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Government Research and Innovation Policies in Japan

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Preface

Japanese research and innovation is presently undergoing more radical changes than probably anytime since Japan was established as a modern society well over a century ago. Although the title of the report includes both “research” and “innovation”, the focus is more on the former.

The report has been produced at the request of the Swedish Research Council, which has also financed a major part.

Most of the figures for research funding are expressed in yen. When converted to Swedish currency, 1 SEK = 14 yen has been used as the exchange rate regardless of year.

The report is written by Lennart Stenberg, Science and Technology Counselor at the ITPS Science and Technology Office in Tokyo. He has been assisted by staff members at the office.

Östersund, January 2004

Sture Öberg
Director-General

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Sammanfattning

De totala FoU-utgifterna i Japan utgjorde 2001 ca 3,09 procent av BNP, den högsta nivån bland de större OECD-länderna och 16 procent av OECD-ländernas samlade FoU-utgifter. Företagsfinansierad FoU i Japan är lika stor som för Tyskland, Frankrike, Storbritannien och Italien sammantagna. Elektronik-, fordons-, instrument-, och maskinindustri samt material- och komponentindustrier knutna till dessa ligger särskilt långt framme. Under de senaste tre åren har inte mindre än fyra japanska forskare tilldelats Nobelpris. De prisbelönade arbetena utfördes för 15-20 år sedan, varefter den relativa nivån på japansk forskning stärkts ytterligare. Några av de forskningsanläggningar och forskningsprogram som drivs i Japan är världsledande, exempelvis Earth Simulator (superdator för klimatsimuleringar), Kamiokande (detektion av neutriner), RIKEN Genomic Sciences Center (bl a strukturgenomik och ”Mouse Genome Encyclopedia”). Dessa och liknande forskningsanläggningar erbjuder intressanta möjligheter för svenska forskare.

Det råder stor politisk enighet i Japan om betydelsen av satsningar på vetenskap och teknik. Trots ansträngda statliga finanser ökade den reguljära statliga budgeten för vetenskap och teknik med nära 60 procent under perioden 1993-2003. Med syfte att stimulera den japanska ekonomin har dessutom extraresurser om i genomsnitt 15 procent tillförts under samma period. Enligt OECD utgjorde 2002 de statliga FoU-anslagen 0.71 procent av BNP i Japan mot 0.87 procent i Sverige. Företagens FoU-satsningar har under det senaste decenniet växt endast långsamt efter en kraftig expansion under 1980-talet.

Sedan mitten av 1990-talet genomförs en reformering av det japanska forskningssystemet på bred front. Detta återspeglar till del övergången från ett system som varit inriktat på att utnyttja och vidareutveckla ideer och teknologi från USA och Europa till ett system inriktat på genuint nyskapande inom både vetenskap och teknik. En viktig förebild är de amerikanska forskningsuniversiteten, inte minst den roll de anses ha spelat för förnyelsen av näringslivet i USA inom i synnerhet IT- respektive Bioområdet.

Inrättandet 2001 av Rådet för Policy avseende Vetenskap och Teknik (CSTP) i dess nuvarande form, med premiärministern som ordförande och ett stort sekretariat, visar en ökad ambitionsnivå ifråga om övergripande samordning, strategi och prioriteringar. Den 2:a handlingsplanen för vetenskap och teknik som avser perioden 2001-2005 och omfattar all statligt finansierad FoU har tre huvudelement:

- ambition att öka de totala statliga FoU-anslagen med 20 procent jämfört med föregående femårsperiod (tveksamt om detta kan uppnås)
- prioritering av fyra områden: IT, livsvetenskaper, miljö, nano-/materialteknik samt utveckling av övergripande strategier för varje område samt för ytterligare fyra områden

- reformering av ”systemet för vetenskap och teknik” med sikte på skapande och utnyttjande av FoU-resultat i världsklass.

Fr o m 2001, omfattar politiken för vetenskap och teknik även humaniora och samhällsvetenskap, vilket inte tidigare var fallet. Deras roll är dock fortfarande relativt undanskymd. Statligt finansierad FoU inom livsvetenskaper och nanoteknologi genomförs till minst två tredjedelar vid universitet medan denna andel inom områdena IT och miljö är mindre än en tredjedel.

Nyckelbegrepp i de systemförändringar som pågår är:

- konkurrens
- resurskoncentration
- rörlighet
- ökade resurser till och självständighet för unga forskare
- samverkan mellan industri, universitet och forskningsinstitut.

En målsättning, som torde bli svår att infria, är att till 2005 fördubbla den andel av medlen till universitet och forskningsinstitut som fördelas som projektanslag sökta i konkurrens från 10 till 20 procent (något högre andelar för universiteten). FoU-resurserna är redan mer koncentrerade än inom EU. Många ledande forskningsgrupper vid universiteten har under senare år haft god tillgång till stora projektanslag och härigenom relativt sett ökat sin konkurrenskraft i förhållande till företag och forskningsinstitut som tidigare ofta hade överlägsna resurser. Fortsatt investeras dock stora resurser i förstklassig utrustning på många forskningsinstitut och många stora företag bedriver synnerligen kvalificerad forskning.

Ändringar i regelverket för statliga universitet (2004) och institut (2001) ger ökad flexibilitet vid anställning av forskare och vid samverkan med näringslivet men samtidigt kopplas resurstilldelning till utvärdering av verksamheten. Detta väntas leda till att universiteten profilerar sig hårdare. Det finns en uttalad ambition från statsmakterna att minska antalet statliga universitet. Nära 80 procent av all grundutbildning sker vid privata universitet mot endast cirka en fjärdedel av forskarutbildningen.

1 Current issues in Japanese research and innovation policy

1.1 Science and technology policy given high priority

Japanese society is currently undergoing deep structural changes. Values and economic, social, and political institutions, which came to be taken for granted are being questioned and alternatives explored. This includes also many of the institutions and practices in the fields of education, research and innovation.

