Securing Australia's Future - Project 9
Translating research for economic and social benefit: country comparisons

Japan

Review of Japan's Policy Measures for Public Research Commercialisation

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Review of Japan's Policy Measures for Public Research Commercialization For Australia ACOLA project

Innovation is effective for growing the economy and solving social problems and therefore, many countries allocate public funds to research and development (R&D) to address these. However, the research results are not often used in industry and society as it was expected; even if academic articles and patents are produced by the R&D. Japan has also increased expenditure for R&D, and promoted the Public-Private Partnerships (PPP). Although the partnerships have achieved many results, their evaluation had not provided information on the social outcomes of public research as a whole.

The ACOLA project *'Translating research for economic and social benefit: country comparisons"* is reviewing translation of public sector research and has included Japan as a country of interest. This report will review the current situation of R&D and innovation in Japan and identifies five policy measures used to translate public-funded R&D into commercial outcomes for Japan.

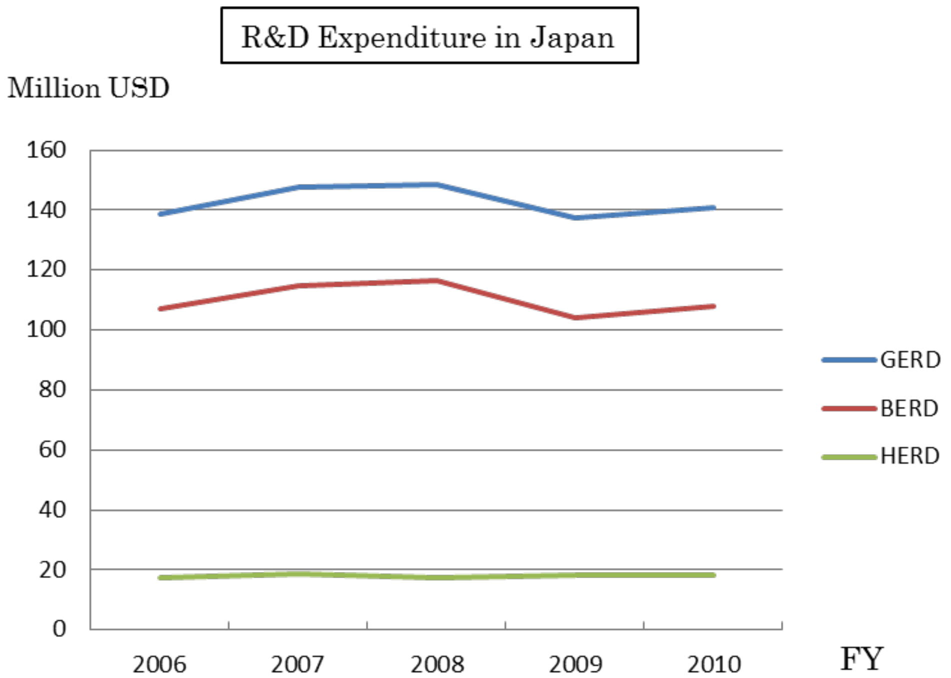
Contents

Japan's Innovation System and Policy

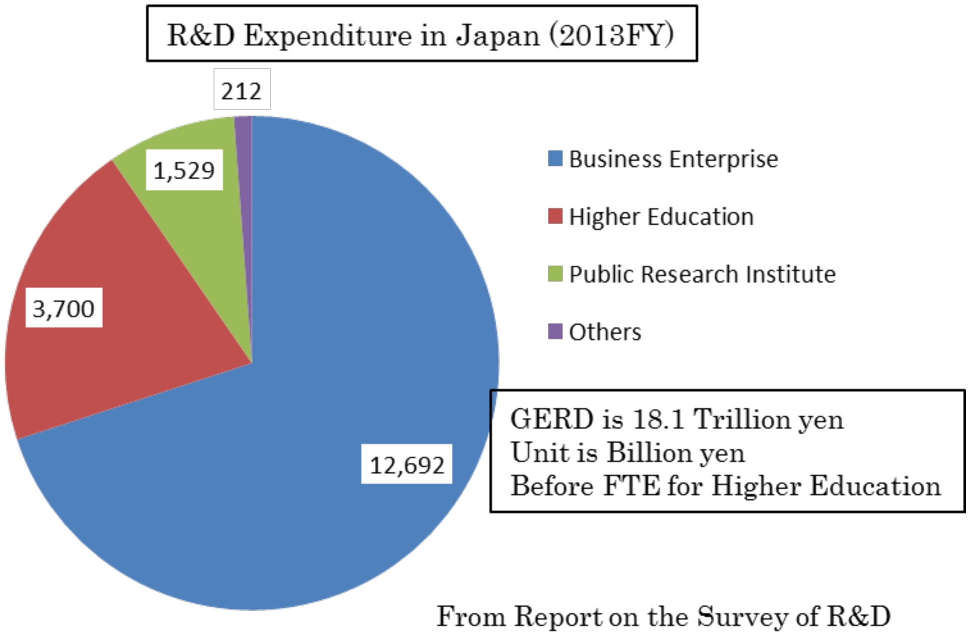
Characteristics of R&D in Japan

Gross expenditure on R&D (GERD) in Japan stood at 18,134 billion yen in 2013FY. Seventy percent was used in business enterprises, and 20.4 per cent was used in the Higher Education sector. Thus, one characteristic of Japan is that a high proportion of R&D is conducted by industry. This point could be thought of as being advantageous for transferring knowledge of public funded research due to "absorptive capacity". On the other hand, product design for merchandise is conducted by companies themselves including SMEs and is not outsourced to universities or public research institutes.

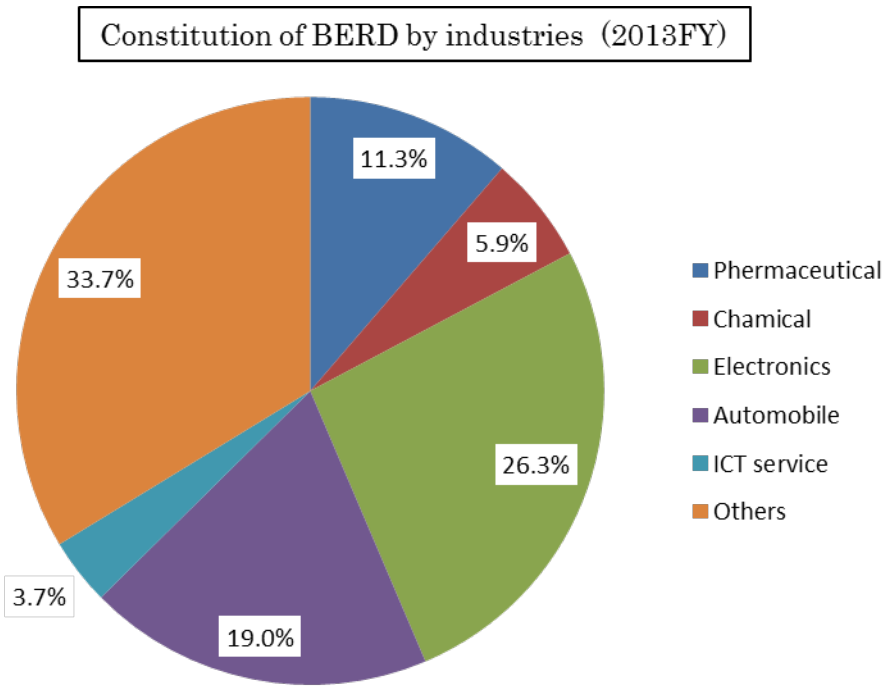
Industrial R&D in Japan, such as the electronics industry and automobile industry has taken an important role. They carried out 26.3 per cent and 19 per cent of Business Expenditure on R&D (BERD) in 2013FY. Regarding company size, larger companies carry out more R&D, as companies who have more than 3,000 employees carried out 66.1per cent of BERD in 2013FY. Many companies understand the importance of innovation and R&D; however, some large companies within the electronics industry are facing difficulties such as more innovation from developing countries and a high exchange rate until 2012.



From OECD, Main S&T Indicators



From Report on the Survey of R&D



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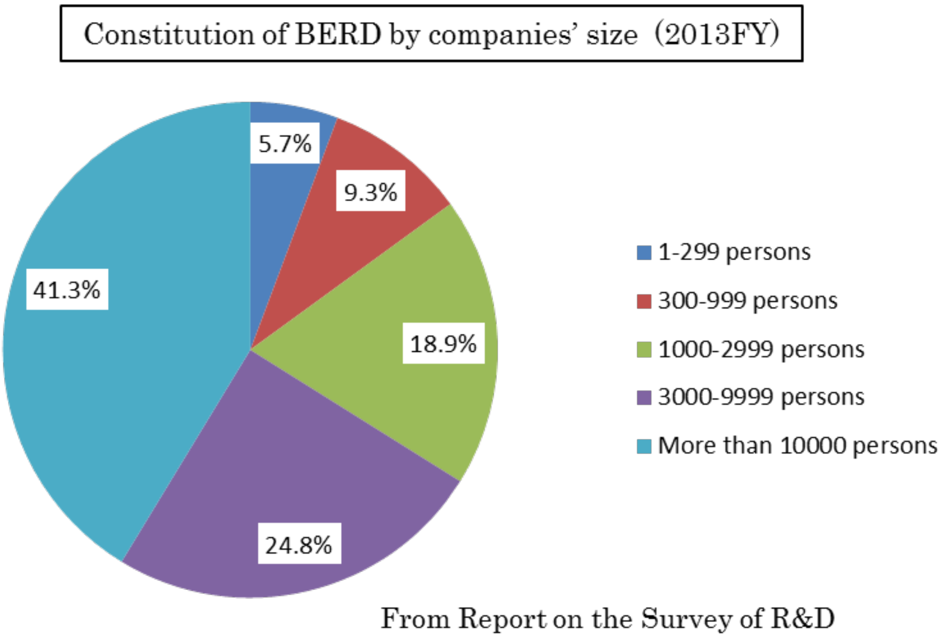
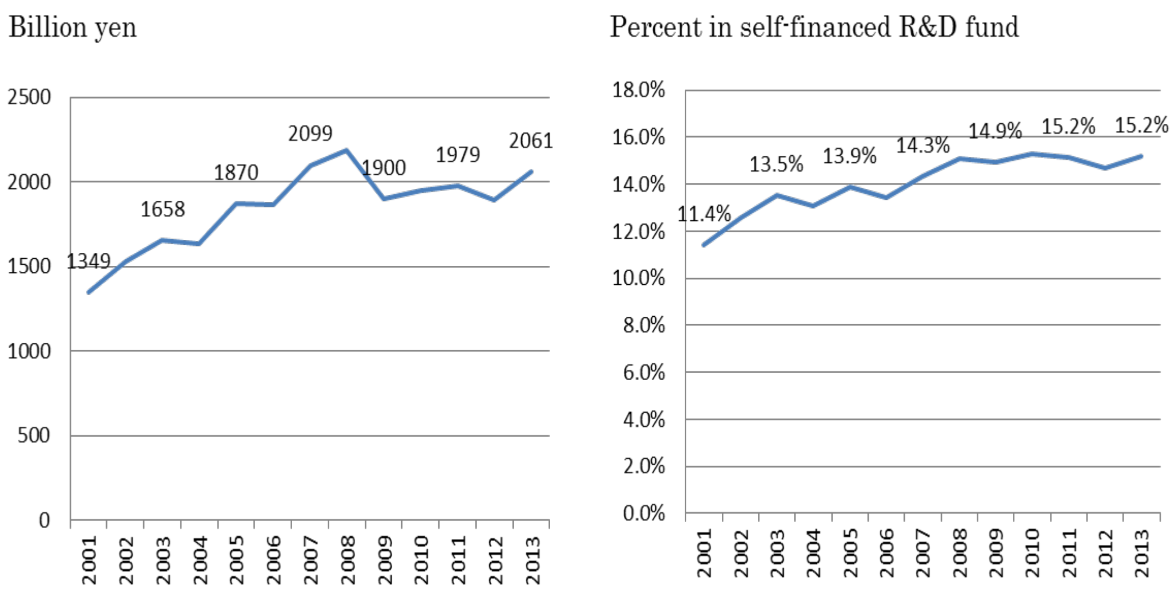


Recently, many companies have an interest in "open innovation" and partnerships with universities and public research institutes. They use 15 per cent of their self-funded R&D expenditure for outside partners. However, most funding is being used for partner companies, and expenditure for partnership with universities or public research institutes looks small. (Detailed date will be shown in Chapter 2.3: Public-Private Partnership policy). Date from the OECD shows the percentage of R&D expenditure financed by industry in Higher Education Expenditure on R&D (HERD) is small in Japan. Additionally, the percentage of R&D expenditure financed by government in BERD also is small in Japan. Thus, funding across public sector and private sector is small, and this is another critical characteristic of Japan's innovation system.

