subsystems, components and parts of satellites and rockets. Turning into the late 1980s, Japanese space research has enlarged its domain. Included are space infrastructure building, experiment under microgravity, moon exploration, etc. and the efforts have been directed to establish their basic technologies. This new trend coincides with a new research boom in the private industry as illustrated in Figure 4.2.

4.2.2 The Academia-Government-Industry Cooperation Structure

In this section, we will examine the nature of the cooperative relationship among academia, government and industry with a case study of space program.

4.2.2.1 ISAS and NASDA

Space development in Japan started in the academic sector with the University of Tokyo. It was then expanded by the public sector with the inauguration of NASDA, which focuses on applications satellites in cooperation with private firms. Recently, private companies were founded to provide communication and broadcasting services. Launching and utilization of satellites have been thus developed in the context of the cooperation among academia, government and industry. ISAS and NASDA have been the central locus of technological development. Here, we review several historical facts of the relationships between ISAS and NASDA.

Let us consider the case of the first satellite of scientific fields. The first satellite, "Ohsumi," was launched by the Lambda Rocket in 1970. The satellite was developed not only by the University of Tokyo's researchers but also by the cooperation among a variety of researchers belonging to different institutions (Ref. 13). More specifically, to develop a variety of technologies in such areas as mission equipment, structure, power supply, telemetry and commands, it gathered the researchers from ISAS, Institute of Industrial Science and Astronomical Observatory of the University of Tokyo, Rikkyo University, Radio Research Laboratory, NTT, NHK Technical Research Laboratories, AIST Electric Test Center, NEC, etc.

Some 120 to 130 researchers from the above institutions had met about 20 times starting from initial technical discussion to the decision of the prototype satellite design. This kind of re-

search group among university professors, their graduates and some their colleagues is often seen when a research on new subjects starts. All members participate to the meetings on their own will and it is held in free atmosphere, and thus the meetings serve as the training ground of young researchers as well.
The technologies created and accumulated in academia during the development of the above satellite transferred to the application satellites through the firms that later participated in the ETS-I project.

Let us take another instance of the creation of NASDA. The installation of the Space Development Promotion Group at STA in 1964 prompted competition between STA and the University of Tokyo for initiative in rocket development (Refs. 14 and 15). At that time, the government side intended to unify all national space development efforts for a single purpose of developing large-scale launch vehicles. On the other hand, the researchers at University of Tokyo attempted to maintain the fundamental technology for space science within academia. The University of Tokyo researchers' intention then faced criticism. The crux of the criticism was that it is not appropriate that a university accounts for space development of the whole nation, which will cause among other things a gigantic expansion of research budget to a degree at which one institution cannot manage properly. The University of Tokyo's position became much weaker as it failed four launch trials in succession. It became widely criticized, especially by one of major daily newspapers that the whole space budget was too big to be concentrated in one research institution of the University. A final negotiation was made that the University of Tokyo's research will be limited to the rockets of diameters of less than 1.4 meter. Another major development was entrusted to another body which was born from the separation of the space research institute from the University of Tokyo in 1981.

4.2.2.2 An Analysis based on Statistical Data

Now we shall analyze the academia-government-industry relationships in term of research expenses borne and research publications by each sector (Source: Proceedings of the Space Sciences and Technology Conference, the Japan Society for Aeronautical and Space Sciences)(Ref. 16). Figure 4.3 illustrates expenses by each sector. The figures were calculated based on the amounts of sales orders which private firms obtained from each sector. Two figures of 1979 and 1989 show that while government was more supportive in 1979, the initiative move to industry ten years later (Ref. 17).

Next, as an indicator of each sector's activity, we will use the number of papers presented by each sector at the meetings of the Japan Society for Aeronautical and Space Sciences. Figure 4.4 shows the coauthorship among academia, government and industry, in 1979 and 1989. In 1979, no coauthorship between universities was found; it means that ISAS solely represented space research in academia. The relatively smaller scale collaborative research between academia and industry comparing with the autonomous research, despite the former's leadership in advanced technologies, indicate a weaker relationship between the two sectors. An additional explanation for this is the consolidation of space research among all three sectors under the leadership of NASDA. Recently, in 1989, the cooperative relationship between academia and industry has been spurred, as the advancements of research in academia require sophisticated applications. Therefore, the frequency of collaborative activities between the two sectors is on the rise as shown in comparing the number of papers from one organization with that of coauthored papers at academic sector. One tendency is the privatisation of government research areas, as the needs and pressures for commercialization increase, which means a decrease trend of cooperation between government and industry. On the other hand, the cooperation between public and private sectors increases in the advanced fields like space environment utilization and space infrastructure building. Therefore, the number of coauthorship between government and industry is relatively increasing.