Some of the impetus for change derives from the poor performance of the Japanese economy since the beginning of the early 1990:s. Some of the root causes of these problems, such as the weak balance sheets of financial institutions and the high propensity of Japanese households to save rather than consume, have little connection with science and technology. Nevertheless, investments in science and technology (S&T) and effective utilization of their results are generally considered to be a key prerequisite for returning the Japanese economy to a stable growth path in the long run.

This basic perspective seems to have broad-based political support and as a result spending on research and development (R&D) continues to receive high priority from both the private sector and the government. In setting the framework for ministries for their preparation of budgets for fiscal year 2004, both Prime Minister Koizumi and the Finance Minister have publicly singled out science and technology as the exceptional area in which discretionary government spending will be allowed to increase.

1.2 USA seen as model

While there is strong support for the need to further increase R&D-investments, there is also a strong opinion favoring radical changes in the system for financing and performing research and innovation. The large apparent difference in economic performance between the USA and Japan during the last decade has been seen as evidence that the American innovation system today is more effective than the Japanese. Especially two differences have been emphasized. One is the creation of new high tech venture companies in such fields as IT and biotechnology, of which there has been very little in Japan. The other concerns the internationally leading position of American research universities and their seemingly effective system for transfer of technology and knowledge to industry.

Of course, the growth of American high tech industry looks somewhat less impressive today than just a couple of years ago. So far, such a reevaluation of the success of the American system does not seem to significantly have slowed the movement towards reforming the Japanese innovation system in accordance with the American model. It should be expected, however, that the discussions of the relative merits of the systems of the two countries in due time will become somewhat more balanced. This can already be seen in discussions of suitable models for corporate governance.

1.3 Reforms at high speed since new Basic Law for S&T in 1995

The enactment of a new Basic Law for Science and Technology in 1995 marked the start of the development of a more cohesive and forceful government S&T policy. Under this law, the government is required to draw up Basic Plans for S&T for periods of five years at a time. The first one covered the period 1996-2000 and contained a program for systemic changes in the Japanese R&D-system, primarily those parts influenced by the government. Major themes were:

- Strengthened cooperation between industry, universities and government research organizations
- Promotion of the establishment of new ventures based on technological seeds or ideas from universities or research institutes
- Increased support for young researchers by drastically increasing the number of post-doctoral fellowships
- Increased mobility of researchers
- More competition for research funds and higher degree of concentration of research funds
- Increase in government resources to R&D

The second Basic Plan for the period 2001-2005 developed further the systemic reform agenda and raised the goal for government R&D-spending. A new element was the designation of four priority fields to which government R&D-spending should be concentrated. For each of the four priority fields, and for four additional fields, fairly detailed strategies have been developed and serve as guidelines for preparation and negotiations of budgets. Although increases in the regular budget have been concentrated to the priority areas, the redistribution of funds to these areas has so far been fairly modest. The overwhelming part of new initiatives and the use of supplementary budgets have, however, been in priority areas.

1.4 Administrative reforms contribute to changes in the R&D-system

After several years of preparation, the system of national public administration in 2001 underwent its largest reorganization so far during the postwar period. A major change was a strengthening of the coordination powers of the Prime Minister. This included the establishment of advisory councils in key areas, with the Prime Minister as Chairman, in key areas and the establishment of a new Cabinet Office serving as secretariat for the councils and other coordination activities. The Council of Science and Technology Policy (CSTP) is one of the new councils. It has a secretariat of almost 100 staff, most of whom are dispatched from various ministries or from research organizations or companies. A special Minister for Science and Technology Policy has also been appointed. Compared to an earlier similar council, the new council has significantly more power due to its position, its large secretariat, its discretion to bring up any matter of science and technology policy it finds relevant, and, last but not least, because it has a say in the budget process.

The administrative reform of 2001 also involved a reduction in the number of ministries and agencies. In the field of S&T, the biggest change was the merger of the former Science and Technology Agency (STA) and the Ministry of Education into a new Ministry of Education, Culture, Sports, Science and Technology (MEXT). MEXT today controls around two thirds of government R&D expenditure.

1.5 Turning national research institutes into Independent Administrative Agencies

As part of the administrative reform in 2001, the legal status of most national research institutes was changed to Independent Administrative Agencies (IAI). This greatly increases the flexibility of the institutes in terms of personnel and financial management. Through the change in legal status, the employees of the institutes are no longer public servants and the institutes have great freedom to design employment contracts according to their own preferences. It also has become possible to carry over financial resources from one year to another, which was earlier extremely difficult. The institutes are now allowed to receive money from the private sector, which was earlier prohibited. While the work plans and budgets of the institutes were previously annually specified in great detail by the responsible ministry, the new IAI:s will be operated at arms-length distance from the ministries through a system of medium-term objectives and plans and regular evaluations of the extent to which the objectives are being fulfilled. The result of the evaluations is supposed to influence the future allocation of government resources.

In connection with the changeover to the new system, some institutes were merged and restructured. The new National Institute of Materials Science under MEXT and the new National Institute of Advanced Industrial Science and Technology (AIST) under METI are thus quite different from their predecessors.

So far there has been little change in the size of government funding to the institutes. The government's intention with the new system will become more clear after the first round of evaluations have been completed

Some funding agencies as well as some R&D-performing organizations have been so-called Special Public Corporations. In the autumn of 2003 most of these were turned into IAI:s. On that occasion a new Japan Aerospace Exploration Agency (JAXA) was formed through the merger of the Institute of Space and Astronautical Science (ISAS), the National Aerospace Laboratory of Japan (NAL), and the National Space Development Agency of Japan (NASDA).

1.6 Corporatization of national universities

Maybe the most dramatic change in the Japanese research system, is the transformation of national universities into IAI:s from April 2004. Previously, national universities have not had any independent legal status, but legally been a part of MEXT.