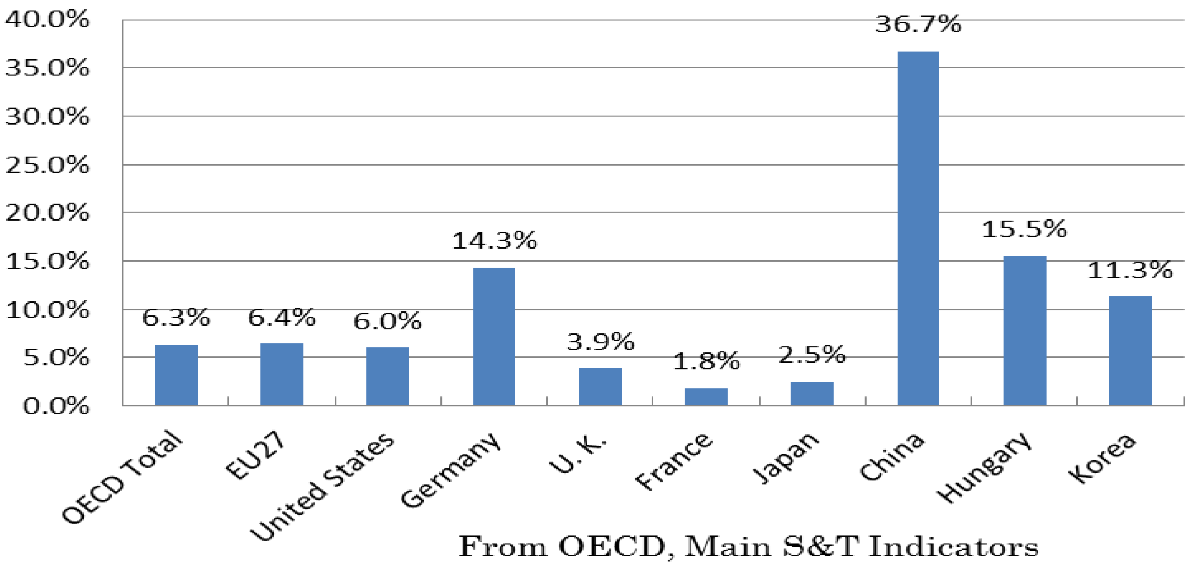
Outside expenditure in self-financed R&D fund in Business enterprise and its ratio



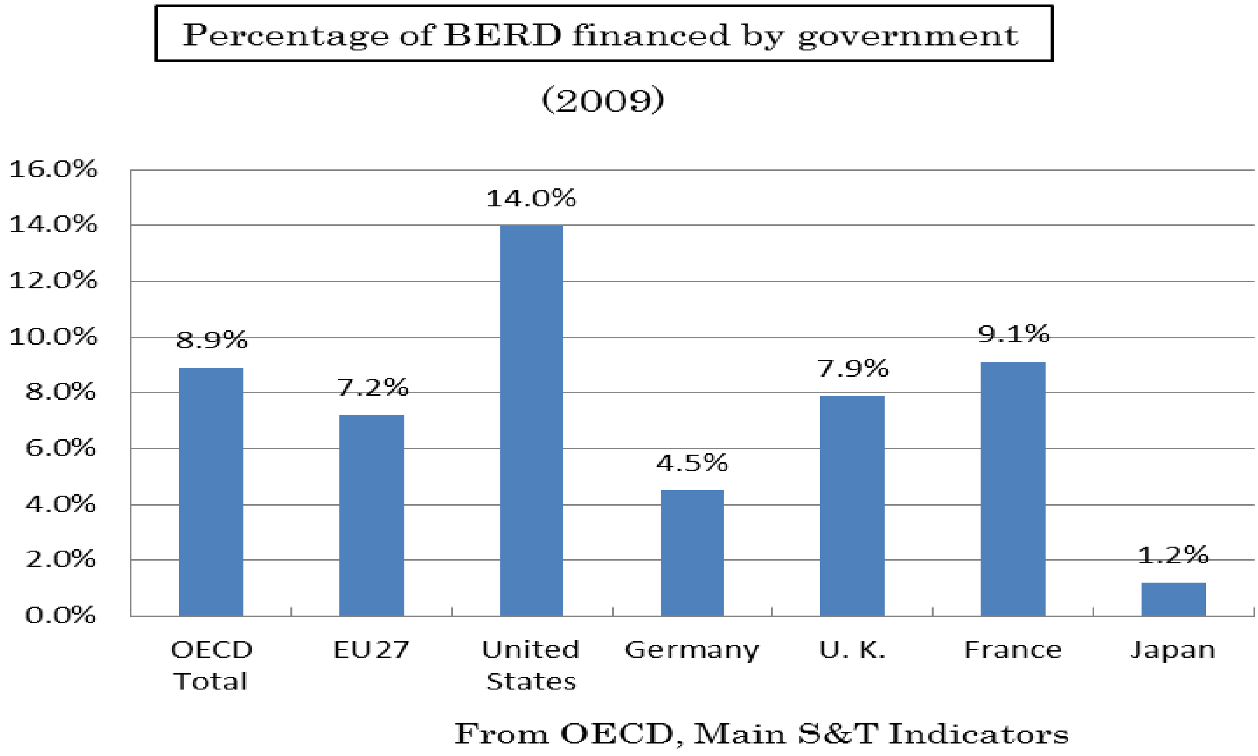
From Report on the Survey of R&D

Percentage of HERD financed by industry

(2009)



From OECD, Main S&T Indicators



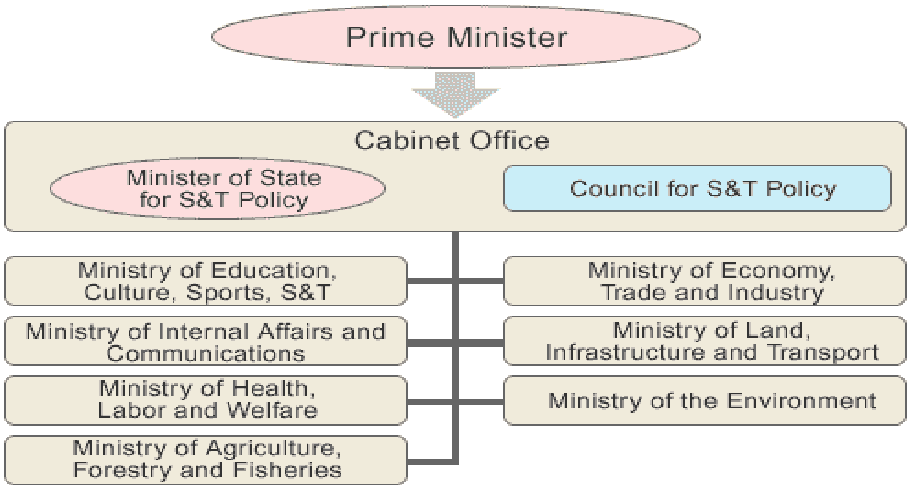
Administrative structure for R&D and innovation policy in Japan

Cabinet Office of Japan's government has the "Council for Science, Technology and Innovation Policy" (formerly named "Council for Science and Technology"), which is the headquarters for science, technology and innovation, and makes a basic policy thereof such as "The Science and Technology Basic Plan". The Cabinet established the first basic plan in 1996, and had revised it every five years based on Science and Technology Basic Law established in 1995. The fourth basic plan was established in 2011 under the Cabinet of the democratic party of Japan, and the "Comprehensive Strategy on Science, Technology and Innovation 2014[1]" was established by the cabinet of Prime Minister Abe. The related Ministers in Japan develop and implement their policies based on the basic policy.

The science and technology budget was 3.9 trillion yen in 2014FY. The major part of the

[1] Reference: http://www8.cao.go.jp/cstp/english/doc/2014stistrategy_provisonal.pdf

budget was for MEXT (Ministry of Education, Culture, Sport, Science and Technology), which was 2.4 trillion yen (61.8 per cent). It included management expenses for grants for national universities, funding for R&D, and management expenses grants for several national research institutes under MEXT.



From HP of Cabinet office of Japan's Government[2]

The budgets are not only used for basic research but also for applied research and innovation. The second largest proportion of the S&T budgets was for METI (Ministry of Economy, Trade and Industry), which was 653 billion yen (16.8 per cent) and far lower than the budget of MEXT. It covered funding programs and management expense grants for a national research institute under METI, with the main purpose to promote industries and develop energy technologies. Other Ministries also had budgets which included management expense grants for national research institutes and their funding programs in their specific fields, such as medical science, environmental science and technology.

Government Budget related to Science and Technology (2014FY)

[2] http://www8.cao.go.jp/cstp/english/about/administration.html

			(Billion yen)	
	original budget	supplementaly budget	total	Percentage
Ministry of Education, Culture, Sports, S&T	2311.8	85.6	2397.4	61.8%
Ministry of Economy, Trade and Industry	539.6	113	652.6	16.8%
Ministry of Health, Lanor and welfare	162.7	3.2	165.9	4.3%
Ministry of Deffence	161.5	0	161.5	4.2%
Ministry of Agriculture, Forestry and Fishers	97.8	8.5	106.3	2.7%
Cabinet Office	74	0.9	74.9	1.9%
Ministry of Land, Infrastructure and Transport	73.3	1.8	75.1	1.9%
Ministry of the Environment	58.2	3.2	61.4	1.6%
Ministry of Internal Affairs and Communicatior	49.3	0.8	50.1	1.3%
Others	123.1	8.8	131.9	3.4%
Total	3651.3	225.8	3877.1	100.0%
	From White paper on science and technology (2015)			

Japan has three main funding organizations, which are Japan Society for the Promotion of Science (JSPS), Japan Science and Technology Agency (JST) and Department of the New Energy and Industrial Technology Development Organization (NEDO). JSPS provides funding for universities, NEDO is for industries and JST is for strategy of government. Further details are below.

a) **JSPS** (Japan Society for the Promotion of Science[3])

JSPS is a public organization under MEXT, and provides Grants-in-Aid for Scientific Research (“KAKENHI” in Japanese), whose budget is 131.1 billion yen in 2015 FY. This is fundamental funding program for academic research from basic to applied research in all fields, ranging from the humanities and the social sciences to the natural sciences. The research projects are competitively selected through a peer-review screening process. JSPS’s budget totaled 301.0 billion yen in 2015FY, including other programs such as international collaboration and developing human resources.

b) **JST** (Japan Science and Technology Agency[4])

JST is also a public organization under MEXT and stipulates itself as the core implementation agency of the fourth phase of the Science and Technology Basic Plan. It has several types of funding programs and several strategic R&D projects. JSTs budget totaled 120.8 billion yen in 2015FY.

c) **NEDO** (New Energy and Industrial Technology Development Organization[5])

3 JSPSs HP: https://www.jsps.go.jp/english/index.html
4 JSTs HP: http://www.jst.go.jp/EN/index.html
5 NEDOs HP: http://www.nedo.go.jp/english/index.html

NEDO is a public organization under METI, and its mission is to address energy and global environmental problems and to enhance industrial technology. It provides funds for many R&D projects (“NEDO projects”). NEDO projects are implemented by business enterprises and by partnerships with universities or the National Institute of Advanced Industrial Science and Technology (AIST) in many cases. NEDOs budget is 131.9 billion in 2015FY. Detailed explanation will be provided in Chapter 2 of this report.

Japan has many national research institutes and these will be discussed below.

a) **AIST** (National Institute of Advanced Industrial Science and Technology[6])

AIST is an institute under METI, and one of the largest public research organizations in Japan. It focuses on the creation and practical realization of technologies useful to Japanese industry and society, and for “bridging” between innovative technological seeds and commercial outcomes. AIST expenditure was 102 billion yen in 2013FY and there are 2,258 researchers and about 5,000 external researchers who are working together. Detailed explanation will be provided in the section Ⅱ-2 of this report.

b) RIKEN[7]

RIKEN is an institute under MEXT and one of the largest and the most comprehensive research organizations for basic and applied science in Japan. It’s mission is to support excellent research in science and technology in order to contribute to the technological and economic development of the Japanese society and the quality of life of the Japanese people. It had 2,852 researchers in 2012 and a budget of 90.0 billion yen in 2012FY.

c) **NIMS** (National Institute for Materials Science[8])

NIMS is also an institute under MEXT with the objective to carry out fundamental research and generic/infrastructural technology research and development in the field of materials science, and to improve the level of materials science and technology. It has 397 permanent researchers and many fixed term researchers, and had a budget of 30.6 billion yen in 2013FY.

6 AISTs HP: https://www.aist.go.jp/index_en.html
7 RIKEN’s HP: http://www.riken.jp/en/
8 NIMS’s HP: http://www.nims.go.jp/eng/index.html

Recently, “innovation” became a key word in Science and Technology Policy in Japan as well as in other countries. The name of the Council of Science and Technology Policy in Cabinet was changed to the Council of Science, Technology and Innovation in May 2014. Additionally, the “Comprehensive Strategy on Science, Technology and Innovation 2014” mentioned above showed a policy direction to transform Japan to “the world’s most innovation-friendly country”, which included encouraging commercialization of publicly funded R&D. Following this, MEXT, METI and other Ministries began implementing their policies based on the basic policy together with universities and their funding organizations and national research institutes, such as JST, NEDO and AIST.

Evaluation system for publicly funded research in Japan

Appropriate evaluation is important for R&D; especially evaluation of publicly funded R&D. Japan has “National Guidelines for Evaluating Government Funded R&D” which were established by the Prime Minister. The first guideline, which included evaluations of research institutes, R&D projects and researchers, was decided in 1997 based on the first Science and Technology Basic Plan, and had been revised based on the revised Basic Plan. Japan has introduced a The Plan-Do-Check-Act cycle (PDCA) in R&D management based on the guideline. The current guideline was decided in December 2012 based on the fourth Basic Science and Technology Plan[9].