Here, in order to understand the meaning of the data, let's consider the logics governing academia, government, and industry. It is presumable that the latent logics for each sector's research activity remain time invariant, although the appeared cooperative relationships among the three sectors change with time.

Academia, in general, has been given the freedom and autonomy of research, and government interference has been shunned. To be exact, the academia consists of scientists and engineers who have different character, respectively. However, here we pay our attention to only a common character of them. That is, they form

networks of professional people. With these human networks, the academia has been influencing many fields including the government and industry sectors.
Second, the government agencies and institutions affect directly or indirectly industry by means of budgets and policies. Particularly in national R&D projects, the government institutions as coordinator of the research also have some functions to set the direction of the research, like a think tank.
Third, private firms in the industry have ambivalent attitudes toward the other sectors. As to the government agencies, they conform to what "the okami (the government or authorities)" says; they also have business calculations as well toward government agencies. It is most noticeable that the Japanese firms respond to national projects out of nationalistic passion, and also out of calculation.

The relationships between government agencies and academia are the mixture of the conformation to national interests and the inherent repulsive tendency for maintaining academic freedom. Overall, however, the relationships have been looser than those between academia and industry. These logics seemed to exist behind the behavior of each sector.

In sum, Japanese space programs have been developed by two leading organs: (1) the academia represented by ISAS which has an inherent tendency to maintain academic freedom and autonomy, (2) the government represented by NASDA which has a manifest goal of catching up with the West with limited resources as a national strategy. With private corporations placed in the middle, the two sectors have differentiated their domains into science fields and application fields and have maintained both competitive and cooperative relationships. These competitive and cooperative relationships can be said to have realized today's rapid growth of space technologies in Japan.

In this setting, the role of private corporations cannot be overemphasized. They join the scientific projects of academia, and elaborate the learning and then use it at governmental projects. The firms have been also the main receivers of foreign technologies through government agencies, which are then transmitted to academia through the scientific projects. In this fashion, the competitive and cooperative relationships between government and academia have been made possible, owing to the existence of private corporations.

We have so far reviewed the relationships among three sectors of academia, government and industry in a case of space program. The remaining tasks are to try deeper understanding of individual research projects and to clarify the overall nature of national science and technology programs as a whole.

Table 4.1 Evolution of Space Organizations and Major Events in Each Sector in Japan

	UNIVERSITY	GOVERNMENT	INDUSTRY
1955 Apr.	<UT>*1) The research on rocket technology began at the Institute of Industrial Science.		
1957 - 58	The 3rd IGY		
1959 July 10		<STA>*2) • Space Science and Technology Promotion and Preparation Committee was convened.	
1960 May 16		• Space Development Council was convened.	
1961 June 2			<FEO>*3) • First Special Committee for the Peaceful Utilization of Space was held.
1963 Apr. 1		• National Aerospace Laboratory was established.	
	R&D of Mu rocket was begun.		
Aug. 10		An experiment of launching rocket was performed.	
Nov. 20			<KDD>*4) • Space Communications Laboratory was opened
1964 Apr. 1	• Institute of Space and Astronautical Science was established.		
July 1		• Space Development Promotion Group was set up.	
1965 June 20	Scientific Satellite Plan was announced.		
1968 Feb. 1		• Katsuura and Okinawa Radio Tracking Stations of the Space Development Promotion Group started their operations.	
June 10			<FEO> • Space Development Promotion Conference was established.
Aug. 16		• Space Activities Commission (SAC) was established.	
1969 Aug. 6			TV broadcasting was opend between Japan and Europe via INTELSAT.
Oct. 1		• NASDA was established.	
1970 Feb. 11	Japan's first satellite ”Ohsumi” was launched.		
1975 May 23		Exchange of Notes Concerning Cooperation between Japan and the U.S.A. for the Plan of Launching GMS, CS and BS.	
Sep. 9		NASDA launched the first application satellite ”ETS-I”.	
1977 Feb. 23		NASDA launched the first Japanese geostationary satellite ”ETS-II.”	
1981 Apr. 14	<MOE>*5) • The Institute of Space and Astronautical Science was established (Tokyo University's Institute was reorganized).		
1982 Aug. 31		<SAC> • Special Session for Space Station was set up.	
1984 - 85			• Private Satellite Communications Companies (JCSAT,SCC,etc.) were established.
1989 Sep. 5		Agreement among the Governments on Cooperation related to the Permanently Manned Civil Space Station.	
Dec. 20		• Session for Space Station was set up.	
1990 Jan. 24	ISAS launched the 13th Scientific Satellite, swinging by the moon.		

