Function of Competitive Fund Institution at Promotion of Science & Technology

— The Central Institution to Design Competitive Circumstances for Successful Research & Development and its Subjects for Reform —

Professor of Nagaoka University ,Hideki Hirota

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Introduction

One of the common ideas many influential Japanese leaders share concerning the future road which Japan needs to select is that the most important driving force to realize continuous Japanese economic development is science and technology(S&T)(1). The critical result of science and technologies activities, the key scientific knowledge leads to the base technologies, which generate the highly competitive industrial products. Therefore S&T is the most fundamental element to guarantee the continuous prosperity of Japan. Japanese government has emphasized the importance of S&T and implemented the very diverse policies to promote domestic research and development(R&D).They include formation of strategic policy vision(2), building very advanced facilities, education to foster capable researchers, reform of R&D-related institutes including universities, gathering overseas scientists and so on.

The most important policy subject to promote S&T is formation of effectively competitive

institution in which the research potentialities of scientists and research institutes are tapped on maximum level. The central element to realize competitive institution of S&T is competitive research fund(CF). This monograph analyzes the grand trend of S&T-related inputs and the situation of competitive research funds.

1. Rapid Growth of Science and Technology-related Input

The diverse scientific input has been rising. The domestic expenditure for R&D, which has been spent by government, private companies and universities, has skyrocketed , from 1970 to 2000.The aggregate amount for it was almost 1 trillion yen in 1970. Even in 1980 it reached only 4.6 trillion yen. The dramatic change began in the latter half of 1980s when diverse leaders started to recognize the end of postwar catching up. Various industries, including steel, shipbuilding, machines, and automobiles, climbed up to the enough mature point. This industrial victory . on the other hand , meant that Japanese economy had to challenge for invention of originally innovative technologies(3).

Table1: Aggregate Expenditure of Domestic Research and Development

Year	Amount of Expenditure of R&D (trillion yen)
1970	1.3
1975	2.6
1980	4.6
1985	8.1
1990	12.0
1995	13.1
2000	14.0
2003	16.8

Source: Original calculation based on S&T White Papers of Ministry of Education, Culture, Sports, Science and Technology and S&T Research Investigations of Ministry of Internal Affairs and Communications

The intensification of S&T in recent decades is testified in terms of the ratio of domestic R&D outlay to gross domestic product. The rate was stagnating from 1.5% to 1.9% in 1970s and increased to the 2% mark in 1980s. From 1990s it ascended rapidly to about 3% because general recognition that the ratio of R&D to GDP had to be 3% was formed. Actually 1990s was the significant period when Japanese S&T policy was accelerated. Many crucial matters concerning promotion of S&T was investigated at government and private sector. Science and Technology Basic Law was enacted in 1995 to create comprehensive S&T strategy.

Table2: Ratio of Expenditure of R&D to GDP

Year	Ratio of R& D Expenditure to GDP (%)
1970	1.7
1975	1.9
1980	2.1
1985	2.7
1990	2.9
1995	2.9
2000	3.0
2003	3.35

Source: Original calculation based on S&T White Papers of Ministry of Education, Culture, Sports, Science and Technology and S&T Research Investigations of Ministry of Internal Affairs and Communications

The table 3 indicates the development of government budget for S&T. In 1980s it was from 1.2 trillion to 1.9 trillion yen. The recent fiscal expenditure for domestic R&D has been over 3 trillion yen. The only increasing budget-fields of Japanese government , which has seriously suffered from fiscal deficit for decades, have been S&T and social insurance.

Table 3 : Government Budget for S&T

Year	Government Budget for S&T (trillion yen)
1970	0.3
1975	0.7
1980	1.2
1985	1.5
1990	1.9
1995	2.4
2000	3.2
2004	3.6

Source: Original calculation based on S&T White Papers of Ministry of Education, Culture, Sports, Science and Technology and S&T Research Investigations of Ministry of Internal Affairs and Communications

The ultimately fundamental element for successful S&T is not budget, facilities or systems, which are secondary factors. The most crucial impetus consists in capable researchers with scientific knowledge base and very original and creative brain. Government has strengthened the generation of researchers. The number was about 200 thousands in 1970s and grew to 300 thousands in 1980s. It amounted to 400 thousands and 500 thousands in 1990s. From

2000 the policy weight was obviously shifted from the just number to more quality[4].