The current version of the guideline further included program evaluations of program-projects management and follow-up evaluations on R&D projects. Background to this amendment was that the fourth Science and Technology Basic Plan has incorporated a new policy perspective that calls for promoting the entire process of innovation—from R&D to application—in an integrated manner. This marks a shift from the conventional "R&D seeds-push" approach, which focuses on the incubation of R&D seeds, to a "problem-solving" approach. (Reference: Hata, Shigenori (2013), “The Significance of the Revision of the National Guidelines for Evaluating Government Funded R&D”[10])

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9 http://www8.cao.go.jp/cstp/english/doc/2012_nationalglfor_eval_gov_funded_rd.pdf
10 HP of RIETI.: http://www.rieti.go.jp/en/columns/s13_0007.html?stylesheet=print

Brief history of policies for commercialization of public R&D results and five current measures of them

Although only the recent situation was mentioned above, commercialization of government funded R&D has a long history. MITI (Ministry of International Trade and Industry, the predecessor of current METI) had made an effort to improve industrial technologies for advanced industrial structures as a part of the industrial policy. MITI had national research institutes (the predecessor of current AIST), and they conducted tests on products of Japanese companies and technological consultation, including advice on the introduction of foreign technologies after World War Ⅱ. In the 1960's, MITI changed its policy to encourage Japanese companies to carry out R&D themselves. Therefore, MITI initiated the program for large-scale national R&D projects with the future vision of each industry in 1966. National research institutes under MITI led R&D for industries, and contributed to make an R&D plan for national projects. Although, companies were to take out the core of these R&D projects, they utilized the results of basic research in the knowledge pool, and cooperation from national research institutes and universities took place. From then, commercialization of R&D outputs became an important challenge for MITI.

Until the 1980s, the MOE (Ministry of Education) promoted universities' research for universities, and STA (Science and Technology Agency) promoted R&D for science and technology, and these results were put into the knowledge pool. MITI identified promising results from the pool and used them in national R&D projects targeted for industries. Thus, the purpose of MOE, STA and MITI were deferent and separated, however their R&D were loosely linked through the pool of knowledge.

After 1996 when the first Science and Technology Basic Plan was established, the MOE, STA and MITI had strong cooperative relations with increasing importance of Public-Private Partnership. In 2001, MOE and STA were integrated, and became MEXT (Ministry of Education, Culture, Sports, Science and Technology). Now, MEXT has a strong interest in the use of results of their R&D for innovation, and a strong cooperative relationship with METI through the university-industry partnership policy and also the management of R&D projects. They carry out their policies to consciously strengthen the ties between R&D and innovation.

Considering the above history, five policy measures were selected which are important for commercialization of public R&D results:

1. National R&D projects by NEDO
2. Bridging function of national research institute: case of AIST
3. Public-private partnership policy
4. Funding Program for PPP: A-STEP Program by JST
5. Promotion of start –ups from universities: START Program by JST

Summary

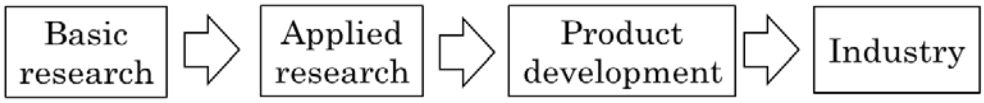
Commercialization of government funded research is sometimes examined based on the linear model of innovation shown in the Bush report in 1945[11], and became a fundamental model of innovation. The model suggests investing in basic research which enables new industries in the future through applied research. However, a counter-argument occurred in the 1980's, where many cases showed that basic research results does not lead to the success of business in the 1970's and 1980's. S. J. Klein examined the product development process in the automobile industry, and proposed the "Chain linked model", which stated that the actual innovation process began with the identification of an unfilled market need and there many feedback loops[12]. D. E. Stokes insisted the existence of use-inspired basic research which is "Pasteur type", and proposed the Stokes' model[13]. Now, many innovation researchers refer to this model, and Pasteur type of research is highly reviewed as important for innovation.

[11] "Science The Endless Frontier", A Report to the President by Vannevar Bush, Director of the Office of Scientific Research and Development, July 1945

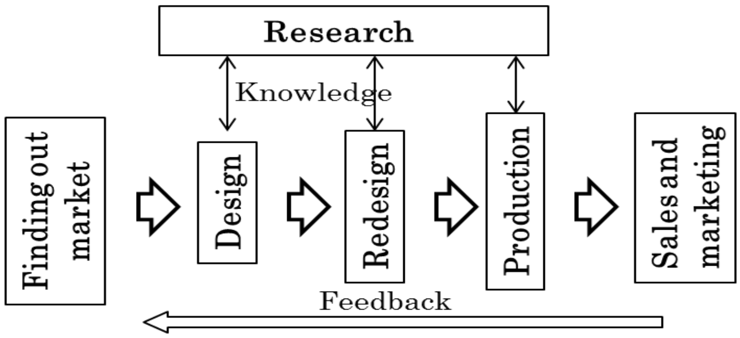
[12] Kline (1985). Research, Invention, Innovation and Production: Models and Reality, Report INN-1, March 1985, Mechanical Engineering Department, Stanford University.

[13] Donald E. Stokes (1997), Pasteur's quadrant Basic science and technological innovation, Brookings institution press, Washington D.C.

a) Linear model



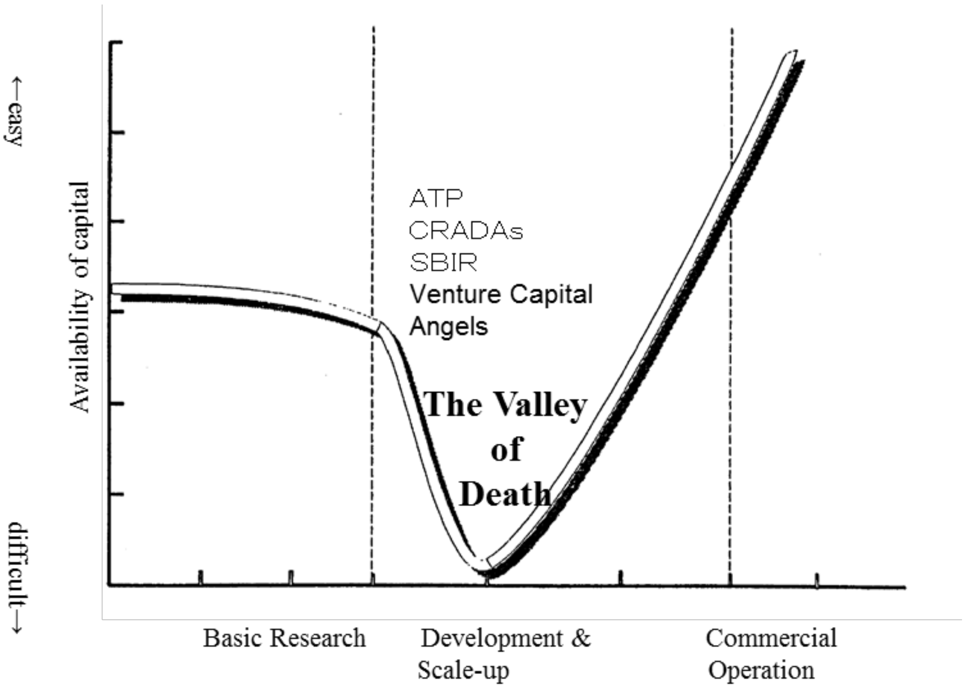
b) Chain linked model (Klein's model)



c) Stokes' model

		Consideration of use?	
		No	Yes
Quest for fundamental understanding?	Yes	Pure basic research (Bohr)	Use-inspired basic research (Pasteur)
	No		Pure applied research (Edison)

Innovation has a variety of processes and the above three innovation models show different aspects in relation to science, technology and innovation. First, the linear model, which has been criticized for several years, is still sometimes used. For example, the figure for "The Valley of Death" in the innovation process, which was argued by NIST (the National institute of Standards and Technology in U. S.) and Prof. L. Branscomb, seemed to be based on the linear model. The knowledge was expected to flow from basic research to innovation through application, although the flow is never automatic. Because this flow is never automatic, government funded research does not always lead to innovation.



Source: NIST (National Institute of Standards and Technology)

Another related theory is the argument of the "National Innovation System". It explains the reason why innovation occurs easily in some countries, and is difficult in other countries, and discusses the importance of policies to facilitate innovation. Many researchers such as Freeman, Lundvall and Nelson argued this theory and the OECD conducted many surveys with member countries[14]. Several countries introduced a legal system such as the Bayh-Dole Act and strengthened patent law with the model of Silicon Valley. However, many countries could not have their own Silicon Valley, and specific policy measures are needed based on the situation of each country.

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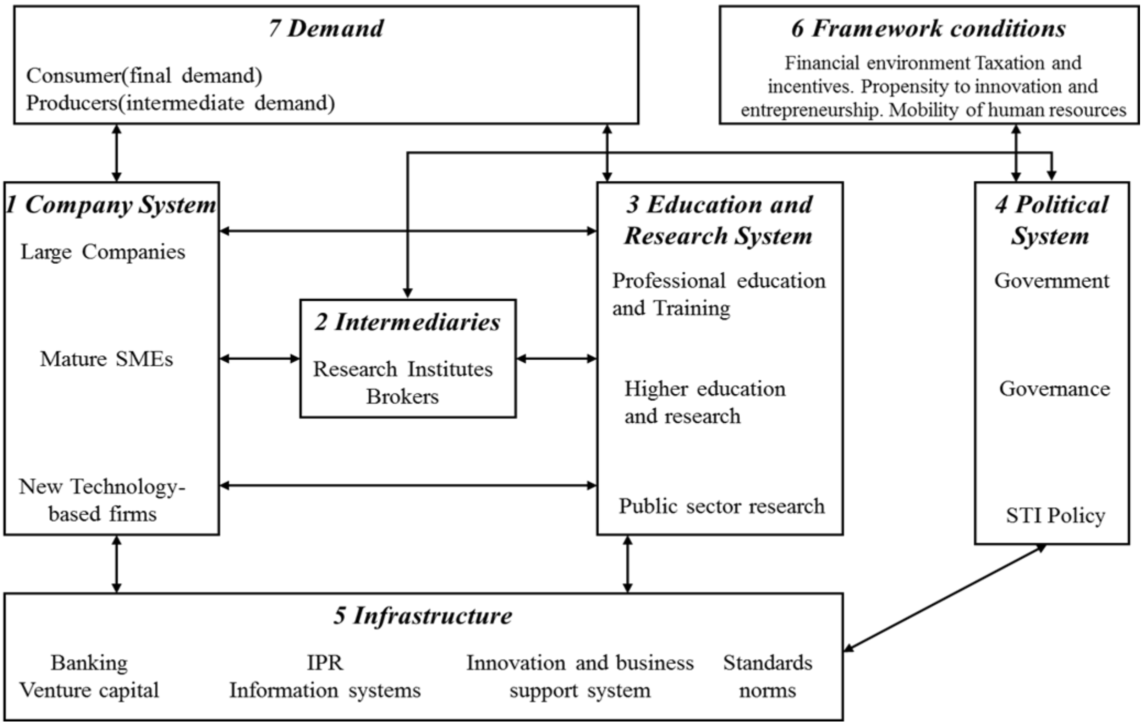
[14] Freeman, C. (1995), "The National System of Innovation in Historical Perspective", Cambridge Journal of Economics, No. 19, pp. 5–24
Lundvall, B-Å. (ed.) (1992). National Innovation Systems: Towards a Theory of Innovation and Interactive Learning, Pinter, London.
Nelson, R. (ed.) (1993), National Innovation Systems. A Comparative Analysis, Oxford University Press, New York/Oxford.
Patel, P. and K. Pavitt (1994), "The Nature and Economic Importance of National Innovation Systems", STI Review, No. 14, OECD, Paris.



Source: OECD W/S in Oslo in 2003

Measures for commercialization of public R&D results

National R&D projects by NEDO

Introduction of NEDO and National R&D Projects

NEDO（New Energy and Industrial Technology Development Organization）is an independent administrative institution under METI (Ministry of Economy, Trade and Industry), and its main activities are funding and managing national R&D projects (NEDO projects). Number of staff is about 800, and its budget is about 131.9 billion yen (2015FY). Almost all income is supported by METI.

Its mission is as follows[15].

a) Addressing energy and global environmental problems

NEDO actively undertakes the development of new energy (e.g., photovoltaic, wind power, biomass and waste, geothermal power, thermal utilization and full cells) and energy conservation technologies, verification of technical results, and introduction and dissemination of new technologies (e.g., support for introduction). Through these efforts, NEDO promotes greater utilization of new energy and improved energy conservation. NEDO also contributes to a stable energy supply and the resolution of global environmental problems by promoting the demonstration of new energy, energy conservation and environmental technologies abroad, based on knowledge obtained from domestic projects.

b) Enhancing industrial technology

With the aim of raising the level of industrial technology, NEDO pursues research and development of advanced new technologies. Drawing on its considerable management know-how, NEDO carries out projects to explore future technology seeds as well as mid- to long-term projects that form the basis of industrial development. It also supports research related to practical application.