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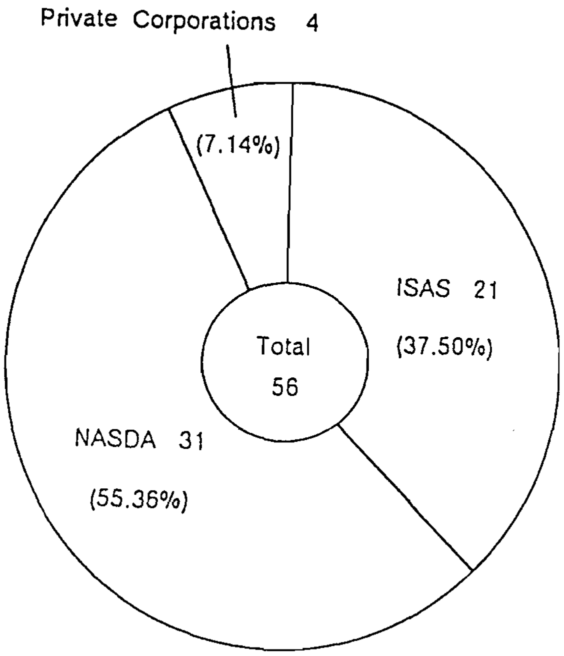
*1) UT : The University of Tokyo
*2) STA: The Science and Technology Agency
*3) FEO: The Federation of Economic Organizations (KEIDANREN)
*4) KDD: Kokusai Denshin Denwa Co.
*5) MOE: The Ministry of Education