Like the case of the national research institutes, initially no significant changes are expected in the financing from the government of national universities. Already the government has, however, sent very clear signals that it would like to see the number of national universities decrease in the future. This has already resulted in some mergers between national universities, e g universities specializing in medicine being merged with universities lacking medical schools.

A couple of years ago, the Minister of Education made a statement that the government wanted to selectively promote the research excellence of Japanese universities in such a way that around 30 would reach a level comparable to the leading universities in the world. This general policy statement was later translated into a concrete program "21 Century Centers of Excellence Program" under which all universities – national, other public, and private alike - were invited to compete for grants to develop graduate schools in different fields. This COE Program will be discussed in more detail later.

Generally speaking the transformation of national universities to IAI:s is expected to make them more active in developing their strategies, organization and activities and in so doing in identifying and nurturing their unique characteristics. Cooperation with industry is becoming easier as many of the cumbersome regulations hindering such cooperation have already been or will be removed. The incentives for national universities to enter into such cooperation will also increase, as they will now be able to control the use of any income from industry.

The government provides much larger institutional funds to national universities than to private universities, in spite of the fact that there are almost four times as many students in private universities as in national universities. As a result students at private universities pay much larger tuition fees than students at national universities. Some observers question whether national universities will be able to maintain their privileged position in terms of institutional funds from the government over the longer run.

1.7 Expanding competitive funding

One of the objectives set for the Second Basic Plan for S&T is to double the amount of government funding distributed as competitive research funds over a five-year period. An increase in the share of competitive funding of total government research funding is seen as an important means for raising the quality of research. The need for transparent and fair evaluation of proposals is emphasized. In 2000 the share of competitive funding was only around 9 percent. By 2003 the amount of competitive funding had increased by around 18 percent compared to the level in 2000. The rate of change has thus been much slower than intended making it seem unlikely that the objective will be met during the allotted five years.

The issue of competitive funding also concerns the system for distributing such funds. The CSTP has devoted a lot of attention to this matter and proposed that ministries and agencies raise the scientific competence of their funding organizations by employing program officers and program directors with scientific backgrounds along the lines of the practice at institutions such as NSF and NIH in the USA.

It is also suggested that as the level of competitive funding increases, indirect costs at a rate of 30 percent be introduced.

1.8 Allowing researchers in companies to apply for Grants-in-Aid

Another idea in the reformed system of competitive funding proposed by the CSTP is that researchers shall be eligible for funding regardless of what type of organization they belong to as long as they meet the criteria established for a certain research program, such as open publication of results. In this case, also researchers working in industry would be able to apply for research grants. In certain programs this is already possible, but not for the biggest research program, Grants-in-Aid. The fact that Mr Koichi Tanaka was awarded the Nobel Prize in Chemistry in 2002 for work he did as a research engineer at Shimadzu Corporation has given the proposal to open up research programs for company researchers special significance and impetus.

1.9 Increasing mobility

The career and employment system for scientists at universities and research institutes has tended to be very rigid. To a large extent this reflects the general system of life long employment and promotion and salary based on seniority practiced in Japan in government and big business organizations. These practices are now being questioned in Japanese society at large including universities and research institutes. As already mentioned the transformation of national research institutes and national universities into IAI:s will give them a large degree of freedom in designing their own career and employment systems.

Some institutions have already introduced fixed-term employment systems for newly employed research staff. Continued employment is dependent on the result of evaluation of the individual's performance. This type of system is expected to become more common. At least one university has also started to use a system of open applications and strict evaluations when recruiting new academic staff.

An aspect of Japanese universities, which has often been criticized and is now recognized as a serious problem, is the long time it usually takes before a researcher is able to pursue his or her research independently of the senior professor. One measure to deal with this is to increase the funding specially targeted for young scientists. More fundamental changes in the organization and career system of universities are, however, probably needed.

1.10 Career opportunities for postdoctoral students

The First Basic Plan for S&T set as a goal to annually provide funding for 10 000 postdoctoral fellows. This meant a drastic increase in the population of postdoctoral students. In addition it has more recently become possible to use research grants for hiring postdocs. In this way the pool of young scientists has been significantly increased. Openings for more permanent positions for qualified researchers in universities or elsewhere have, however, not increased at all to the same extent. As a result the question of how to fully utilize the talent of all the researchers, who have had postdoctoral training, has come to be seen as one of the key issues for science and technology policy.

1.11 Fighting bureaucratic sectionalism

Traditionally the budget process in Japan has primarily been a bottom-up process in which most of the initiative has come from the individual sections of individual ministries, each section usually being responsible for the implementation of a particular regulation or promotion activity specified by law. There has been little room for coordination across ministries, except for the selection and adjustment of budget proposals performed by the Ministry for Finance, which has little expertise in science and technology matters. In the field of science and technology each ministry has maintained more or less its own research and development system with its own research institutes. Until 1995, very nearly all government funding of universities was channeled through the Ministry of Education. This "bureaucratic sectionalism" has been widely recognized and criticized and given its own label "tatewari", which roughly means "vertical division".

Some steps have been taken to overcome tatewari and to achieve a better integration and coordination of government S&T policy. Since 1995 also other ministries than the Ministry of Education have begun to support research at universities, although this still represents a small part of their total R&D-budgets.

While the regular budget process has shown great inertia and allowed very little real coordination across ministries, the compiling of supplementary budgets during the last decade has worked in a different way, at least in the field of science and technology. In these cases there seems to have been a more intense interplay between political will and strategic visions on the one hand and the devising of concrete measures by the ministries on the other. A clear example of this was the so called Millenium Projects started in year 2000. These focused on the development of new technologies under three themes: informatization, the aging society and the environment. These were the same themes as those recommended by the Japan Federation of Economic Organizations (later transformed into the present Nikkei Keidanren). Projects under the aging society theme focused mainly on genomics and drug discovery for age-related diseases.