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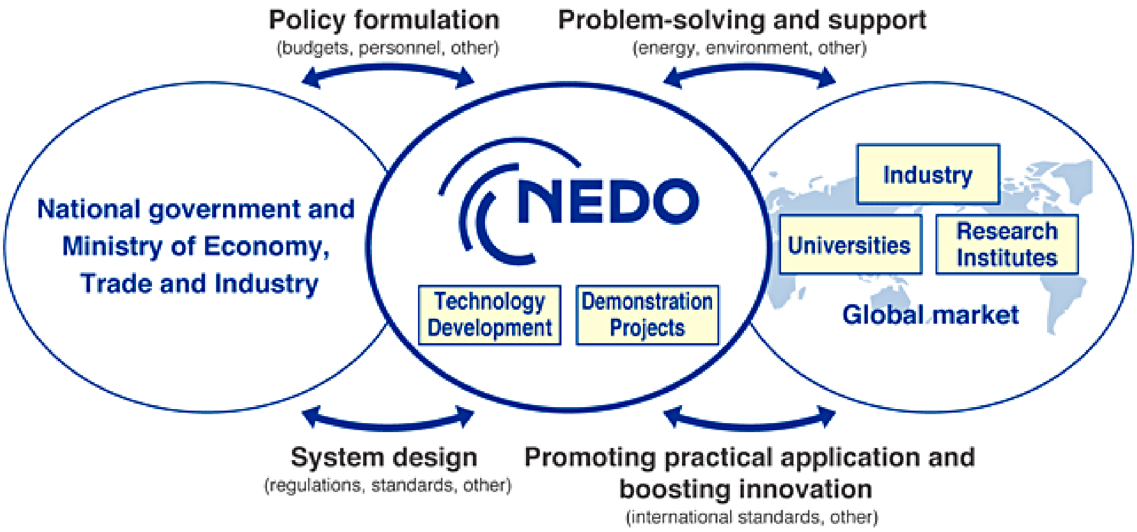
[15] From HP: http://www.nedo.go.jp/english/index.html



For these missions, NEDO is funding and managing 64 national R&D projects because development of some technologies are high risk and are difficult to be developed by private companies only. To implement these national projects, NEDO itself does not employ researchers, but involves companies, universities and national institutes which have a high level of technologies and research capabilities. The total budget of 64 national projects is 121.5 billion yen (2015FY), which is 92.1 per cent of total budget of NEDO.

(2) Bridging basic research to practical R&D by national projects

Public research in universities is mainly basic research for fundamental understanding. Some universities produce technology seeds, or suggestions for further research and problem solving. However, they are usually fragmented, need to be assembled with other technologies, and needs time and risky development processes for commercialization. National R&D projects which have technological targets form some element technologies for the target, and are conducted with a large budget over a 5-10 years term. R&D teams also consist of universities, industries and national institutes and have the characteristic of translational research from basic research to practical R&D.

National R&D projects need specific management for their success, which is different from management for basic research or commercial development. Therefore, NEDO has developed its own management style. Specifically, NEDO conducts 4 stages of management from pre-projects through to post-projects, and bridging from basic research to practical R&D.

1st Stage: Information collection and technology road mapping

NEDO collects information in many technology fields globally and NEDO makes technology road maps for projects planning.

2nd Stage: Planning national R&D projects

NEDO makes a plan of national R&D projects by looking ahead 5-10 years, including target setting by interviews with many experts and a technology survey.

3rd Stage: Conducting national R&D projects

NEDO builds R&D teams consisting of companies, universities and national institutes, and manages national R&D projects including modifying the R&D plan based on changing of circumstances.

4th Stage: Review and follow-up surveys

NEDO conducts external evaluations on each national R&D project at the end, and follow-up surveys thereafter. Thereby, NEDO conducts the PDCA cycle and improves their management capability.

Additionally, NEDO upgrades management capabilities of staff. It employs not only new graduates from universities or graduate schools but also mid-career engineers from companies. Staffs improve management capabilities by on the job and in-house training.

(3) Research result of NEDO

Research funded by NEDO produces many academic papers and patents. Although they are important, NEDO takes a serious view of commercialization from research results. Research results are expected to be commercialized by companies that are involved in national R&D projects through the process of in-house commercial development after NEDO projects.

NEDO has a 30 per cent target rate of commercialization. The actual result was 36 per cent in 2009FY, stating the rate of commercialization from questionnaire survey to 1,600 companies. This shows that NEDO achieved its target for this period.

Examples of commercialized research:

a) Solar power generation which was commercialized by many Japanese companies
   MITI and NEDO have conducted many long-term projects for high-efficiency solar power generation technologies, including basic research.
b) Railcar traction inverter commercialized by Mitsubishi Electric
   Power consumption reduced by 38.6per cent by using the world's first SiC power module.
c) FeRAM commercialized by Fujitsu
   NEDO has developed many semiconductor technologies. This is one successful result.
d) Residential Fuel Cell System commercialized by Osaka Gas
   Results of an R&D project of High-efficiency Solid Oxide Fuel Cells were commercialized and is disseminating now.

(4) Evaluation

All independent administrative institutions have mid-term plans and should be evaluated by external committees in Japan. NEDO has been evaluated by a committee under METI, "Independent Administrative Institution Evaluation Committee", annually. (This changed this year, and the Minister of METI will evaluate NEDO from 2016 onwards.) An evaluation report on NEDO in 2013 says "NEDO has a good management system, from seeking technology seeds to conducting national R&D projects" "It can be assessed as very good in that the commercialization rate of NEDO is 36 per cent which exceeds the target of 30 per cent". The committee gave NEDO an "A" in evaluation points of S, A, B and C. Thus, NEDO received a good evaluation.

Additionally, NEDO itself conducted an evaluation of "Cost-Effectiveness" of NEDO projects. The results suggest that national R&D projects have economic effects more than 30 times of their costs as shown below[16].

[16] Detailed information and examination is shown in following paper.
Yamashita, M., Yurugi, Y., Shishido, S., Yoshida, T. and Takeshita, M. (2013):"Impact evaluation of Japanese public investment to overcome market failure review of the top 50 NEDO Inside Products", Research Evaluation, Vol.22, pp.316-336.

Table: Cost-effectiveness of NEDO Projects

(units: 100million yen)

	NEDO Budget Outlay		Sales Performance		Future Sales Forecast (total from 2013 to 2022)
	Project Costs Per year	Cumulative Project Costs	Most Recent Sales Per Year(2012)	Cumulative Sales After Release (up to 2011)	
Solar Power Generation	58	1,735	13,131	78,466	215,735
Gas Turbine	35	532	3,037	14,697	45,441
Residential HP Water Heater	12	154	3,740	17,672	44,040
Residential Fuel Cell	49	880	350	652	21,840
Wind Power Generation	4	85	1,218	7,346	17,774
Blue-ray Related Product	12	61	1,633	17,508	17,419
Coal Thermal Power, Power Generator, Geothermal Power	72	827	79	4,136	3,633
Semiconductor, Electrical Component	34	249	4,804	28,713	88,396
MEMS	18	250	486	1,760	10,126
High-Performance Ceramic	5	123	945	105	1,050
Waste Power generation, Furnace	19	143	495	4,448	5,235
High-performance Industrial Furnace	11	80	17	886	1,063
Automotive Sector	14	70	642	956	48,482
Wastewater Treatment, Soil Washing	11	61	420	3,288	7,271
other	-	2,363	5,395	56,766	162,874
Total	-	7,613	36,392	237,399	690,379

From NEDO brochures "NEDO PROJECT SUCCESS STORIES"[17]

(5) Explanation and comments by the report author

Success of the semiconductor industry is famous in the history of MITI's policy. The success was based on the national R&D project conducted by MITI. Now, the program for national R&D projects has been transferred to NEDO. Basic research and practical R&D are combined in every NEDO project for future commercialization. Knowledge transfer from the public sector to the private sector also occurs in terms of national R&D projects, which is usually 5-10 years. This measure is successful in Japan.

On the other hand, there were many arguments on what type of projects should be supported by public funds, such as whether basic research or applied research should be a focus of public funds? And whether long-term or short-term projects are important? Now, many stress the importance of projects with clear exit and implementation strategies including fundamental understanding, which is "Pasteur type". Regarding the rate of commercialization, it depends on the characteristics of the projects and whether

[17] http://www.nedo.go.jp/english/publications_brochures_index.html

they are high risk or not; calculating the rate of commercialization is not simple.

I would like to stress the importance of management, as many NEDO staff have mentioned. Success of national R&D projects depends not only on the amount of funds but also on management. Especially, project planning is thought to be key to management, information collection and follow-up surveys are also important for the base of management.

Moreover, there may be an “effect of NEDO”. Collaboration among companies may be easier in NEDO projects. One NEDO employee, whose name is Dr. Yoshida, pointed out this effect based on his experience with companies. This effect would be very important in the age of “open innovation”.

Bridging function of national research institute: AIST

(1) Introduction of AIST

AIST (National Institute of Advanced Industrial Science and Technology) was established in 2001 as an independent administrative institution by aggregating 15 research institutes within MITI. The mission of AIST is “to promote economic and industrial development, and to secure a stable supply of resources and energy”, and does this by “pursuing mining and manufacturing industry development, conduct geological surveys, set measurement standards, offer technological support, disseminate research results, and develop human resources that can help strengthen technology management capabilities[18]. It focuses on the creation and practical realization of technologies useful to Japanese industry and society, and on “bridging” innovative technological seeds and commercialization outcomes.

AIST is one of the largest public research organizations in Japan. It employs 2,255 researchers and 398 postdoctoral or visiting researchers, and accepts 4,598 external researchers from companies and universities. Thus, collaboration with industry and academia is conducted in research bases of AIST. Revenue of AIST was 94 billion yen in 2013. METI supports 70.5 billion yen (75 per cent), and NEDO funds 13.2 billion yen (14.0 cent) for NEDO projects conducted by AIST. Thus, 89 per cent of AIST budget is covered by public funding.

[18] From AIST’s brochure: https://www.aist.go.jp/en_digbook/aist_pamph/book.pdf

AIST has 22 research institutes and 20 research centers in 7 technology fields, which are a) energy and environment, b)life science and biotechnology, c) information technology and human factors, d) material and chemistry, e) electronics and manufacturing, f) geological survey and g) metrology. These research organizations are located in 10 research base across Japan. The most large research base is “AIST Tsukuba”.

- Researchers (foreign nationals) 2,258 (96)
  - [Permanent] .... [1,928]
  - [Fixed term] .... [330]
- Administrative employees (foreign nationals) 675 (1)

Total number of employees: 2,933 (97)

- Executives (full time) 13
- Visiting researchers 159
- Postdoctoral researchers 200
- Technical staff 1,441

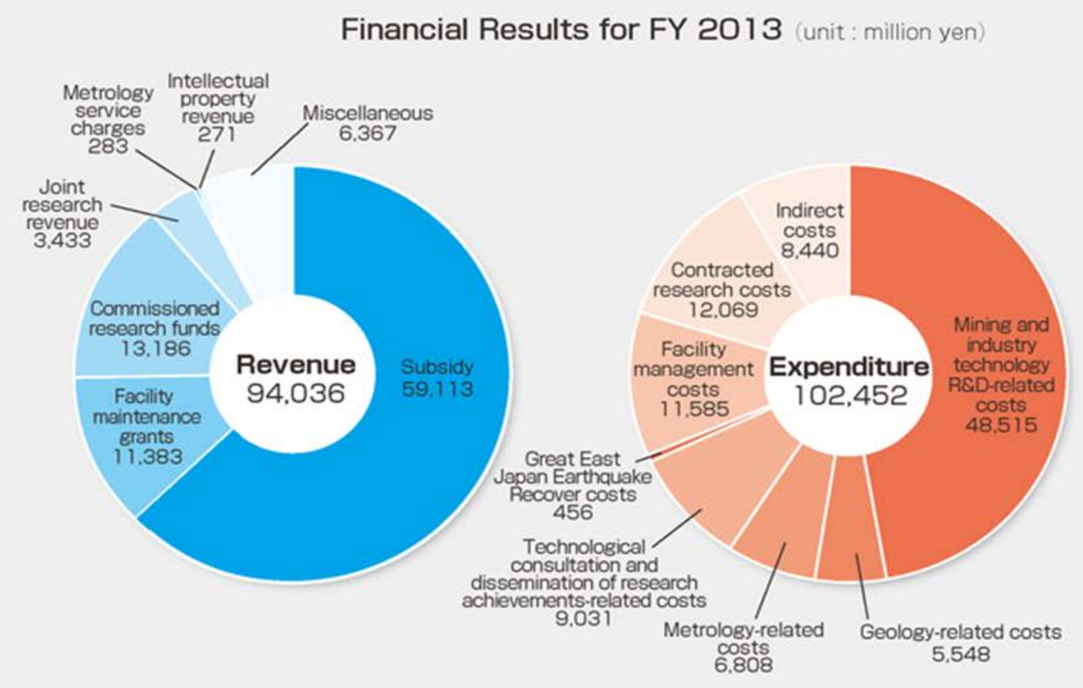
(As of April 1, 2015)

Number of researchers accepted through industry/academia/government partnerships

- Companies 1,774
- Universities 1,852
- Other organizations 972

(foreign nationals :426)

(Total number of researchers accepted in FY 2013)



Notes 1: Total may not become 100 % due to rounding off.
Notes 2: The amounts of revenue and expenditure are adapted from "Financial Statement" prescribed in Article 38 of the General Rule Act for Independent Administrative Corporations. The expenditure outreaches the revenue as we carried forward the balance of previous years.

Employees of AIST have the basic principle that they pursue “full research” that integrates all stages of research, from basic to production, in order to meet the needs of the economy and society. Therefore, employees of AIST establish an AIST charter as follows.

CHARTER

***Full Research* in Society, for Society**

The common goal of humankind is to achieve a society in which every person can enjoy a comfortable life. Science and technology can lead the way to such a society. The mission entrusted to AIST and its staff, as members of the scientific community, is to develop science and technology that complements society and the environment.

We, the staff members of AIST, recognize our mission and responsibility is to work towards achieving such a society through research and development in industrial science and technology.

- **Accurate Assessment of Social Trends**

We endeavor to ascertain social trends and needs at every level of society from local communities to the international stage, identifying key issues promptly to propose scientific and technological solutions in collaboration with other organizations.