Ratio of Number of Satellites Launched as of November, 1992

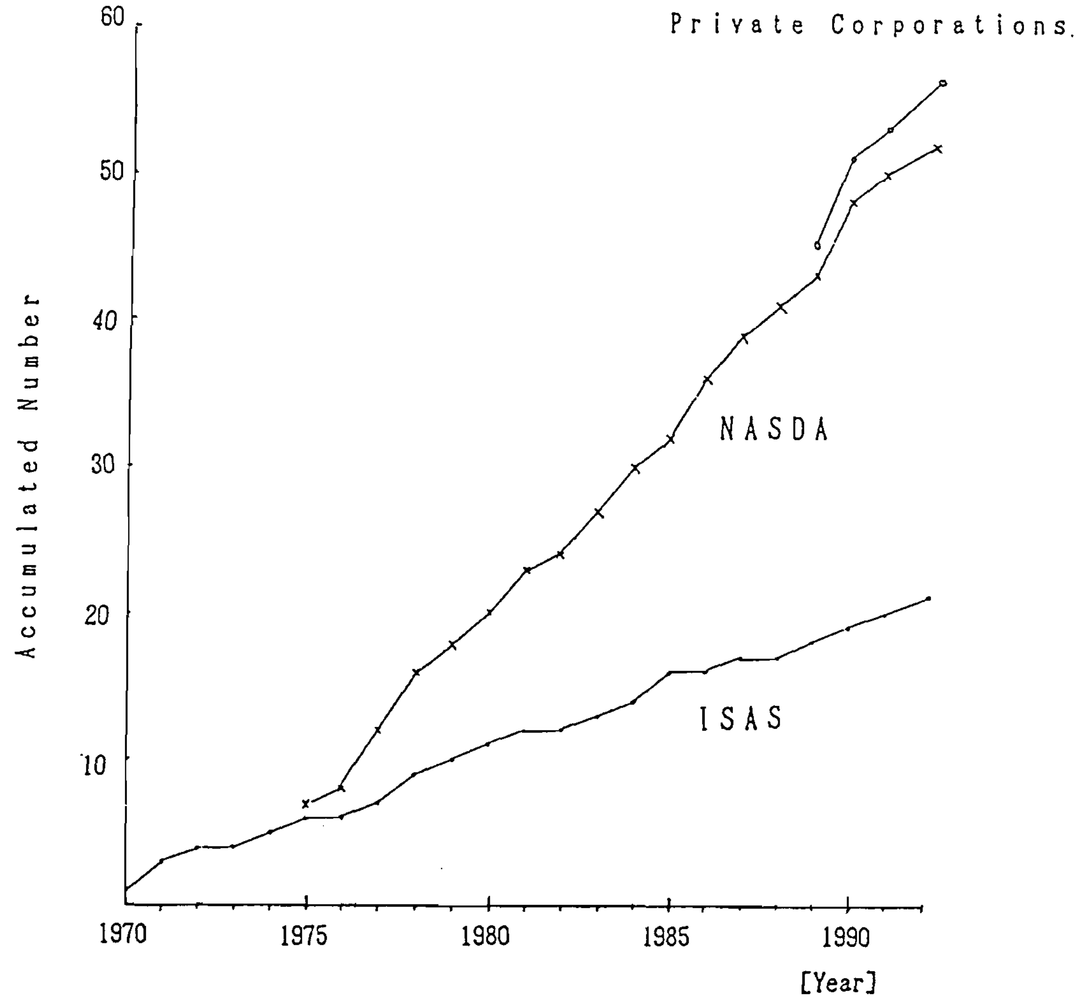


Fig. 4.1 Accumulated Number of Satellites Launched by ISAS, NASDA and Private Corporations