1.12 Four priority fields

The establishment of the new CSTP in 2001 was a major step towards strengthening the coordination of government S&T policy across ministries. Different from its predecessor, CSTP was given an explicit role in the budget process. To fulfill this role the CSTP has designated four priority fields: life sciences, information and communication, environment, and nanotechnology/ materials. For each of these, CSTP has taken the initiative to develop fairly detailed strategies for government promotion of science and technology. Similar strategies have been developed for another four areas: energy, manufacturing technology, social infrastructure, and "frontiers" (space and oceans). The four priority fields represent around 45 percent of total government R&D-spending and the additional four fields another 38 percent.

The responsibility to develop concrete measures and budget proposals still rests with the individual ministries. They are supposed to follow the strategies developed by CSTP. Their incentive to do so is that their budget proposals are reviewed by the CSTP, which submits its evaluations of major budget items to the Ministry of Finance. The strategies are revised annually by the CSTP.

How this new priority setting process is actually working in practice is of course very difficult to judge for an outside observer. Probably its efficacy depends a lot on the persons involved and the quality of the dialogue between CSTP, individual ministries and experts in the field. This appears to vary considerably between fields.

1.13 Comprehensive strategies for priority fields include more than S&T

In at least three of the priority fields, S&T promotion strategies have been developed in parallel with more comprehensive strategies involving policies in other fields, including education, legal frameworks and government regulations.

Already in 1994, an “Advanced Information and Telecommunications Society Promotion Headquarters" was established within the Cabinet and a number of similar coordinating bodies have since followed. In July 2000 a high profile “IT Strategy Council”, chaired by Mr. Noboyuki Idei, Chairman and CEO of Sony, and consisting of leading representatives of Japanese IT-industry and research, was set up to help the government draw up a strategy. In January 2001 the “e-Japan Strategy” was established with ambitious objectives: “Japan must take revolutionary yet realistic actions promptly in order to create a ‘knowledge-emergent society’, where everyone can actively utilize IT and fully enjoy its benefits. We will strive to establish an environment where the private sector, based on market forces, can exert its full potential and make Japan the world's most advanced IT nation within five years.”

Environmental issues have gradually received higher priority as illustrated by the fact that the former Environment Agency in 2001 was turned into the Ministry of Environment at the time when the number of ministries was greatly reduced. Immediately after the Kyoto Protocol was adopted at the COP-3 meeting in Kyoto in December 1997, a “Global Warming Prevention Headquarters” was established in the Cabinet. Also for other environmental issues such as solid waste and hazardous chemicals there is a certain degree of inter-ministerial coordination.

Political interest in the promotion of biotechnology and life sciences has increased strongly during the last six ears or so. As elsewhere in the world, the field has been seen as offering great opportunities for the creation and growth of new industries. A fear that Japan was loosing ground to the USA in the field of genomics and related drug discovery motivated increases in government funding for R&D in these fields. More recently the need for policy development outside of R&D has been recognized as well. Inspired by the “IT Strategy Council” the biotechnology and pharmaceutical industry urged the government to establish the “Biotechnology Strategy Council”. Such a council was established in July 2002 with the Prime Minister as chairman and submitted its first report in December the same year.

The fourth priority field nanotechnology/materials has so far largely remained an issue restricted to science and technology policy. It was recognized as a priority field at a rather late stage in the preparation of the Second Basic Plan for S&T. An important trigger was the announcement of by the Clinton Administration of the National Nanotechnology Initiative in July 2000. As Japan prided itself of already being at the forefront of nanotechnology, the US initiative prompted the inclusion of nanotechnology among the priority fields.

The selection of life sciences, IT and environment as priority fields emerged after discussions over several years. Importantly these fields had come to be recognized as being important both for the development of future Japanese society and for the creation and growth of future industries. In the case of life sciences, the connection with social needs was primarily related to health, including indirectly through the development of foods, and to some extent through the their potential of solving environmental problems. As mentioned earlier the ageing Japanese society was seen as a major factor making the prevention and curing of disease increasingly important.

It is interesting to note that the strategy for nanotechnology has largely come to intersect with the other three priority fields. Devices and materials for use in IT, environment and energy related applications, and health related applications are seen as major objectives for promotion of nanotechnology. In a way nanotechnology therefore serves as a supplier of new basic technologies for the three other priority fields.

It should also be noted that there is a stronger link in Japan than in Sweden between the development of society and development of domestic industry. Development of new industry will in Japan almost always be strongly linked to the transformation of Japanese society in one way or another. The simple reason is that due to the size of the Japanese economy, the domestic market will, with few exceptions, be the single most important market for Japanese companies. In reverse, Japanese companies have traditionally been expected to dominate the domestic market in most fields. While the latter can no longer be taken for granted, the domestic market will continue to be the primary focus of Japanese firms, although their sustained competitiveness will require that they achieve a presence on global markets.

1.14 Contributing to economic revitalization

The expected contribution to the future development of the Japanese society and economy is clearly the main reason for the strong political support for increasing government spending on science and technology. An increasing share of government funded R&D-projects are carried out in cooperation between industry, academia, and government research institutes.

It is not possible to estimate the scale of the resources being devoted to projects of this kind, as there does not need to be any transfer of funds from the government to the private sector for such cooperation to take place. Data showing government funding of R&D performed in industry therefore is not a particularly relevant indicator. As an example may be mentioned that a large part of the research performed at the National Institute of Advanced Industrial Science and Technology (AIST) has direct relevance to industry but has so far received almost no financial support from industry. Almost 6000 persons work at AIST, of whom around 2300 are "permanent" research staff.

While there were earlier many obstacles to effectively managing cooperative projects across sectors many of these obstacles have already been removed and most of remaining ones will be removed as national universities become IAI:s in 2004.

There are in fact several reasons to believe that the cooperation between companies, universities, and other research organizations may become more productive and produce more innovation in Japan than in most countries, possibly including the USA. Japanese industry already has a very high research capacity in most fields, and a large number of companies are usually active in each field. There should therefore be few problems for researchers in universities and research institutes to find suitable industrial partners also in the most advanced technical fields.