- **Creation of Knowledge and Technology**

We value each person's autonomy and creativity and display our collective strength through collaboration and synergy, developing knowledge and creating new innovative technology based on advanced research efforts.

- **Application of Research Findings**

We contribute to Japan's industrial development by applying our research findings to academic pursuits, intellectual infrastructure development, technology transfer, and policy proposals. We endeavor to enhance and disseminate science and technology through human resources development and the open sharing of information.

- **Responsible Conduct**

We are actively involved in improving our own abilities and our working environment in order to perform our duties more effectively. We respect both the letter and the spirit of the law and maintain a strict sense of ethics in all our affairs.

(From HP of AIST: https://www.aist.go.jp/aist_e/about_aist/charter/charter.html)

(2) Method to bridge results of basic research to industry by AIST

AIST has a strategy for promoting innovation and is reinforcing this through the implementation of an open innovation hub. It says "AIST plays a central role at the open innovation hub, and in collaboration with government-industry-academia applies its human resources in various research fields, leading-edge infrastructures, accumulated research findings, systems for technology fusions, personnel training and regional research bases and their networks." AIST aims to deliver on the strategy in the following 3 stages to reinforce the functions of open innovation hub.

Stage 1: Creating Promising Seeds

- Development of function of utilizing research achievement
- Gathering and development of talent

Stage 2: Developing Outstanding Technologies

- Enhancement of collaboration with industry
- Promotion of open innovation in regions
- Reinforcement hub function by internationalization

Stage 3: Establishing Paths to the Market

- Preparation of strongholds
- Enhancement of networks with industry[19]

Open innovation hub is Tsukuba's Innovation Arena for Nanotechnology (TIA-nano). This is a global nanotechnology research and education complex under the leadership of AIST, NIMS (National Institute for Materials Science), Univ. of Tsukuba and KEK (High Energy Accelerator Research Organization) with the support of Keidannren (Japan Business Federation) in Tsukuba city.

Research at AIST is reviewed flexibly based on the stage of R&D. There are two types of research units a research center and a research institute. They are explained as follows.

Technology-seeds established in a research institute are further developed by -scale R&D in a research center, and transferred to industries.

[19] (From brochure "AIST –Organization and Outline-" p7) https://www.aist.go.jp/pdf/aist_e/pamphlet/organization_outline_e_201409.pdf

AIST has research supporting administrative departments, which help research units to achieve AIST missions.

(3) Example of research results

AIST has produced many outcomes that contribute to industry. Examples include:

a) Ceramic coating by Aerosol Deposition Method in Room Temperature (Aerosol deposition method)

Dr. Akedo developed an aerosol deposition method for ceramics coating without the baking process, utilizing an ordinary temperature shock compaction phenomenon. TOTO put this coating technology into practical use in semiconductor manufacturing apparatus in 2007. Other companies are also currently examining its commercialization.

b) Mass-production of single-wall carbon nanotube; “Super Growth Method”

A revolutionary method to synthesize single-wall carbon nanotube, which was named “Super Growth Method”, was developed by Dr. Hata. Its synthetic efficiency is 1,000 times higher than previous methods. The quality of single-wall carbon nanotube when synthesized using this method is high in purity. Zeon conducted joint research with Dr. Hata and is constructing a new factory for mass production.

c) Magnetic tunnel junctions (MTJs) for magnetic head and MRAM (Spintronics field)

Dr. Yuasa developed magnetic tunnel junctions (MTJs) using magnesium oxide (MgO) which had a giant MR ratio up to 180per cent at room temperature. He had joint research with Canon Anelva for mass-production of that device. Canon Anelva commercialized a magnetic head of hard disk drive (HDD) using the device in 2007. Additionally, he had joint research with Toshiba for developing magnetoresistive random-access-memory (MRAM), and Toshiba started the sample shipping in 2014.

Research centers are limited-term (typically 7 years) organizations with clear goals. Research resources of AIST, such as budget and personnel, are strategically distributed, and research centers have priority to the resources.

Research institutes are bottom-up organizations. Research institutes aim to keep continuity of operation to implement mid- and long-term strategies of AIST. Research institutes are also expected to maintain technical potential of AIST and to develop new fields of technology.

(From AIST’s HP: http://www.aist.go.jp/aist_e/about_aist/organization/index.html)

d) Drag discovery assistant robot “Mahoro”

Due to the workload in experiments for drag discovery increases, and dangerous circumstances such as virus risks, a robot substitution is necessary. Dr. Natsume, who is a researcher in the biotechnology field of AIST, developed robot “Mahoro” which has movement instruction interface with Ysukawa Electric. This robot can perform tasks with far more accuracy and reproducibility than experienced lab technicians. Ysukawa Electric commercialized this robot in Dec. 2011.

e) Research Center for Compact Chemical System

Research Center for Compact Chemical System set up consortium "Clayteam" with 47 private companies to develop the new use of “bentonite” a clay produced abundantly in the Tohoku district. It succeeded in the development of the clay film which is superior in the heat-resistant and gas-barrier characteristics. This clay film was commercialized in 2006, and used as a substitute for asbestos.

(4) External evaluation on AIST and introduction of a new indicator for evaluation

AIST has been evaluated by the committee under METI, “Independent Administrative Institution Evaluation Committee” annually as well as NEDO. The evaluation report on AIST in 2013 says “AIST, as national core research institute, is producing excellent results”, “It has world first results which are highly practical in each field” and “There are many research units or research themes which exceed the annual plan in both the quality and quantity of research results”. The Committee evaluated AIST with an “A” in evaluation points of S, A, B and C. Thus, AIST received a got good evaluation.

In spring 2015, the Japanese government is proposing changes to the evaluation system of AIST. AIST had introduced a new numerical indicator and target that increased AISTs income by 15 per cent, exceeding the total revenue forecast for the next five years and triple previous years.

(5) Interview to a policy maker: Dr. Yasunaga

An interview took place with Dr. Yasunaga, Vice-President of AIST. He explained why AIST is successful in bridging to industries. Examples below:

AIST has achieved excellent results that are useful for industries, such as SiC, carbon nanotube, spintronics, and aerosol deposition.
Dr. Yuasa's success in spintronics field shows the characteristic of AIST's research. Selection of the material of tunnel barrier in magnetic tunnel junctions (MTJs) is key for large magnetoresistance (MR) ratio. Although aluminium oxide has been used, Dr. Yuasa didn't choose it, because it has a limited magnetoresistance ratio of up to 70per cent. Although magnesium oxide (MgO) was known theoretically to have a large MR ratio, no one can make MTJs with MgO. Dr. Yuasa selected MgO in early stage of his research. He manufactured his own vacuum film forming apparatus for MgO tunnel barrier in 2002, and made MTJs with MgO in 2003. The MR ratio was 180 per cent (MR ratio of aluminium oxide is 70 per cent). R&D has expanded, and Dr. Yuasa is the head of Spintronics Research Center, and his capability and the characteristics of AIST have contributed to this success. Dr Yuasa conducted R&D thinking about a manufacturing process. That is the reason why he manufactured film forming apparatus. A characteristic of AIST is to keep a close eye on engineering as well as pure physics.

The development of the aerosol deposition method (the AD method) for ceramics coating driven by Dr. Akedo was seen as a challenge many. He was continuing R&D on ceramics coating to make a micro-actuator with ceramics. Naturally, it is common sense to bake ceramics. Ceramics coating also should be baked for tight gluing. However, he came across an accidental product. In 1994 Dr Akedo sprayed fine ceramics particles on a substrate in a vacuum without baking it, and found little ceramics were close together on the end of the substrate on the next morning. He found this was a new coating method, although nobody trusted (in an academic society) that ceramics were made without baking. He worked on its application and a study to elucidate its mechanism which is important for this technique to be trusted, and for seeking optimum as the industrial technology. He proofed an ordinary temperature shock compaction phenomenon in 1999. He started joint R&D with 6 companies in a national project funded by NEDO in 2002. An aerosol deposition method developed by him is now commercialized. He points out that it is important to get back to basic research whilst continuing to use applied research as both are like the mutual amplification.

An activity of the intermediation by AIST played an important role in the success of the single-wall carbon nanotube (CNT) by Dr. Hata. CNT had a ‘boom’ more than ten years ago, but it was multi-walled CNT that was cheap, but had low performance. Dr. Hata thought that single-walled CNT that performed well was necessary for industry, and developed “Super Growth Method” of single-wall CNT in 2004. Dr. Yumura, (a senior researcher with great achievements) collaborated with a young Dr. Hata, to find an appropriate business partner that had serious intention for practical use of single-wall CNT. He then found Zeon, Zeon conducted joint R&D seriously, and worked with AIST to build a pilot plant. Now, Zeon is constructing a new factory for mass-production. Basic research and applied research were both involved in this example. Finding a good partner contributed to its success.

As shown in the above three examples, AIST has traditionally let excellent researchers conduct R&D freely for industries. AIST acknowledges the research sites, as a matter of course for research institute, and senior level individuals act as role models for bridging the research and industries.

(6) Explanation and comments by author

Originally, AIST had 15 MITI (the Ministry of International Trade and Industry) research institutes, which emphasize the history of Japan’s industry including electronics with a technical aspect. Today, AIST is expected to create new business based on basic research, because Japanese companies are necessary to expand the business in the world's first technologies. Therefore it is important that AIST bridges between basic research in academia and practical R&D in industries, and AIST has really achieved fruitful results.

The key to the success of AIST is to respect the independence of the individual researcher who shares AIST’s characteristic culture. This culture is shown very well in the “Charter” for all staff at AIST.

Researchers of AIST draw up national R&D project plans and suggest them to NEDO when they want to make the large-scale collaborative R&D using findings from basic research. If they succeed, they go outside of the research institute and develop their own research centers. Therefore, the organization structure is flexible. The number of external researchers from companies, universities etc. has increased and exceeds number of the researchers at AIST. Thus, many joint R&D are conducted in the site of AIST in open innovation hubs.

A weak point of AIST is the small amount of income from companies. AIST introduced a new ratio of income indicator this year. Although this indicator is for input to R&D, it would be related to the evaluation of AIST by industries. I expect AIST would reach this goal.

Public-private partnership policy

Public-private partnership policy in Japan

In 1996, Japan's government decided the first **Science and Technology Basic Plan** based on Science and Technology Basic Law established in 1995. The basic plan aimed to construct new systems for R&D to cope with the new era, including a cooperation and exchange system beyond public and private sectors.

Following this policy, Japan arranged its legal system for public-private partnership through leadership of METI and MEXT. The **TLO Act** (Act on the Promotion of Technology Transfer from Universities to Private Business Operators) was established in 1998, where METI and MEXT promoted the TLO (Technology Licensing Office) to provide subsidies etc. Seventeen TLOs were established based on this act until 2000FY, whose number became 47 in 2009. Moreover, Act on Special Measures Concerning Revitalization of Industry and Innovation in Industrial Activities, which included the Bayh-Dole clause, was established in 1999. This clause permits universities or public research institute to license their patents invented in R&D using public funds. However, partnerships between university and industry didn't progress very much with little mutual credibility in 1990's.

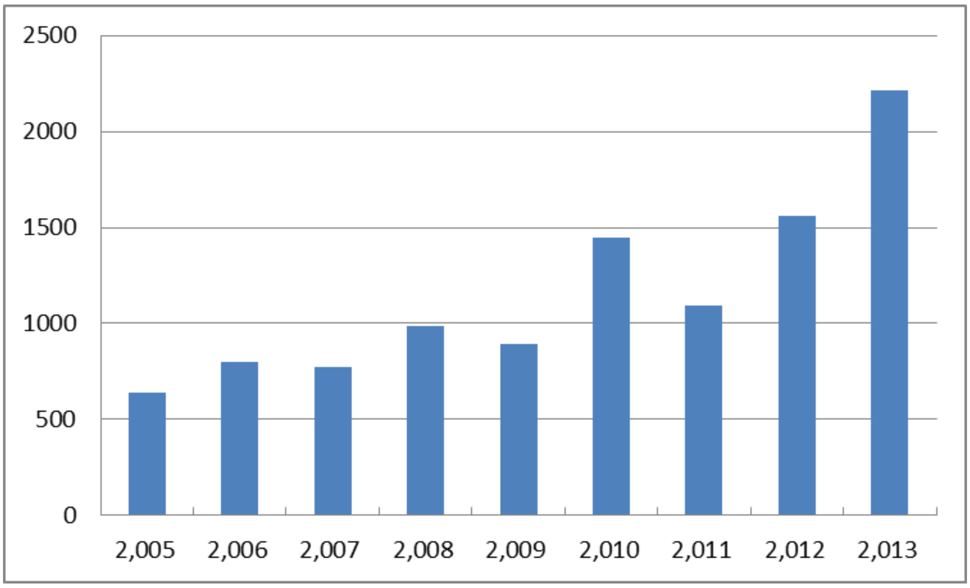
In 2001, CSTP (Council for Science and Technology Policy) was newly established in Cabinet Office of Japan's Government as a part of the reorganization of Japan's central government ministries and agencies. The second science and technology basic plan was also decided in 2001. That plan stressed the necessity of "restoration of R&D results to society through industrial activity", and the importance of public-private partnership as well as the first plan. Then CSTP hold a top-level meeting from universities and industries in Dec. 2001, and disseminated the importance of public-private partnership to them. CSTP also organized exhibition of research results of universities named “Innovation Japan”, whose organizer has been transferred to JST and NEDO. Through these efforts, credibility between industry and university was gradually enhanced, and partnership has progressed thereafter.