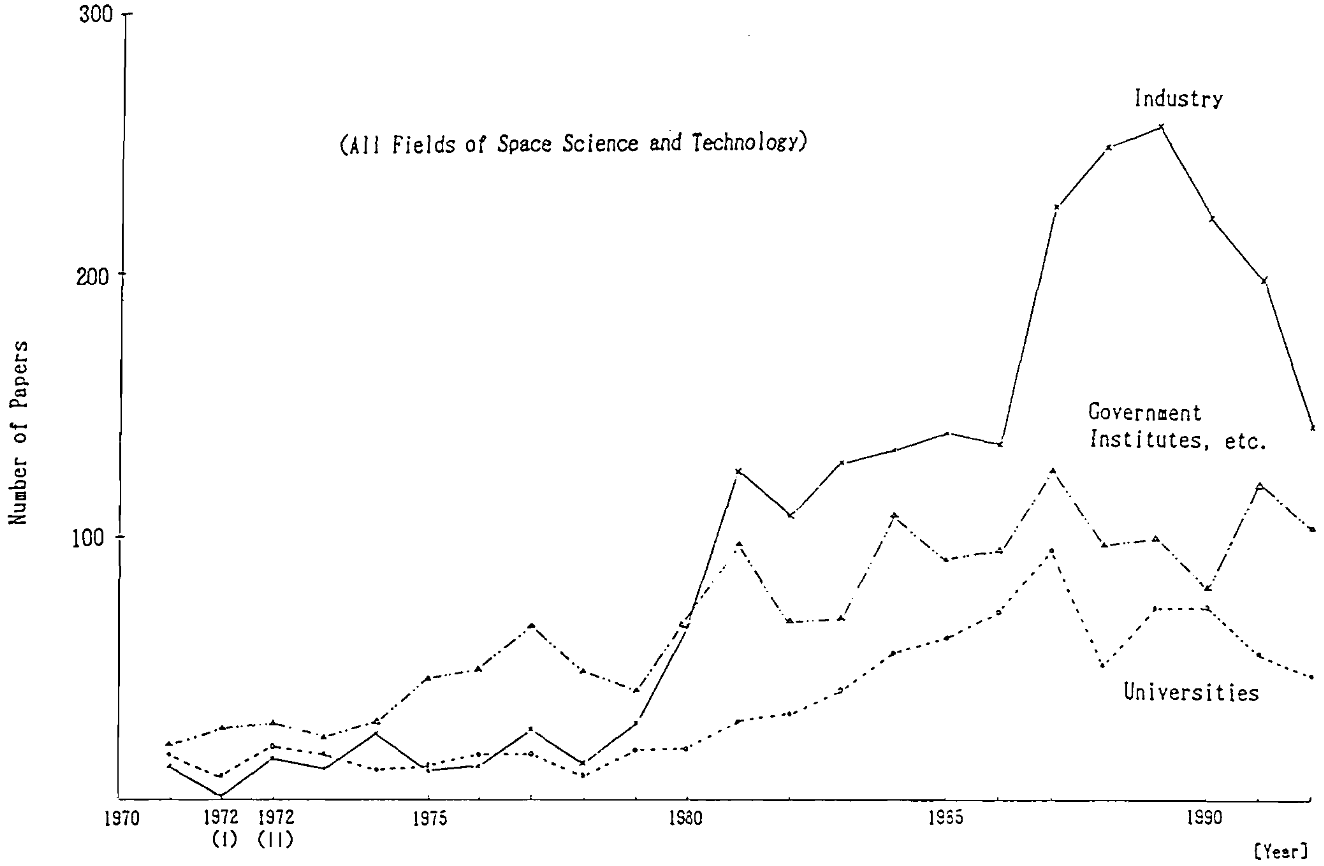
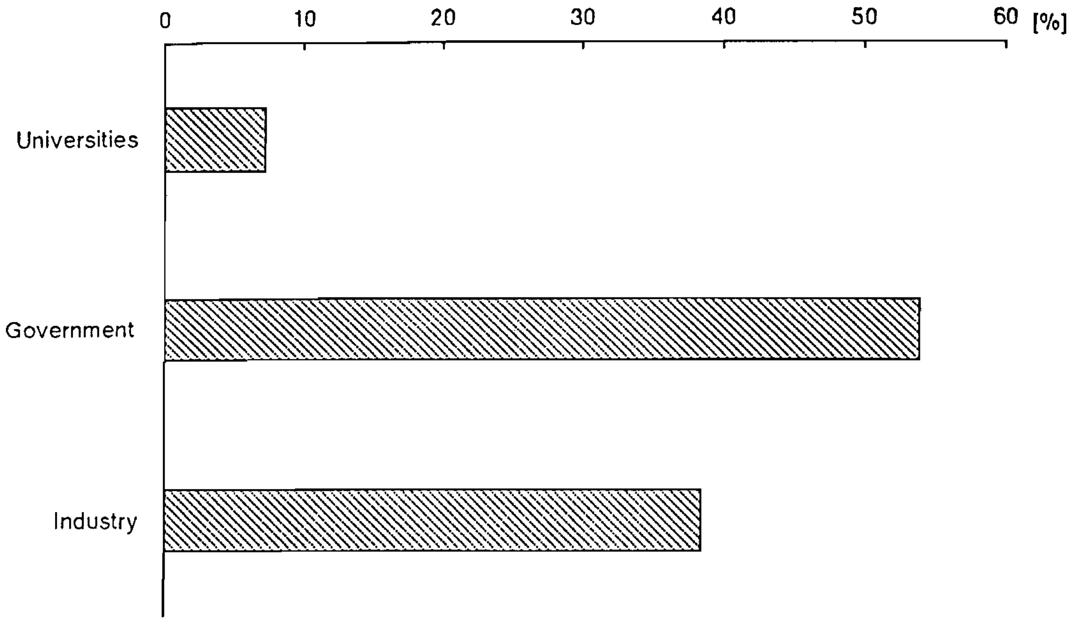