Table 4 : Aggregate Number of Domestic Researchers

Year	Aggregate Number of Domestic Researchers (10 thousands)
1970	19
1975	25
1980	30
1985	38
1990	48
1995	57
2000	64
2004	78.7

Source: Original calculation based on S&T White Papers of Ministry of Education, Culture, Sports, Science and Technology and S&T Research Investigations of Ministry of Internal Affairs and Communications

2. Importance of Competitive Funds

One of the most important policy subjects to promote S&T is formation of effectively competitive system where scientists and institutes play to produce scientific knowledge. Government has to deal with some matters to actualize domestic competitive system, containing terminable contraction rule for researchers and completely fair reputation system[5].

The central element to realize competitive system of S&T is competitive research fund (CF). CF is the fund some agencies supply publicly for researchers to challenge for scientific activities. The system of CF determines degree of competitiveness of domestic research activity.

Actually CF has the various functions. Firstly researcher can get necessary expenses for research activities by CF. Secondly researchers can have their research plans and activities be reputed by outside watchers under CF system. Thirdly CF is able to let high competition in the society of researchers and institutes takes place, leading to maximum output of domestic R&D.

The capital of CF has two portions, direct cost as the capital for research activities of researchers and indirect cost as the money to be supplied to the research institutes hiring the researchers. Direct cost includes material expense and personnel expenses for research assistants and researchers themselves.

Generally CF institution has two types. Bottom up type and Top down type. Bottom up type

is funding system in which researchers basically set their own research subjects. Top down type is the fund where researchers cannot set their subjects and follow the subjects funding agencies set. Concerning grant amount per one subject, it is relatively small at bottom up and relatively large at top down. However the number of institutions of bottom up is many and it is a few at top down.

Table 5 : Types of Competitive Fund Institutions

	Research Subject	Funding per a subject	Number of Institutions
Bottom up type	Free	Relatively Small	Many
Top down type	Pointed	Relatively Large	A Few

3. Development Process of Competitive Funds in Japan

Table 6 shows the number of formation of institutions of CF. In 1950s , 1960s and 1980s each decades generated only one institution of CF. The three traditional funds were Welfare Scientific Research Grant of then Ministry of Welfare and Labor in 1950s, Grants-in-Aid for Scientific Research[6] in 1960s and Science and Technology Promotion Adjustment Grants in 1980s , taken charge by then Ministry of Education ,which work as the principal institutions now.The rush of construction of institutions started in 1990s. Nine were built by seven ministries including Ministry of the Environment, Ministry of Agriculture, Forestry and Fisheries, then Ministry of International Trade and Industry and then Ministry of Construction. Thirteen institutions have been designed since 2000.

Table 6 :Formation of Competitive Fund Institutions

Year	The Number of Formation of Institutions
1950s	1
1960s	1
1980s	1
1990s	9
From 2000	13

Obviously government has increased budget for CF rapidly, recognizing that it is the key factor to design nationally competitive system for S&T. In 1996 government formed the First

Science and Technology Basic Plan as the grand S&T strategy, which insisted on requirement to increase expenditure of CF. The Second Science and Technology Basic Plan was designed in 2001, launching the plan to expand CF more. The amount jumped from 70 billion yen in 1990 to 360 billion yen in 2004, about five times growth for 15 years.

Table 7 : Government Budget for Competitive Funds

Year	Government Budget for CF (billion yen)
1990	70
1995	124
2000	292
2004	360

Source: Original calculation based on S&T White Papers

4. Current Institutions of Competitive Funds

The current number of domestic institutions for CF is 26 , which are taken charge by seven ministries.