Several additional measures were also taken. MEXT carried out the program promoting universities to establish offices for the intellectual property, which manage the intellectual properties from the research of the universities, from 2003FY to 2007FY. 43 universities established the office based on this program. In 2004, national universities, which were part of MEXT’s organizations in the past, gained legally independent status as the national university corporations, increasing flexibility for partnership with industry. Additionally, MEXT amended the Basic Act on Education in 2006, and decided social contribution as the third role of university adding to education and research. Other measures were also carried out by MEXT, METI and ministries for technology transfer and collaboration between universities and companies. For example, METI provided subsidy to universities for building facilities to carry out joint research with companies under one roof. As a result, the number and amount of technology transfer and collaboration increased after 2001.

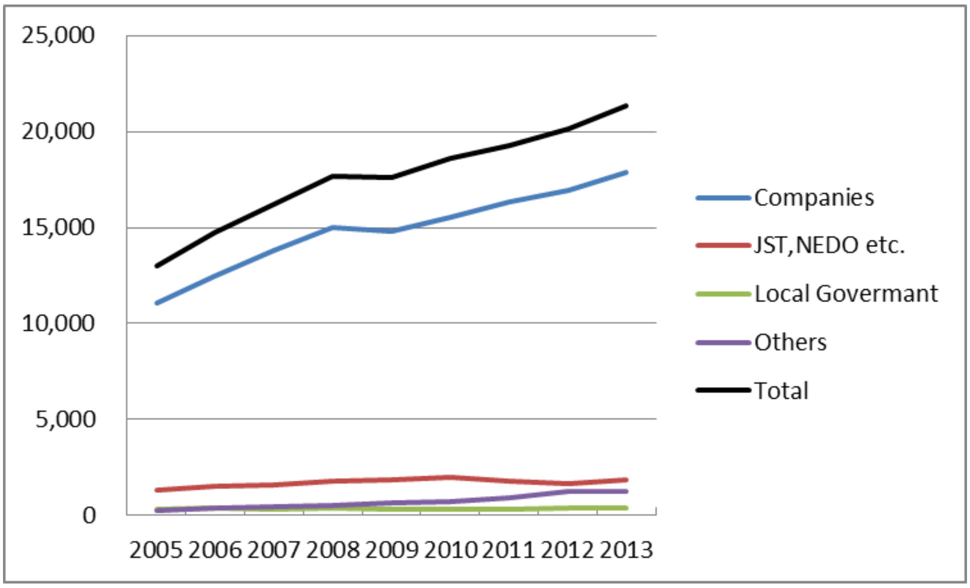
(1) Progress and current situation of Public-Private Partnership

The number of patents which universities possess increased 10 times for domestic patents and 7 times for overseas patents from 2005 to 2013. University income from licensing or transferring patents was 2.2 billion yen in 2013. This amount is 3.5 times that of the income in 2005 (6.4 billion yen). The income from joint research is 51.7 billion yen including 39.0 billion yen from joint research with companies. This has increased from 32.3 billion yen in total, with 24.9 billion yen in joint research with companies in 2005. Amount of income from contract research is 169.1 billion yen in 2013 which has increased from 126.5 billion yen in 2005; it includes 51.4 billion yen from Government, and 97.6 billion yen from JST, NEDO etc. and only 10.5 billion yen from companies. Then universities’ income from companies is mainly for joint research in Japan.

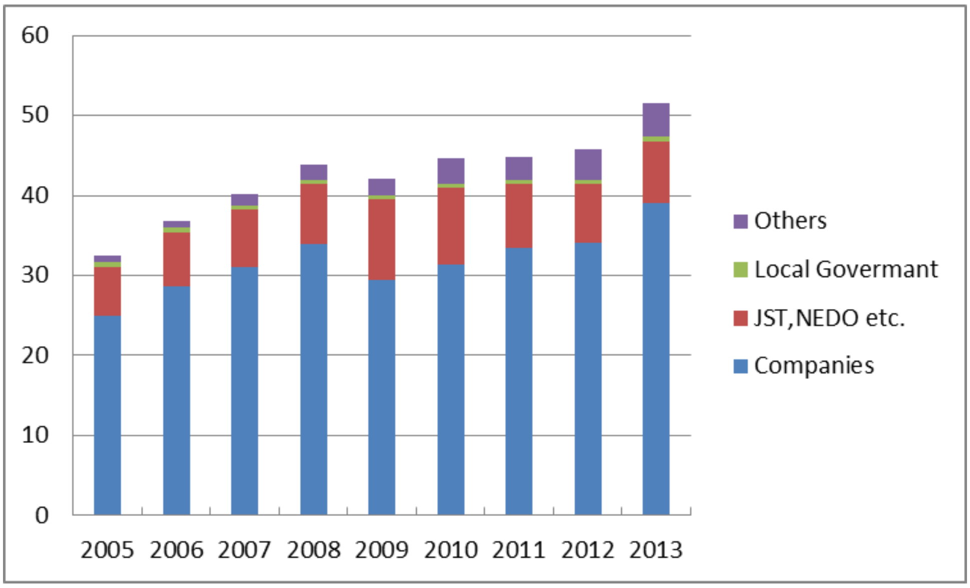
Amount of universities' income from patent enforcement (Million yen) including royalties and transfer fees of patents.



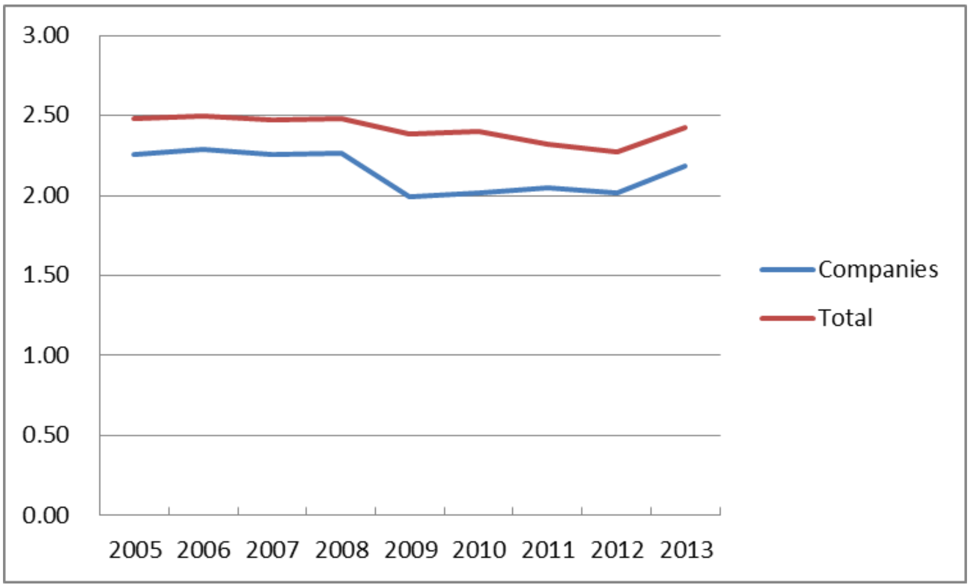
Number of joint research



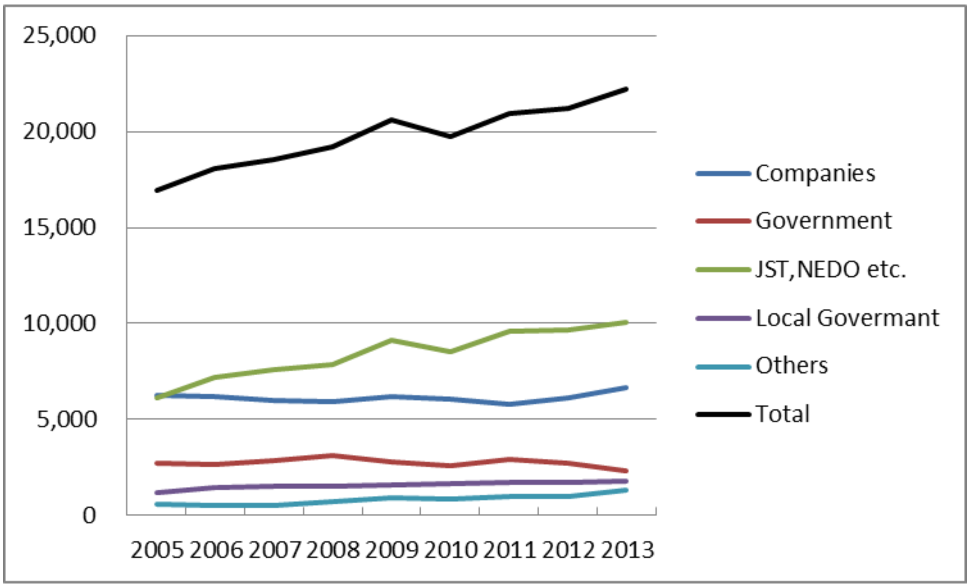
Amount of joint research (Billion yen)



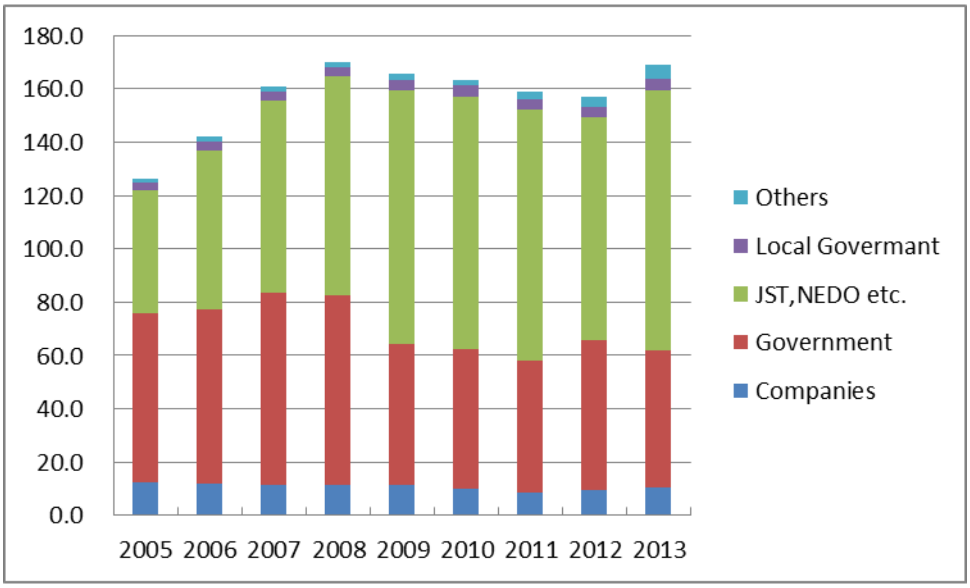
Average amount of joint research (million yen)



Number of Contract research



Amount of Contract research (Million yen)



Private-public partnership has progressed in Japan, especially by joint research between universities and companies. However, total income of universities from companies is 51.7 billion yen, and is very small (1.4 per cent) compared with R&D expenditure in universities which is 3.7 trillion yen before conversion to full-time account. The increase rate has not been high recently with the main cause being the average amount per one joint research is low, 2.2 million yen. Expanding this amount is the next challenge for Japan.

(3) **Next policy against universities for commercialization of results of their research －Interview with a Director of MEXT**

Interview with Mr. Sakamoto, Director University-Industry Collaboration and Regional R&D division, Science and Technology Policy Bureau, MEXT. He explained its policy as follows:

Universities use public funds, and as a result they should not conduct self-contained education and research for academia, and should pay attention to social receivers of their fruit. Therefore, MEXT has conducted institutional reforms for innovation, including developing TLO. The reason why contributions to society was decided as the third mission of universities is that creating social values should be grappled with systematically by universities, but not be the volunteer of individual universities' researcher. Specifically, MEXT has introduced a program promoting intellectual property offices in universities. The program deploys strategies for cooperation among industry academia and government, the program for universities' self-supporting system for industry-academia-government collaboration, and COI (Center of Innovation) program etc. Thereby, MEXT will associate technology seeds with industries depending on its' various phases.

For future direction, universities should expand the organizational cooperation; this means the organization of university vs. the organization of company as well as the cooperation between restrictive players within these organizations. Therefore, MEXT administers the COI program. Under COI, a university works together from the viewpoint to make a vision in the future of the companies. Moreover, they break down the vision into the future product, the method of the design, the technological target necessary for the vision and they make a team consisting of university and company researchers conducting R&D under one roof. In this way, as well as the technological problem of the company, universities are demanded to step into the stage of examining corporate strategy in the future.

The society does not highly evaluate the contribution of universities. Of course in late years the total amount of joint research has increased. However, the average amount per one joint research is still only 2 million yen. This is the same as the amount when companies use a university for the A-STEP trial program. Although Japanese companies pay a large amount of expense for joint research with overseas universities, the amount of expense for the joint research with domestic universities is small. Japanese companies explained this situation in “the COCN report” last March. It points out “Judging from consciousness of the industry, this situation is natural. An overseas university makes a proposal of R&D projects plan systematically based on their own analysis on the R&D theme necessary for the company. The university also makes a commitment on the results by taking the risk and employing new research staff if necessary. On the other hand, there are many cases for a company to fund the R&D when an individual university researcher wants to carry out joint research with Japanese universities. As a result, the difference in the scale of the amount occurs between such joint R&Ds.” There are the advanced cases in Japan. Osaka University has 37 “Joint Research Course”and 6 “Collaborative Research Centers”which carry out education also. These 43 units each require 30 million yen annually, and are reliant on funds from companies to operate. Osaka University wants to expand this system into 100 units, which is a similar scale to the Faculty of Engineering. The organization culture would be changed if this was realized.