1.15 A Nation Built on Intellectual Property

A topic closely related to science and technology, which has received high-level political attention in recent years, is that of intellectual property. As intellectual property was considered an issue crossing the boundaries of many ministries and not limited to science and technology the Strategic Council on Intellectual Property was set up in February 2002 "in order to quickly establish and advance a national strategy for intellectual property".

Based on the strategy proposed by the Council in July 2002 a new Basic Law on Intellectual Property was enacted in March 2003 and a promotion program for "creating, protecting and utilizing intellectual property" adopted by the cabinet in July 2003. Measures for encouraging the creation of IP mainly focus on universities, including ways to increase the attention given to IP among university researchers, the role of technology licensing organizations (TLO), cooperation between industry and universities and the establishment of new ventures based on seeds from universities. Proposed measures for strengthening the protection of IP include areas like regenerative medicine, new plant varieties, computer software, design models, and brand names. Greater involvement in international standardization is one of the measures proposed to improve the practical utilization of IP. A special section is devoted to promotion of the "contents industry" emphasizing the strong link, which exists between this industry and culture and arts. Strengthening of education of specialists in IP law and management is also suggested.

The USA is regarded as the model for how universities should manage their intellectual property. The passing of the Bayh-Dole Act in 1980, which gave American universities the right to patent technology resulting from research funded by the federal government, is considered to have contributed to the alleged success of American universities in generating and transferring technology to industry. It has therefore been suggested that Japanese universities in the same way should be given the rights to the inventions produced by research, which is conducted on their premises. These rights today belong either to the individual researchers or in special cases to the government, but a change is expected.

1.16 Regional development

An overwhelming part of R&D activities in Japan are concentrated in either the region including and surrounding Tokyo (Kanto) or in the region centered on Osaka, Kyoto and Kobe (Kansai).

While it is probably correct to say that the regional dimension has not been very pronounced in Japanese national science and technology policy, there are certainly examples of promotion measures, which have included an explicit regional dimension. Decisions about the location of new national universities have, for example, ever since the establishment of the imperial universities included considerations concerning regional distribution.

Policy initiatives to encourage technology transfer from academia to companies, research cooperation between universities and industry, as well the creation of new venture companies based on seeds from universities have in practice usually had an explicit regional dimension. A number of such measures have seen the light during the last 20 years starting with Centers for Collaborative Research supported by the Ministry of Education and the Technopolis program supported by the Ministry of Industry and Trade.

Recently both MEXT and METI have launched cluster programs. Financed by MEXT, the “Intellectual Clusters” program has awarded 35 MESK per year to each of 13 regions for carrying out R&D-projects in cooperation between industry, academia and other research organizations. The clusters, which have been selected through an open competition, focus on IT, life sciences, and nanotechnology.

One of the clusters is the “Greater Kansai Cluster” in life sciences, involving both Osaka and Kobe. Resources for developing this cluster, have been channeled through a number of other initiatives as well. A couple of years ago, an initiative to promote regenerative medicine was concentrated here. This was partly in response to criticism that earlier large scale life science programs in fields such as brain science and genomics were all located in Kanto but could also be justified by the scientific competence already accumulated in the region. Osaka has received special funding for development of Saito, a new life science park near its university hospital and medical school, as part of a grant for urban revitalization. At least some prefectures and some of the large cities have special sections devoted to the promotion of industrial development and academia-research cooperation in high technology fields.

Another major regional science and technology initiative also focuses on life sciences and biotechnology. The Japanese government has declared that it plans to open a new world-class graduate school university in Okinawa in September 2006 focusing on life sciences and nanotechnology. The plan calls for an investment of 5.7 billion SEK and an annual operating budget of 1.4 billion SEK. The university will be established by the public sector but be run as a private institution. The idea is to invite top scientists from all over the world to teach and do research at the new university. The Japanese government has sought advice from Nobel laureates and other leading international scientists in designing the university.

1.17 Cooperation with other countries in Asia-Pacific

The manufacturing sector of Japan has during the last decade experienced growing competition from its Asian neighbors, first from Korea and Taiwan especially in advanced electronic products, and more recently from China in a number of labor-intensive industries. To meet this competition, Japanese manufacturing firms have tried to shift their focus towards higher value-added products and during the last couple of years undertaken a large-scale relocation of factories to China. While initially the market for the latter factories was predominantly outside of China today sales of the output from Japanese firms' manufacturing in China is fairly evenly divided between China, Japan, and other countries, primarily USA and EU.

Until quite recently China was primarily seen as a threat to Japanese industry. Lately the tone of commentary has markedly changed due to unexpectedly strong growth in Japanese exports of advanced parts and machinery to China. The opportunities offered by China as a market for Japanese companies have come into focus.

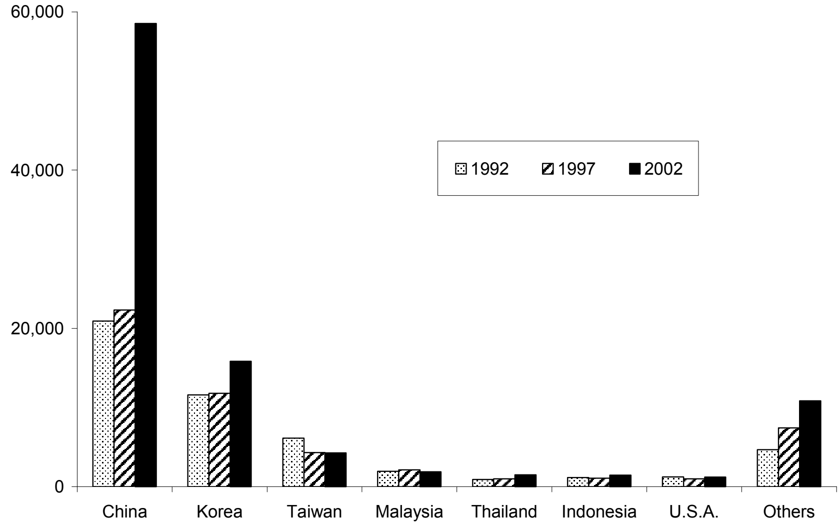
Associated with the growth in their sales and manufacturing in China, Japanese firms have also expanded their R&D activities in China. Rapid upgrading of the level of industrial technology in China, strong demand for the new high-end products, and a shortage of software engineers in Japan are some factors, which have contributed to speeding up this process.