Table 8 : Number of Institutions for Competitive Funds at Ministries (2005)

Ministries	Number of Institutions
Ministry of Education, Culture, Sports, Science and Technology	7
Ministry of Health, Labor and Welfare	2
Ministry of Internal Affairs and Communications	6
Ministry of Agriculture, Forestry and Fisheries	5
Ministry of Economy, Trade and Industry	1
Ministry of the Environment	3
Ministry of Land Infrastructure and Transport	2

Table 9 shows the budget shares of CF of the ministries. Ministry of Education, Culture, Sports, Science and Technology occupies 77% of total domestic CF and Ministry of Health, Labor and Welfare has 12%. The two lager distributing ministries take possess of about 90%. Other ministries pies are relatively small. Ministry of Internal Affairs and Communications has 4%. Ministry of Agriculture, Forestry and Fisheries occupies 2%. Ministry of Economy, Trade and Industry and Ministry of the Environment has 1% respectively. Ministry of Land Infrastructure and Transport occupies only 0.2% of national competitive funds. However tiny

scale never means the small effectiveness of R&D because result of R&D depend on other various factors such as originality and flexibility of scientists' brain and accidental discovery. Sometimes a little seed grant can open newly scientific frontier.

Table 9 : Budget Shares of Competitive Funds of Ministries (2004)

Ministries	Share(%)
Ministry of Education, Culture, Sports, Science and Technology	77
Ministry of Health, Labor and Welfare	12
Ministry of Internal Affairs and Communications	4
Ministry of Agriculture, Forestry and Fisheries	2
Ministry of Economy, Trade and Industry	1
Ministry of the Environment	1
Ministry of Land Infrastructure and Transport	0.2

Source: Original calculation based on S&T White Papers

Regarding the relation between the CF institutions and the stages of R&D (basic/ applied/development), the institutions for basic research are 10. The institutions for applied research are 18. The institutions for development research are 9. CF seems to be provided to three stages evenly in terms of number of institutions. However the principal institutions of Ministry of Education , Culture, Sports, Science and Technology as the largest distributor are those for basic research, which means that almost half of domestic CF works for basic research activities.

Table 10 : Research Stages and Institutions for Competitive Funds (2004)

Research Stages	Number of Institutions
Basic Research	10
Applied Research	18
Development Research	9

5. Distribution of Competitive Funds

Concerning the recent distribution of competitive funds in terms of research fields, the maximum share holder has been life science , which has occupied around 50 %. The second largest field is nano-technology and material , about 15 % , being said to be very advantageous field of Japan in the world S&T race. Information technology as the third gets about 10%, followed by environment ,about 5 %.

Table 11: Research Fields and Recent Distribution (2000~2004) of CF

Research Fields	Share of Funds (%)
Life Science	48～52
Nano-technology and Material	13～16
Information Technology	8～11
Environment	4～7

Source: Original calculation based on S&T White Papers

CF is distributed to universities , public research institutions and private companies. Actually 80 % has been provided for universities and 15 % for public institutes. Though private companies and their institutes have been regarded as the crucial key player to boost Japanese technology level ,they capture only 5 %, which is one of the most controversial problems of Japanese CF institution.

Table 12 : Research Organizations and Distribution of CF (2004)

Research Organizations	Share of Funds (%)
Universities	80
Public Institutions	15
Private Companies	5

Source: Original calculation based on S&T White Papers

Table 13 indicates distribution of CF in terms of ages of researchers to get them. The largest ages group is fifties , getting over 40% . The second largest is the group of forties to occupy about 30%, followed by thirties and sixties, from 12% to 13%. Relatively small share is distributed to the thirties though they are regarded as the most revolutionary people who tend to break through scientifically tough wall to cut scientific frontier open.