In addition to research for elucidating phenomenon and systematizing the knowledge; and, research for the possibility to apply the scientific knowledge, which is difficult to carry out in the company’s research, universities are expected to perform the full-scale collaboration with companies.

Thereby, universities could excavate a new research theme and cultivate a new scientific field through the creative interaction between new collaborative research and traditional research. In this way, universities can develop by broadening its frontier through partnerships with private companies.

Professor Honda Kotaro said “Industry is a gymnasium for science”, based on his experience in scientific elucidation of magnet steel to develop KS magnet steel and created new science. The joint research course of Osaka University is the modern version of “a gymnasium for science”. They yield new research themes by thinking about problems of the industries 10-20 years after. Nagoya University has also founded similar research institutes. Universities need to introduce fund from industries in the future, because public funds could not be increased by the Japan’s financial situation.

For the future university-industry partnership, universities would need reform of mind set and the capability to manage the organization. For the management of universities, the intellectual property management and risk management would be needed. For risk management, managing conflict of interest, and prevention of leakage of technology would be required.

(4) Explanation and comment by author

Until the 1980's, universities didn't consider partnership with industry to be important in Japan, although some professors, especially in faculty of engineering, carried out joint research with companies. At that time, many faculties thought that universities' research should be non-profit, and secretariats of universities didn't support activities for partnership. That situation was changed by the first science and technology basic plan in 1996. For 10 years from 1996, Japan made an effort to introduce public-private partnership policies similar to foreign policy such as U.S. As a result, partnership with industry improved in those 10 years and the increase rate was relatively high.

However, in these 10 years, the increase rate slowed down, and indicators showed that the level of partnership were still much lower than the U.S. . Incomes of many intermediate organizations such as TLO (Technology Licensing Office) are small, and cannot cover their expenditure. Moreover many subsidies to support these organizations were terminated based on the original thought that partnership activities should be profitable.

Now, many relevant persons think that public-private partnership is not so easy, or that special management based on the situations of universities' research or location would be necessary. There would be some room for improving management in universities and intermediate organizations. Additionally, it is necessary to examine policy measures to promote the university-industry partnership more. The role of government, universities, companies and intermediate organizations should be considered carefully, including the thought that the partnership should be basically carried out by funds from private companies.

Funding Program for PPP: A-STEP Program by JST

(1) Introduction of JST and its A-STEP program

Universities use a large percentage of government expenditure for R&D promotion, and its research results are needed to contribute to society, through industry-university partnership. Therefore, **JST** (Japan Science and Technology Agency) implements the **A-STEP** (Adaptable and Seamless Technology Transfer Program through Target-Driven R&D) program used for the practical application of university research output.

JST is an independent administrative institution under MEXT (Ministry of Education, Culture, Sports, Science and Technology), and one of the core institutions responsible for the implementation of science and technology policy in Japan, including the government's Science and Technology Basic Plan. Revenue of JST is 106.6 billion yen including government subsidy which is 101.0 billion yen (94.8 per cent) in 2015 FY. JST explains its mission and visions as follows;

Mission:

We contribute to the creation of innovation in science and technology as the core implementing agency of the fourth phase of the Science and Technology Basic Plan.

Visions:

1. To achieve innovation in science and technology through creative research and development.
2. To maximize research outcomes by managing research resources on the virtual network.
3. To develop the nation's infrastructure for science and technology to accelerate innovation in science and technology.

(From HP of JST: http://www.jst.go.jp/EN/about/index.html)

For achieving this mission and vision, JST has several R&D programs focused on technology transfer. One of them is A-STEP program. This program supports industry-academia and collaborative R&D across a wide range of phases to develop commercial applications of research output generated by basic research in universities. Several types of funding are provided under this program, depending on the characteristics of each R&D phase. Its objectives are explained as follows;

Objectives of A-STEP program

This program supports collaborative industry–academia R&D based on the results of high-quality basic research (research output, IP, etc.) to ensure that the benefits of research are passed onto Japanese society. Depending on the R&D phase and objectives of each particular project, A-STEP determines the optimal R&D funding and R&D period to enable the seamless pursuit of medium- to long-term R&D. Through this approach, the program aims to bridge the gaps between academic research results and industry to realize highly effective and efficient innovation.

(From HP of JST: http://www.jst.go.jp/tt/EN/univ-ip/a-step.html)

(2) Operational information of A-STEP program

A-STEP program is a competitive funding program for promoting collaborative industry–academia R&D based on the research output and IP generated by basic research. JST selects R&D projects from many applications from academia, and supports the planning of them. Full-scale R&D stage can be separated to Stage Ⅱ and Stage Ⅲ. Then, abstract of 3 stages are as follows;

Table: Abstract of 3 Stages in A-STEP

		Stage Ⅰ	Stage Ⅱ	Stage Ⅲ
		FS Stage	Full-scale R&D stage	Full-scale R&D stage
Use		Verification of potential	Verification of practicality	Verification testing
Type of fund		Grant	Mutching fund funding to academia only	Some repayment etc. for success
Standard amount for one project		1.7 or 8 mil. yen	60-200 mil. yen	300-2,000 mil. yen
Number of approved projects	2012FY	1,247	46	6
	2013FY	868	49	8
	2014FY	484	40	1

Budget of A-STEP program is as follows.

		(Billion yen)
2013FY	2014FY	2015FY
14.7	12.7	8.1

Overview

Fields: All fields of natural science. A-STEP comprises 10 types of support at the feasibility study (FS) stage and the full-scale R&D stage.

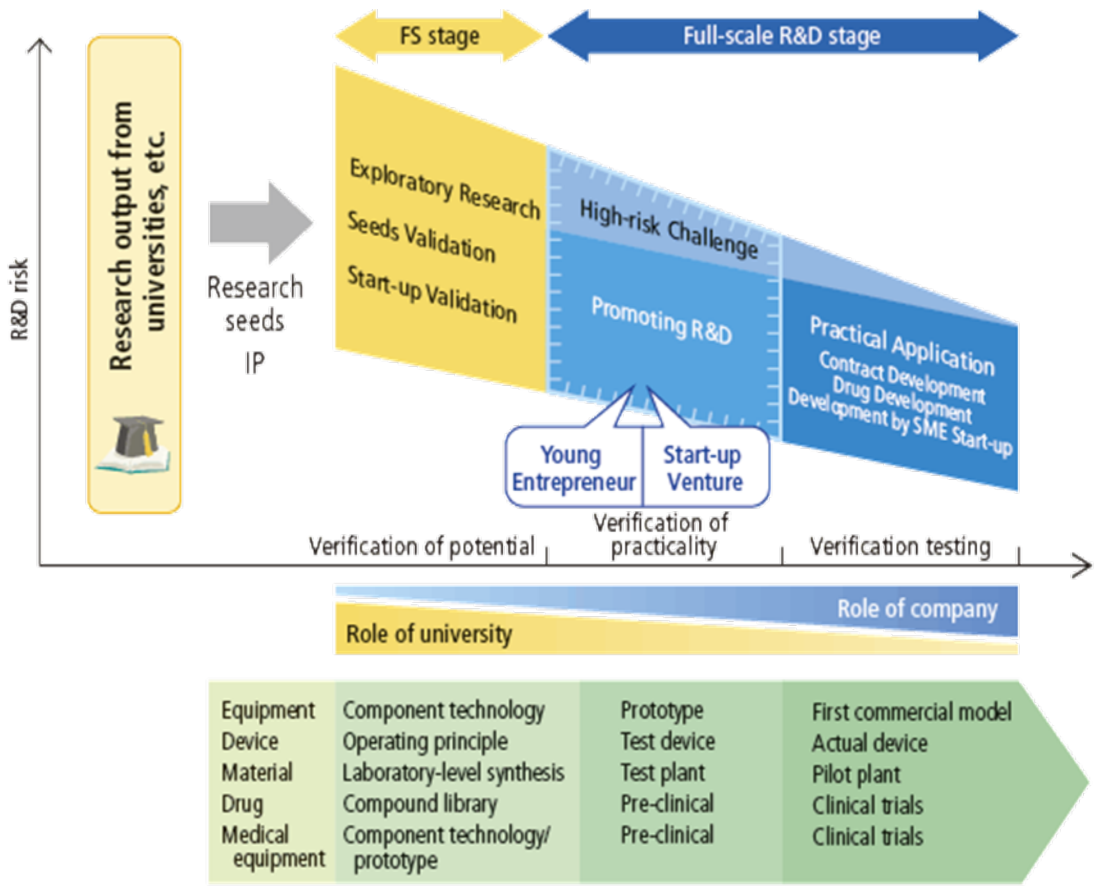
FS stage:

Investigation of technology transfer potential; validation of potential as a technology seed that will meet the needs of companies; and validation of potential to become the technology seed for a university-launched start-up company.

Full-scale R&D stage:

R&D in preparation for the establishment of a university-launched start-up venture that aims for the practical application of technology seeds; and R&D during the practical verification and testing phase through joint R&D by an industry–academia partnership.

(From HP of JST: http://www.jst.go.jp/tt/EN/univ-ip/a-step.html)



(From HP of JST: http://www.jst.go.jp/tt/EN/univ-ip/a-step.html)

Unique characteristics of A-STEP

•***One-stop support***

A-STEP unifies such functions as consultation services for universities and companies and front-office services for the receipt of applications. By contacting the A-STEP office, all relevant information can be acquired.

•***Seamless R&D support***

At the full-scale R&D stage, in which applicants may freely combine several types of support into one application, A-STEP provides seamless, medium- to long-term support through "stage-gate evaluation" whereby each type of post-evaluation and pre-evaluation for the next type are carried out together. This approach facilitates the pursuit of R&D that has produced strong results without having to reapply for further support. The system also helps us to provide a seamless connection between R&D output and further R&D, thereby enabling the rapid utilization of results.

•***Optimizing flexible R&D***

At the selection stage, in cases where it is judged that an earlier stage support type is preferable over the support type being applied for, it is possible to continue with selection based on a revamped plan and proceed to R&D execution in accordance with the advice of the evaluation board. This is designed to facilitate the creation of a flexible R&D environment in which researchers and companies are encouraged to boldly make their R&D plans as effective and efficient as possible.

(From HP of JST: http://www.jst.go.jp/tt/EN/univ-ip/a-step.html)

(3) Example of products

Product Name: Autologous Cultured Cartilage “JACC“

Development Company: Japan Tissue Engineering Co., Ltd. (J-TEC)

Product Information

J-TEC’s autologous cultured cartilage JACC also received the government approval in July 2012, and is listed as an item covered by the national insurance since April 2013. The therapeutic technique of autologous cultured cartilage transplantation was established by Professor Mitsuo Ochi of Hiroshima University, and the technique was transferred to J-TEC. A small amount of cartilage is taken from the patient’s knee, and cultured after having been mixed with atelocollagen gel and shaped into a three-dimensional form.

J-TEC is a bio-venture company, possessing all of the functions including research and development, regulatory development, manufacturing, sales, and post-marketing surveillance. J-TEC was founded in February 1999 on the premise to develop regenerative medicine based on tissue engineering, and is the only company in Japan with a QMS compliant facility capable of producing tissue-engineered medical products[20].

(4) Evaluation

JST has been evaluated by the committee under MEXT, which is the “Independent Administrative Institution Evaluation Committee”. The evaluation report on JST for mid-term period (2007-2011FY) is as follows:

“As a result of ex post evaluations on the 1,152 projects, 737 projects (64 per cent) were evaluated as ‘enough result was provided’ and this achieved the target (more than 50 per cent of the projects) in the mid-term plan”.

Year of ex post evaluation	2010FY	2011FY	Total
Number of evaluated projects	148	1,004	1,152
Number of projects which evaluated as “enough results was provided”	86 (58 per cent)	651 (65 per cent)	737 (64 per cent)

[20] From HP of JST: http://www.jst.go.jp/tt/EN/univ-ip/products.html

(5) Explanation and comments by author

There were various programs for the translation of basic research results of of universities etc. to industries through joint research in Japan. METI had a matching fund program for this purpose, but has finished. MEXT and JST also had various programs, and some of them were arranged. Now, A-STEP program by JST is a core measure for this purpose.

In A-STEP program, a program director and program officers in JST support the management such as the R&D planning as well as funding. Many projects supported by A-STEP program gain enough research results. In addition, it provides incentive for researchers of universities to transfer their research results to industries.

On the other hand, technology transfers from universities to industries in Japan seem not to be sufficient as a whole as mentioned in previous section.