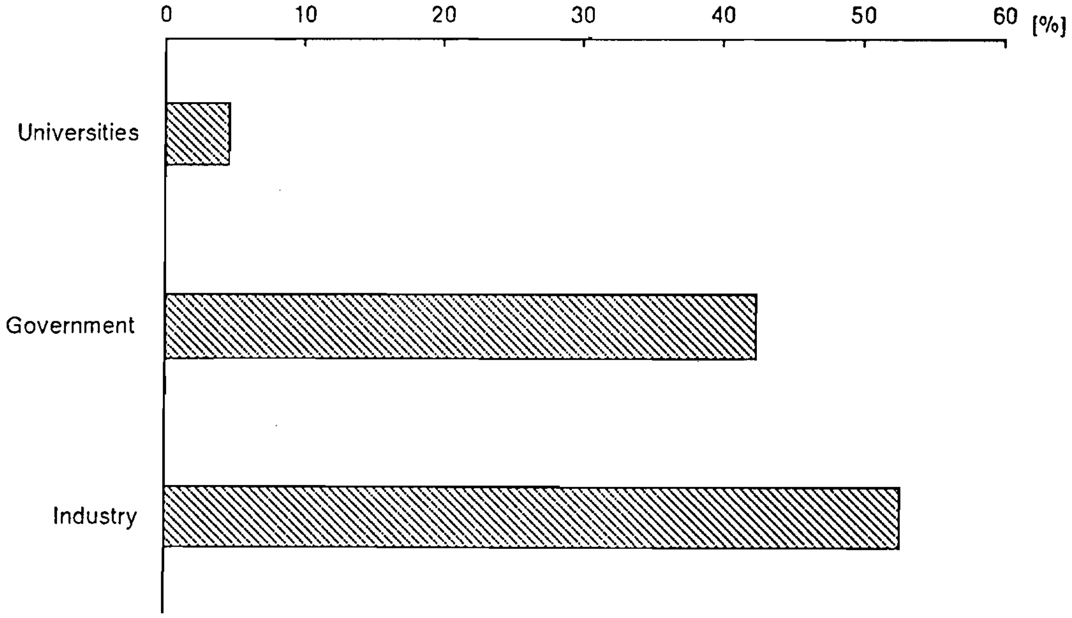