According to a recent OECD-report[1], in 2001 China spent USD 60 billion on R&D. The currency conversion has been done using so-called purchasing power parities (PPP). The corresponding figures for Japan and Korea for the same year were USD 104 billion and USD 22 billion respectively. Added together these three countries spent USD 186 billion, which was the almost exactly the same as for the whole of the EU!

Most likely the use of purchasing power parities significantly inflate the present R&D-power of China. The quality of R&D-activities in China is, however, rapidly increasing. Establishment of R&D-facilities by foreign firms in China and the return to China of top scientists who have made a research career in the West, especially in the USA, are two major contributing mechanisms.

[1] *OECD Science, Technology and Industry Scoreboard 2003*

Figure 1-1 Foreign Students at Higher Education Institutions in Japan



Note: Number of foreign students who enter Japan with student visas to attend Japanese universities, graduate schools, Junior colleges, technical colleges or vocational schools for educational purposes.

Source: MEXT

Many students from China, Korea and other Asian countries receive higher education in Japan. The number has almost doubled since 1998 and reached more than 95 000 students in 2002. Chinese students, who account for almost all of the recent growth, make up 61 percent of the total and Korean students another 17 percent.[2]

Most of the foreign students enter graduate school. At the University of Tokyo more than 2000 foreign students were enrolled in 2002, representing 7.3 percent of all students. Almost half were enrolled in doctoral programs, where they represented 16 percent of the total. In engineering a third of all the doctoral students were foreign nationals.

During the last decade there has also been a dramatic shift towards Asia in Japan's exchange of scientists with other countries. This holds both for foreign scientists invited to Japan and Japanese scientists sent abroad as illustrated by data from Japan Society for the Promotion of Science (JSPS), which is an important source of funding for the exchange of scientists (Figure 1-1 and Figure 1-2).

North America still receives 29 percent of all Japanese scientists sent abroad through the JSPS, but the share is down from 54 percent in 1993 and in absolute terms the number has increased by only 20 percent. The number of Japanese scientists going to Europe through JSPS is only half of the number going to North America, but the number has more than doubled since 1993. Surprisingly, a somewhat larger number of Europeans go to Japan through the JSPS than in the opposite direction. Three times as many European as North American scientists come to Japan.

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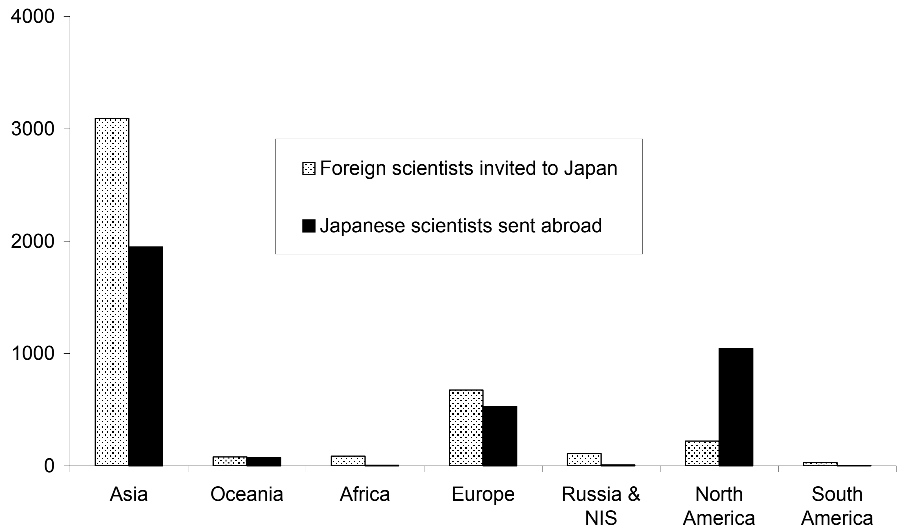
[2] *Numerous cases have been reported of foreign students entering Japan on student visas but then not pursuing their planned studies.*

In terms of exchange with other Asian countries, Korea is today the country receiving most Japanese scientists through the JSPS followed by China and Thailand and then Indonesia (Figure 1-2 and Figure 1-3). Scientists from China dominate the flow in the other direction followed by scientists from Korea. India, Thailand and Indonesia also send many scientists to Japan.

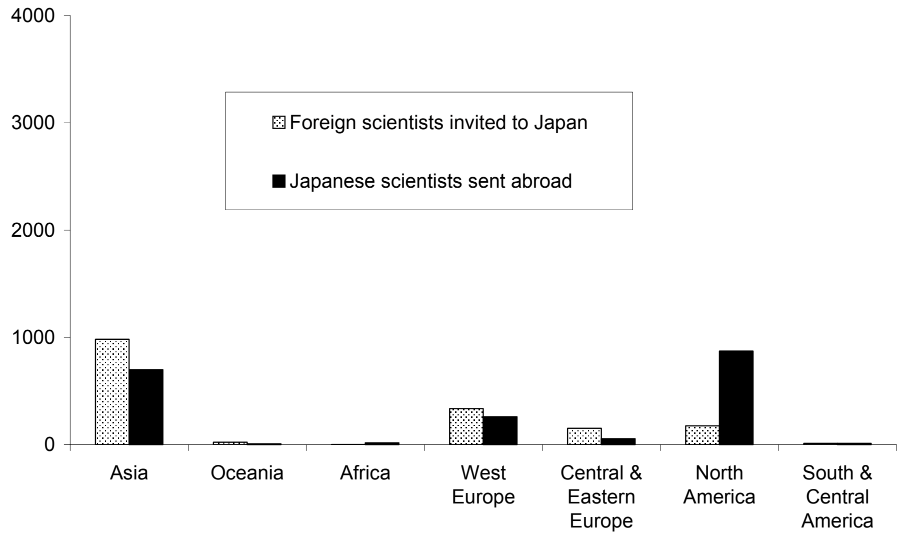
Although JSPS does not account for all the exchange of scientists between Japan and other countries, the changes in the flow through JSPS is in itself noteworthy and suggests that the international linkages of Japanese science may indeed be changing.