Table 13 : Ages of Researchers and Distribution of CF (2004)

Ages of Researchers	Share of Funds (%)
The Thirties	13
The Forties	33
The Fifties	41
The Sixties	12
The Seventies	1

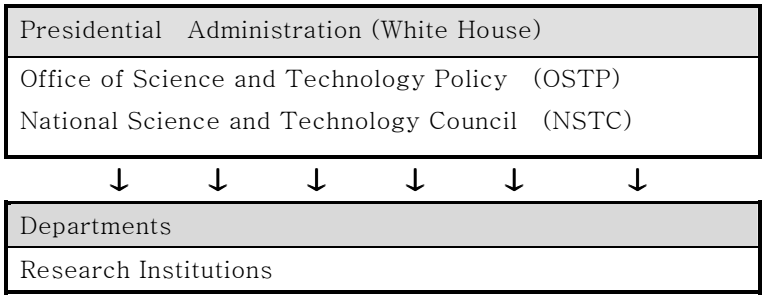
Source: Original calculation based on S&T White Papers

6. Competitive Funds of US and Lesson for Japan

In the race of global S&T competition, the United States is running as the front runner. US is the very top at this field in terms of quantity (national R&D expenditure , government budget, highly influential theses ,real invention ,etc.) and quality(institutions, its management, capable researchers ,etc.). The substantial lessons exist.

Basically US policy formation and implementation system is typical top down style. Presidential Administration, which contains Office of Science and Technology Policy (OSTP) and Science and Technology Council (NSTC), directs S&T-related Departments like Department of Health and Human Services, Department of Defense. The very advantage the top down guarantees is the speed and scale of policy change. When some modification of S&T policy is recognized, US government can carry out the reform at high speed and large scale. Formation of Council for Science and Technology Policy (CSTP) of Japan in 2001 meant the beginning of top down style of Japanese S&T policy. But it never has top down function enough.

Figure 1 : US S&T Policy System



The share of competitive funds in total government budget for S&T is enormous in US[7]. The share is around 35% in US and it is about 10% in Japan. The substantial weight of CF leads to the degree of competitiveness of scientists society. The relatively large share of US symbolizes highly competitive research system. The weight of CF needs to be expanded in Japan in order to design more competitive system.

Table 14 : Total Government Budget for S &T and Competitive Funds in US and Japan(2003)

	Total Government Budget for S &T (billion yen) (X)	Competitive Funds (billion yen) (Y)	Y/X (%)
US	10,200	3.600	35
Japan	3,500	350	10

Source: Original calculation based on US National Science and Technology Council Annual Reports

The S&T-related Departments or the research institutes of them take charge of the supply of competitive funds[8]. The five largest distributors of CF are National Institute of Health(NIH), National Aeronautics and Space Administration(NASA), National Science Foundation(NSF), Department of Defense(DOD) and Department of Energy(DOE).NIH covers fields containing biology, chemistry, and pharmaceutics. NSF covers the fields including physics, statistics, and social science. Also NSF has CAREER Award which is the special CF only for young researchers. The CF of NIH and NSF is bottom up style in which research subject is designed freely by applicants. The CF of NASA and DOD is top down style to have the applicants follow the specific subjects decided by two institutes.

Table 15 shows the shares of CF of the distributors. Some 50% competitive grant is shared by NIH, 11% by NASA, 10% by NSF,10% by DOD, and 4% by DOE.

Table 15 : Budget Shares of Competitive Funds in US (2003)

Organizations	Share(%)
NIH (National Institute of Health)	50
NASA (National Aeronautics and Space Administration)	11
NSF (National Science Foundation)	10
DOD (Department of Defense)	10
DOE (Department of Energy)	4

Source: Original calculation based on US National Science and Technology Council Annual Reports

Table16 indicates distribution of competitive funds in terms of organizations to get them in the United States. Overwhelmingly CFs are supplied to universities. Private companies have caught about 10%.

Table 16 : Distribution of CF in terms of Research Organizations in US (2000)

Organization	Share(%)
Universities	89
Private sectors	10
State	1
Oversea	1

Source: Original calculation based on US National Science and Technology Council Annual Reports

Universities absorbing the maximum amount of competitive grants have high responsibility at basic research. Therefore the inside system of them is quite different from those of other advanced nations. Completely competitive rules are applied at researchers of universities.