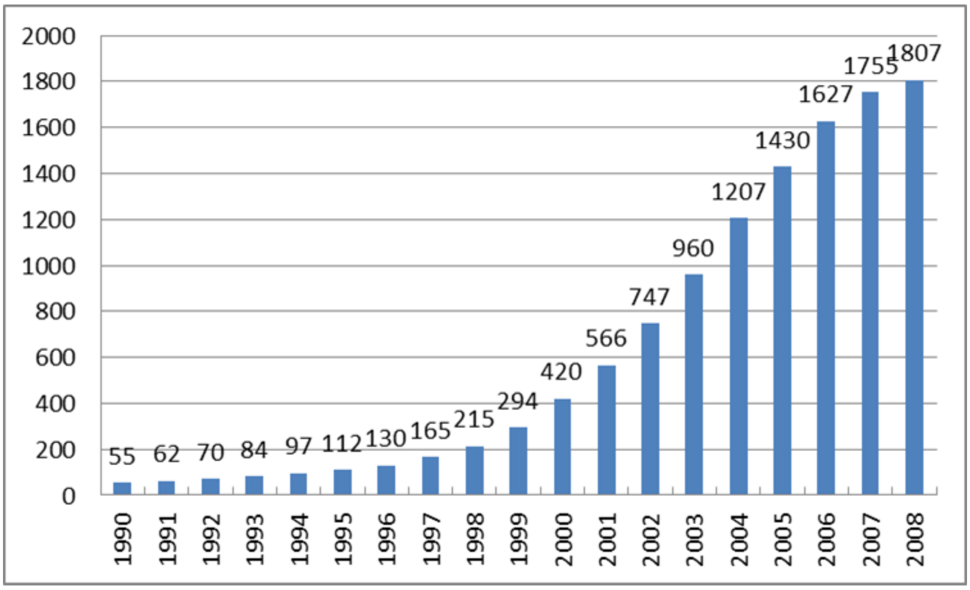
Promotion of start –ups from universities: START Program by JST

(1) Start-ups from universities in Japan

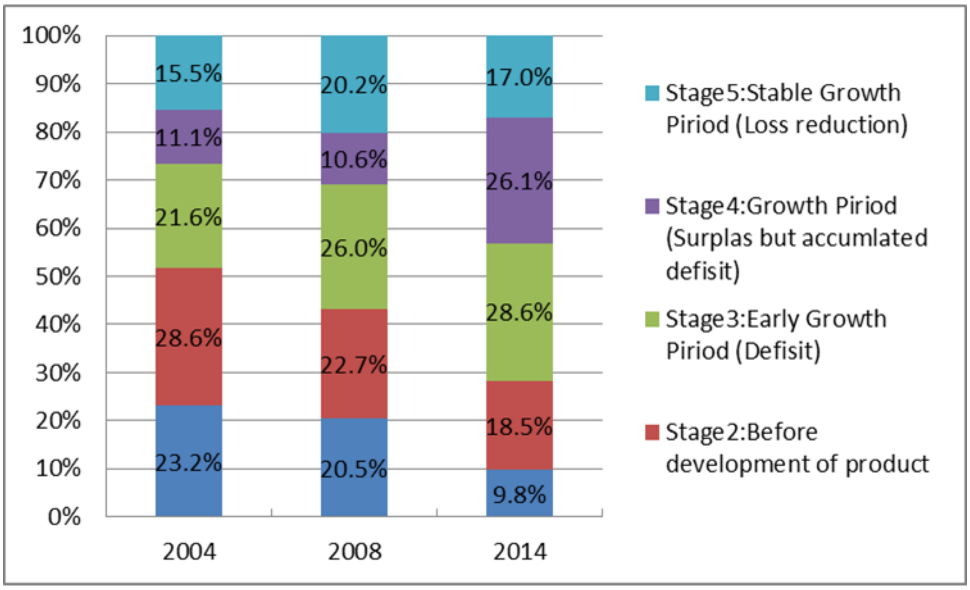
The start-up from university is expected as an important tool for the commercialization of research results of universities. However, there was little conventional venture company establishment in Japan, including start-up from university. The reason of this situation was pointed that venture capitals, particularly VC providing hands on service, were not developed well, or that there was small social understanding to start up business and many excellent talented persons of found jobs in larger companies.

To change this situation, METI announced the plan to establish 1000 start-ups within 3 years in 2001. This target was achieved in 2004, by efforts of ministries, universities and private sector, for example, MITI provided subsidy to R&D by start-ups. The University of Tokyo established its VC named UTEC (University of Tokyo Edge Capital), and promoted start-ups. Half of the start-ups were in an early stage and were developing the products before commercialization. As of 2008, the number of start-ups from universities increased to 1,800; however, the companies which succeeded in business were few. The policy to promote start-ups from universities was in the middle way from the view point of the social use of research results of universities.

Therefore, MEXT and JST started “START program” which is explained in next section, in 2012FY.



Rewrite from METI’s survey



Rewrite from METI’s survey

(2) START program

START program (Program for creating start-ups from advanced research and technology) was initiated by MEXT in 2012, and transferred to JST in 2015. This program aims to develop business/IP strategy and commercializing technology seeds in universities that are risky but have great potential, by combining government funding and private sector's commercialization knowhow before a foundation of start-ups.

This program consists of two sub-programs which are "project support" and "project promotor support". "Project promotor support" sub-program calls for application and chooses business promoters from capable persons who have commercialization know-how and who want to promote R&D and business building integrally. This sub-program provides the business promotors with expenditure for the activities to discover the promising technological seeds and to provide hands-on support with using their human network and know-how. Thus this sub-program aims at the inducement of the private fund within 3-5 years. On the other hand, "project support" sub-program calls for application of good technological seeds from universities or public research institutes firstly. Secondly technological seeds in the applications are evaluated and due diligences are carried out by the approved business promotors. Thirdly, universities and business promotors submit joint applications of projects to bring promising seeds to market and fourthly, JST examines these applications. Approved projects can gain expenditure for R&D from JST. And the approved universities etc. support the R&D managed by the business promotors.

56 business promotors in 13 units and 58 projects have been approved including finished projects under this program.

This program has the following characteristics[21].

a) A researcher and a business promotor with a team of experts jointly formulate an appropriate R&D and business development plan.
b) For the project of R&D and business development, milestone management on the basis of market needs is carried out by a team.
c) This program aims at the establishment of start-ups having high corporate value and the inducement of the private fund through enforcing projects.

[21] Reference to JST's pamphlet of STSRT program in Japanese:
http://www.jst.go.jp/start/jigyo/pdf/pamphlet.pdf

(3) Explanation and comments by author

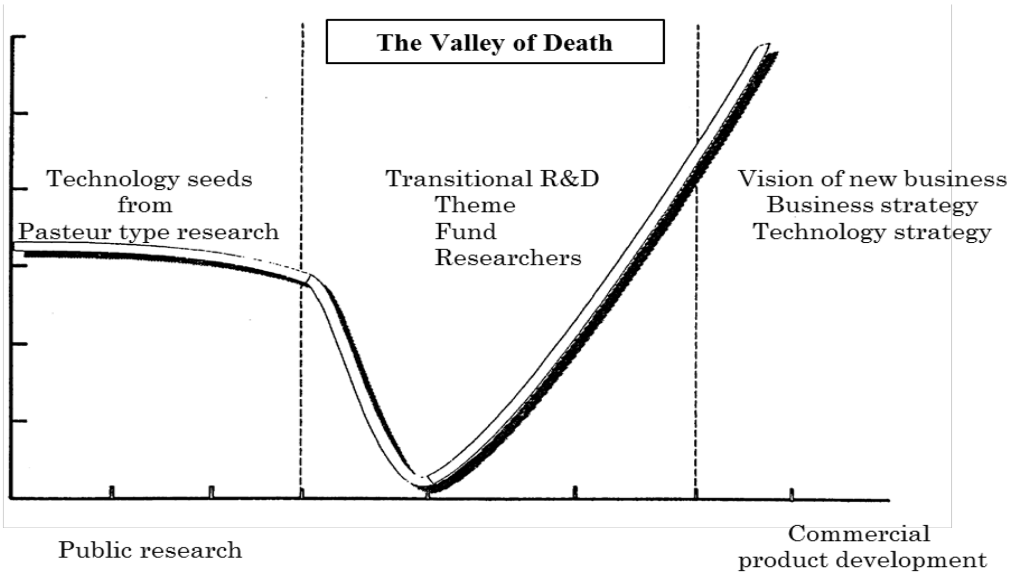
In Japan, venture companies did not grow very much for a long time. When many start-ups from universities were established ten years ago, they seemed to include companies which didn't have plans for commercialization or earning profit.

However, the situation is now changing and there are some start-ups growing and gaining profit. Last year, METI conducted a survey on the situation of start-ups from universities. The report says there were 1,807 start-ups in 2014 although this number is 58 fewer than 1807 start-ups in 2008, percentage of companies which have profitable business increased from 30.8 per cent to 43.1 per cent.

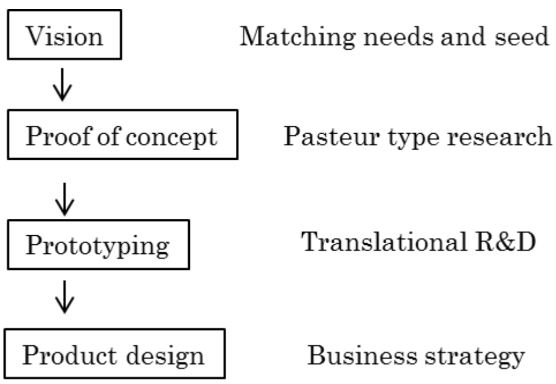
Additionally, MEXT and JST has initiated START program which supports activities in early stage (pre-venture). It is too early to evaluate the result of this program because it was made just three years ago. However, many expect this program to earn excellent start-ups from universities because it has a unique scheme to use a combination of public funding and management skills of the private sector.

Discussion and Conclusion

Five measures mentioned in Chapter 2 have proven successful. However, the challenge of Japan as a whole to commercialize results of public R&D seems to be not enough as shown in the graphs and indicators in I -1 and II-3. In other words, "the Valley of Death" seems to exist between public research and product development of innovation system companies in Japan. In order to bridge this "Valley of Death", the plan, funding and researchers for translational R&D would be necessary. Public research in universities and national research institutes would also be expected to produce many technical seeds before the translational R&D projects. Pasteur type of research which considers use would be useful for it. Additionally, private companies would be expected to have vision and strategy for new business by using new technologies.



Many innovations are expected to proceed through following processes within the above system.



There are several types of policy measures to realise innovation systems. The first is establishing institutions such as the PPP mentioned in Ⅱ-3. Japan has already established a fundamental institution as well as other countries. The second is a funding program. This report explained the program of NEDO project, A-STEP program for industry-university collaboration, and START program for university-led start-ups, which are useful for the translational R&D. The third is research in organizations including universities. This report explained the case of AIST and the thought of MEXT about the future vision of universities. Japan' government provides management expenses grants to national universities and national institutes, and they are within reach of the government. We should examine the appropriate set of policy measures as a whole as well as improvement of each policy measure. The followings are my observations:

(1) Challenge of funding programs

This survey made it clear that each funding agency is strongly conscious of the importance of management as well as the program budget. NEDO makes effort to improve their staff capabilities to manage R&D projects, and to feed-back the results of the follow-up evaluations on each past project. JST uses management capability of the private sector for the START program. Thus, the funding organizations are making an effort to improve the efficiency of funding programs by improving their management capabilities.

Another problem is the allocation of government budget among funding programs. There are several types of funding programs. Some of the programs are targeted to for universities, some targeted to companies and some for collaborations. Another difference is budget for management expense grants to national organization, the competitive fund by applications under call for process, and the fund for national strategic R&D projects. Although one role of government policy is to decide how to allocate the budget among these funding programs, the standard of judging appropriate allocations is not clear. Although each program is evaluated and usually given high review, the evaluation process does not show the guideline of appropriate allocation among programs.

(2) Challenge of national research institutes and universities

Research in national institutes and universities is within the reach of government policy. Although their researchers need academic freedom, they are expected to earn many technical seeds useful for economic or social application. Then the valance of centralization and decentralization in research management is the problem for research organization. From this point of view, AIST is a successful case.

Characteristics of management of AIST are to respect the independence of a researcher or research team, to infiltrate the organizational mission into individual researchers or teams through organizational culture shown in its charter. To change organization structure, from personal research to research center with companies through team research, flexibly depending on a technical life cycle. Historically, MITI repeatedly discussed with its researchers about national institutes, and changed their organization for many years, and integrated 15 institutes to AIST in 2001. This resulted in the current success.

Now, there is social discussion about the necessity to reform management of universities in Japan. The management of AIST would be good reference for universities. Moreover, AIST and universities need new management for introducing more private funding. Japan should learn from the successful overseas experiences with industry partnerships.

(3) Examining appropriate set of policy measures

A variety of policy measures are necessary depending on a life cycle of the innovation. However, the budget allocation among them is not necessarily as clear as mentioned above. In addition, the foundation of the new program based on the future vision is difficult to be accessed in advance although; existing programs can be evaluated based on their results.

A solution to these problems would be that it becomes one method to learn the experiences of the overseas policies. Additionally, it would be necessary to analyze a strength and weakness of Japan's innovation system and their cause. These have already been performed, however are not enough. I personally think this would be the most important point for the foundation of policy making.

Moreover, it would be a long-term challenge to develop scientific method to examine policy with objective grounds in the long term. Therefore MIXT enforces the **SciREX**

(Science for RE-designing Science, Technology, and Innovation Policy) program[22] from 2011. This aims at the evolution of policy formation processes and at the pioneering of related interdisciplinary academic fields, to support policy formation and practice under rational processes based on objective evidence.

(4) Improving innovation management of private companies

Private companies are main players of innovation, and have enough funds for R&D in Japan. The role of government should be complementary with companies' activities. Therefore dialogues between the government and industries or encouraging companies by policy measures would be useful, although activities of private companies are basically beyond the range of government measures.

Some companies point out the defects of public sectors such as universities, which are expected to be collated. On the other hand, there is possibility that Japan's problem might be caused by management style of some companies, i.e. some companies might not be so active to partnership with universities, and to the development of new business and new market. Now many companies have an interest in "open innovation", and it would be important to have dialogues and to examine appropriate management style for innovation.

[22] See http://gist.grips.ac.jp/en/about/scirex.html