Figure 1-2 Number of Scientists Exchanged through JSPS Programs in fiscal year 2002



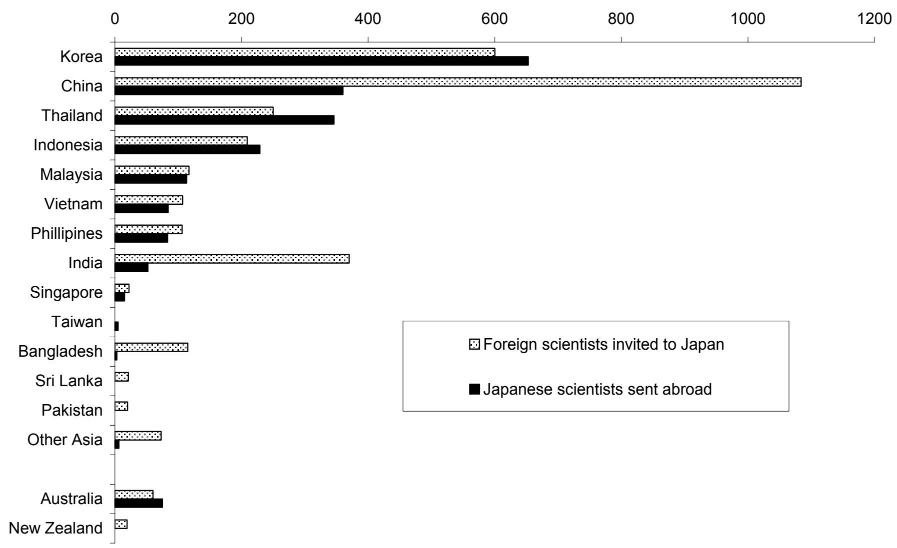
Source: JSPS

Figure 1-3 Number of Scientists Exchanged through JSPS Programs in fiscal year 1993



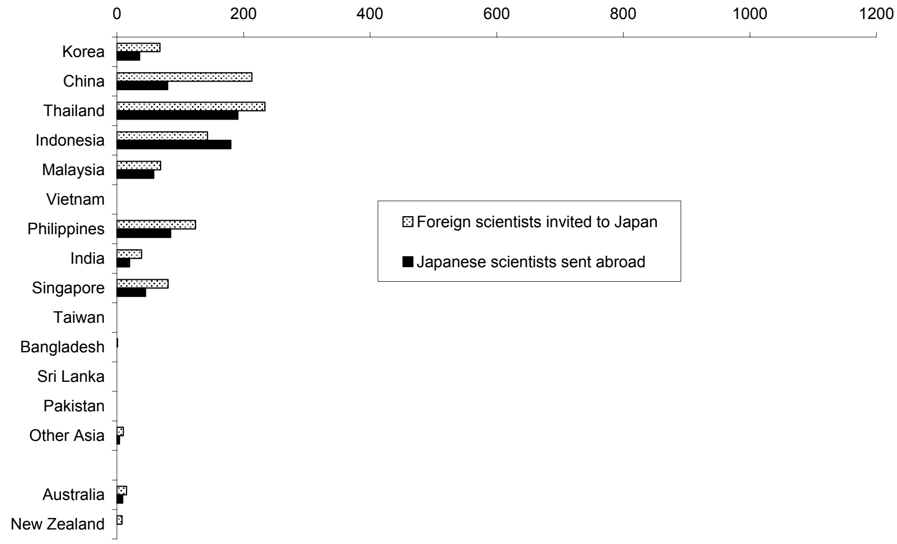
Source: JSPS

Figure 1-4 Number of Scientists Exchanged with Asian countries and Oceania through JSPS



Source: JSPS

Figure 1-5 Number of Scientists Exchanged with Asian countries and Oceania through JSPS



Source: JSPS

2 Quantitative data on R&D in Japan

2.1 Highest R&D-intensity among large OECD-countries

According to the most recent OECD-statistics, R&D-expenditure in Japan represented 3.09 percent of GDP in 2001. This is higher than any of the other large OECD-countries, but lower than Sweden and Finland.

The relative contribution of industry and the government in financing R&D is similar to that in Sweden. In Japan industry financed 73 percent of R&D in 2001 compared to 72 percent in Sweden. The corresponding figures for government financing were 19 and 21 percent respectively.

In the Swedish case the remaining 7 percent were fairly evenly split between financing from abroad and other national funding, a large part of the latter coming from private research foundations. In Japan most of the remaining 8 percent represent private universities' funding of their own research. This number is likely to overestimate the actual R&D-funding of private universities.

2.2 National statistics overestimates R&D expenditure at Japanese universities

The official Japanese figure for total R&D-expenditure as a percent of GDP is 3.29 for 2001. The large discrepancy from OECD data is due to the fact that OECD uses a more conservative estimate of R&D expenditure in Japanese universities than the Japanese Statistics Bureau. The OECD estimate of university R&D expenditure in 2001 was 70 percent of the official estimates by the Japanese government. The OECD estimate is meant to better reflect the actual time spent on R&D by academic staff at Japanese universities.