The reputation , promotion and income of researchers of universities are decided by the capture of CF and result of research which are implemented by using the fund. Winning tenure post as the highest position at universities mainly depends on acquirement of CF[9]. Universities always try to hire excellent researchers to get large amount of CF because they can acquire indirect cost as the important origin of revenue when excellent scientists win CF. Universities use start up cost for excellent researchers coming from other schools . Start up cost is the generous expense for new researchers, diverse cost to get their research activity to take off at new circumstances, including cost for facilities, cost for movement, cost for residence and cost for new assistants. The average start up cost is about 1 million dollars. Start up cost is investment for researchers in order to aim at big return (big indirect cost) by big CF they will win. Generally universities get five times return as much as start up cost, as the indirect cost of CF researchers get. Universities have Sponsored Program Administration Office (SPAO), which is the office to promote acquirement of CF and deal with various assistant activities of CF applications. SPAO is supported by part of indirect cost of CF. Also universities have Research Foundation Office (RFO) which take charge of accounting of CF researchers get.

The selection process to choose application of CF is fair and open in US.

For example, the research plan as crucial part of application form are sent to Center for Scientific Review (CSR) at NIH. The pages of research plan of NIH-CF are over 15. Those of Grants-in-Aid for Scientific Research is about 5. Japanese space is small. CSR divides the research plans into the suitable study sections to evaluate them.

The number of study section at NIH is around 200. The member of each study section consist of very veteran researchers and young researchers. The study section submits the minute critique, summary statement, to the applicants. This kind of detailed statement is not at Japanese CF institutions.

Generally basic research activity is emphasized at US S&T. Basic research (science) is the most important foundation to generate useful technologies and competitive patents. Only very original science (basic research) can generate original technology. NIH tends to adopt the research plans to seek for ultimate substance of science or the research plan to try innovative challenge. The application of NIH-CF is basically three times, February, June and October. Generally researchers in Japan apply CF one time a year.

Competitive fund is the driving force to form highly competitive R&D circumstances in US.

Conclusion

Japanese institution of competitive funds has some problems. Government needs to expand the share of CF at total budget for S&T to create more competitive research environment.

Also judgment system to repute and adopt research plans has to be effective. Some valuable application to CF may be rejected because of impossibility to recognize their very original research plans. The application papers have to be modified to the style to express the enough contents of research plans. It is sometimes said that judgment to adopt plans tend to be done, mainly based on the positions, careers or previous achievement of researchers to submit applications. The ultimate criteria to judge has to be the substance of research plans , not academic position, careers and previous achievement. Some very adventurous researchers having relatively small number of achievement may generate very original research result to let national S&T make great stride.

S&T policy including CF institution is new academic field in the study of policies science, which consists of many policy science fields containing economic policy, industrial policy and social policy. S&T policy is expected to be more progressive by absorbing creative analysis.

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Notes

(1)Mr. Okuda , then Chairman of Japan Business Federation, indicated the idea that science and technology is the most important key to realize continuously Japanese economic prosperity(Japan Economy Newspaper-No.43191). The national slogan, Japan as the Nation to Create S&T, is well known.

(2)Government presented the S&T Basic Plan three times. The First S&T Plan was formed in 1996, The Second Plan in 2001 and The Third Plan in 2006.

(3)Also Asian rising nations such as South Korea, Singapore or Thailand were catching up at the traditional industries at that time, which started to let Japan move toward new frontier of industries.

(4)Regarding the relation between the institutes and the number of researchers in 2004, private companies have 45.9 thousands researchers, universities researchers are 28.4 thousands. The researchers of public institutions are 3.4 thousands. The researchers of non-profit organization are 1.0 thousand.

(5)Regarding terminable contraction for researchers, generally public research institutions introduce it. Universities tend to hesitate to form it completely though some top class research universities accept it.

(6)Grants-in-Aid for Scientific Research of then Ministry of Education was derived from Science Promotion Grant in 1918.

(7)Regarding aggregate expenditure of domestic research and development, US spent 39.6 trillion yen in 2003.

(8) There exist big private foundations to supply CF in US. The well known one is Howard Hughes Medical Institute (HHMI) which spends over 400 million dollars a year for medical research.

(9) Other important criterions for tenure are numbers of these, quality of them and ability of education. Also Tenure sometimes mainly depends on ability of education of teachers at the universities to regard education as first priority.