Fig. 4.2 Number of Papers Presented at Space Conference in Each Year

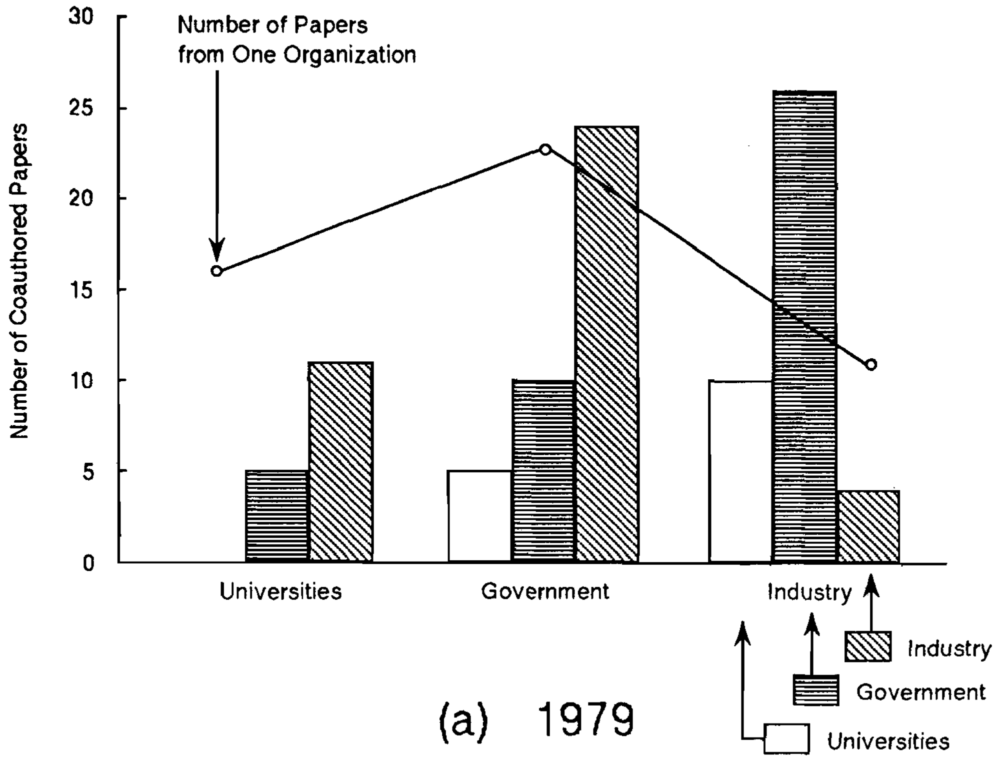


(a) 1979

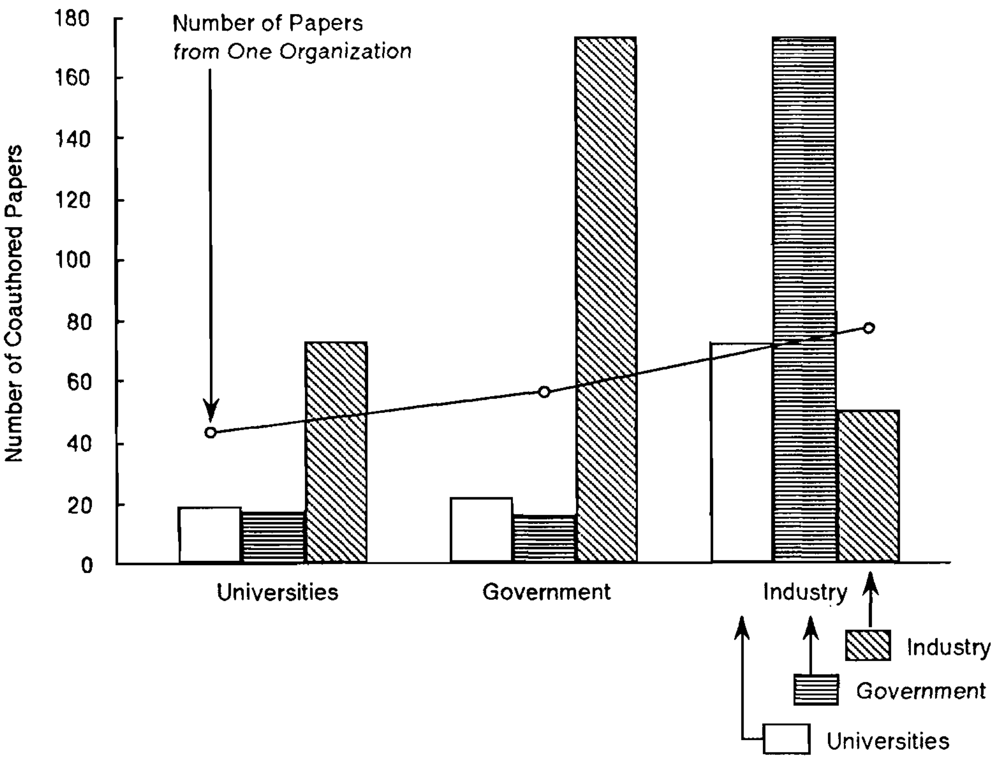


(b) 1989

Fig. 4.3 Ratio of Sales to Different Sectors in Space Business



(a) 1979



(b) 1989

Fig. 4.4 Coauthorship among Universities, Government and Industry

5. CONCLUDING REMARKS

This report is a first step to the understanding of national science and technology programs by using statistical approach. We have developed conceptual frameworks for the research and then analyzed the current activities of national organizations as core promoters of national programs. In addition, we presented a perspective to analyze national programs, i.e. aspect of the cooperative relationships among government institutes, private corporations and academia with a case study of space program. Tentative conclusions of the analysis are summarized as follows:

1. National programs as a subject of analysis require diverse angles or perspectives for proper understanding. In this analysis, we have presented a research framework which consists of stimulus factors, system structure, resources and outcomes as fundamental elements.

2. Before performing case studies of individual national programs, we have performed a questionnaire survey on the current status of national R&D institutions which function as the implementer of national programs. In this analysis, we have identified four types of government and public research institutions: (1) Scientific Knowledge Creation (SKC) type; (2) Science Application (SA) type; (3) Public Knowledge Creation (PKC) type and (4) Policy Promotion (PP) type. The four types of institutions were then explained in terms of major several characteristics.

3. National programs are implemented in the setting of the organic relationships among government, industry and academia. We presented this as one perspective to the analysis of national programs. And as a predecessor of this analysis, by adopting space program, the relationships were then analyzed in terms of two major indicators: (1) research expenses borne and (2) coauthored papers published by those three sectors.

The purpose of this report is to serve as the starting point for further research of this subject. Detailed research on each of specific national programs is to be done from now on with the research framework presented here. The research framework will also need further elaboration and refinement, corresponding to particular analyses.

The national science and technology R&D projects today take important positions not only domestically but also internationally as they draw much attention from abroad, particularly from the perspective of international cooperation and contribution. As such, it is much desirable that empirical studies on this subject with using statistical approach are further carried on. Proper understanding of the nature of national programs will serve as a good laboratory in which the directions for international cooperation are identified and tested.

In concluding this report, the authors express sincere gratitude to the institutions and researchers who kindly provided us with data and/or responded to our questionnaire survey.

REFERENCES

1. See, for example, the US Vice President Quayle's address at the World Space Congress on August 31, 1992.

2. Itoh, Shigeyuki, *Shisutemu Poritekkusu [System Politics]*, Tokyo: Keiso-shobo, 1987.

3. Wallerstein, Immanuel, ed., Yamada et al. trans., *Sosho Sekai Shisutemu 1 Warudo Ekonomi [Series World System 1: World Economy]*, Tokyo: Fujiwara Shoten, 1991.

4. Kamatani,Chikayoshi, *Gijutsu Taikoku Hyakunen no Kei: Nihon no Kindaika to Kokuritsu Kenkyu Kikan [A 100-Year Plan for Technology Power: Japanese Modernization and National Research Organizations]*, Tokyo: Heibon-sha, 1988.

5. Uemura, Yukio, *Kagaku Gijutsu Seisakuron [A Study of Science and Technology Policy]*, Tokyo: Rodo Junpo-sha, 1989.

6. The Commission on the History of Science and Technology Policy, ed. (supervised by NISTEP, STA), *Historical Review of Japanese Science and Technology Policy*, Tokyo: The Society of Non-Traditional Technology, 1991.

7. Nihon Kagakusha Kaigi, ed., *Kagaku Gijutsu Seisaku-shi Nenpyo [A Chronology of Science and Technology Policy]*, Tokyo: Otsuki Shoten, 1981.
8. Arakawa, Kiyoshi, *Nihon no Gijutsu Hatten Saiko [A Review of Science and Technology Development in Japan]*, Tokyo: Kaimei-sha, 1991.

9. Aoyama, Yoshiyuki, *Sangyo no Showa Shakai-shi 4: Kaden [The Showa Society History of Industries - Vol. 4: Home Electronics]*, Tokyo: Nihon Keizai Hyoron-sha, 1991.

10. Keidanren, *Uchu Kaihatsu Handobukku [A Handbook of Space Development]*, 1991.

11. Space Development Committee, *Wagakuni no Uchu Kaihatsu no Ayumi [A History of Space Development in Japan]*, 1978.

12. The Institute of Space and Aeronautical Science (ISAS), the Ministry of Education, *Uchu Kukan Kansoku Sanjunen-shi Nenpyo*

[A 30-Year Chronology of Space Observation], 1987.

13. Hayashi, Tomonao, "Kagaku Eisei Zen-Zen-ya [The Night before the eve of the Science Satellite]," *Kiseki: Uchu Kukan Kansoku Sanjunen Kinen Zuiso-shu [The Trace of R&D: A Collection of Papers in Commemoration of the 30th Anniversary of Space Observation]*, ISAS, 1986, pp.149-152.

14. *Nihon no Uchu Kaihatsu no Ayumi, Vol.1 [A History of Space Development in Japan, Vol.1]*, Tokyo: The News Letter Publishing Corp. and Nihon Uchu Kaihatsu Kenkyujo, 1976.

15. Saito, Shigebumi, *Nihon Uchu Kaihatsu Monogatari [A Historical Story of Space Development in Japan]*, Tokyo: Mita Shuppan-kai, 1992.

16. Mitsuma, Hidehiko, "Cooperative Aspects of Space Research and Development Activities in Three Major Sectors in Japan," Proceedings of the Eighteenth International Symposium on Space Technology and Science, Kagoshima, May 17-23, 1992, pp.2413-2418.

17. See, the materials published by The Society of Japanese Aerospace Companies, Inc., etc.

1993. 93.10.15