Even the OECD estimate must, however, be considered as very approximate. In any country estimates of how much time academic staff at universities spend on R&D are highly uncertain. This causes particularly large problems in the Japanese case as almost all salaries of researchers at universities are paid from institutional funds rather than from project funds. In the case of doctoral students, neither institutional funds nor project funds are used for their funding. There are some exceptions to this but they are still fairly small in the large picture. As a result the research work of doctoral students basically does not enter into the R&D statistics at all!

A special problem concerns the large differences that exist among universities in the extent to which academic staff devote themselves to research as well as in the extent to which they are able to attract doctoral students. In the Japanese R&D-statistics, private universities show somewhat larger R&D-expenditure than national universities. Judging from other data that will be presented below, this would appear to greatly inflate the R&D activities of private universities.

Table 2-1 Financial flows in Japanese R&D-system fiscal years 1991, 1996, 2000, and 2001

Fiscal year **1991**, **excluding** humanities and social sciences
billion SEK

	R&D-performing organizations					
Source of R&D-funding	Gov. res. inst.	Universities	Private res. inst	Industry	**Total**	Percent
Government	70.6	62.5	10.1	9.5	**152.7**	16.8
Private universities	0.0	37.8	0.0	0.0	**37.8**	4.2
Private research institutions	0.2	0.0	4.5	0.8	**5.5**	0.6
Industry	1.6	3.8	21.4	685.0	**711.8**	78.3
Foreign sources	0.0	0.0	0.1	0.7	**0.8**	0.1
All sources	**72.4**	**104.2**	**36.1**	**696.0**	**908.6**	100.0
Percent	8.0	11.5	4.0	76.6	100.0	

Fiscal year **1996**, **excluding** humanities and social sciences
billion SEK

	R&D-performing organizations					
Source of R&D-funding	Gov. res. inst.	Universities	Private res. inst	Industry	Total	Percent
Government	90.4	83.6	12.5	8.2	**194.7**	19.7
Private universities	0.0	45.8	0.0	0.0	**45.9**	4.6
Private research institutions	0.0	0.3	4.7	1.1	**6.1**	0.6
Industry	1.7	4.8	26.4	708.3	**741.1**	75.0
Foreign sources	0.0	0.0	0.1	0.9	**1.0**	0.1
All sources	**92.1**	**134.5**	**43.6**	**718.5**	**988.6**	100.0
Percent	9.3	13.6	4.4	72.7	100.0	

Fiscal year **2000**, **excluding** humanities and social sciences
billion SEK

	R&D-performing organizations					
Source of R&D-funding	Gov. res. inst.	Universities	Private res. inst	Industry	**Total**	Percent
Government	104.4	90.4	13.0	13.2	**221.0**	20.6
Private universities	0.0	46.0	0.0	0.0	**46.0**	4.3
Private research institutions	0.0	0.3	6.0	0.6	**7.0**	0.7
Industry	1.1	5.4	28.0	757.6	**791.9**	74.0
Foreign sources	0.0	0.1	0.1	4.4	**4.6**	0.4
All sources	**105.5**	**142.1**	**47.1**	**775.7**	**1070.5**	100.0
Percent	9.9	13.3	4.4	72.5	100.0	

THE FOLLOWING TABLE USES A DIFFERENT CLASSIFICATION. AMONG PRIVAT RESEARCH INST. ONLY NON-PROFIT INST. ARE INCLUDED. HUMANITIES AND SOCIAL SCIENCES HAVE BEEN ADDED.

Fiscal year **2001**, **including** humanities and social sciences
billion SEK

	R&D-performing organizations					
Source of R&D-funding	Gov. res. inst.	Universities	Private res. inst	Industry	**Total**	Percent
Government	104.8	117.5	14.5	11.5	**248.4**	21.0
Private universities	0.0	105.7	0.0	0.0	**105.8**	9.0
Non-profit research institutions	0.2	1.4	5.4	1.3	**8.3**	0.7
Industry	0.9	6.3	5.8	800.6	**813.5**	68.9
Foreign sources	0.0	0.1	0.1	4.4	**4.6**	0.4
All sources	**105.9**	**231.0**	**25.8**	**817.9**	**1180.6**	100.0
Percent	9.0	19.6	2.2	69.3	100.0	

Source: White Paper on Science and Technology 1993, 1998, and 2003

R&D-statistics for Japanese universities is thus very difficult to interpret and its usefulness for more detailed analysis may indeed be questioned. In this report we will use both OECD-data and national statistics but try to help the reader to interpret the data.

2.3 At least 60 percent of government R&D-funding to non-university organizations

Table 2-1 provides an overview of the financial flows in the Japanese R&D-system for 1991, 1996, 2000, and 2001, using the official Japanese R&D-data. In order to conform to OECD standards, the numbers for university funding from government and private universities should both be reduced to around 70 percent of their level in Table 2-1.

In 2001, government funding to research institutes and to universities was of the same size. Using the more conservative OECD estimates for university R&D expenditure, government funding of R&D at universities would be about 70 percent of that going to institutes. Using a plausible estimate of the private universities' self-financing of research it would seem reasonable to conclude that total R&D at universities and at research institutes are comparable in size, although very different in structure.

Less than one percent of financing of government R&D-organizations other than universities comes from industry. This share is expected to increase significantly in the future as most national research institutes have been or will be transformed into so called Independent Administrative Institutions (IAI), allowing them to receive income from private sources, which was prohibited under their status as national research institutes.

Between 2000 and 2001, the classification of private research institutes in the R&D-statistics was changed and only non-profit private research institutes are included in this category from 2001. This reduced the size of the sector by 50 percent from 2000 to 2001. Although the sector is a small part of the total R&D-system it has in some cases had an important function of combining public and private R&D-funds and R&D-personnel from several companies. As most of the restrictions on the acquisition and utilization of resources at government research institutes and other government R&D-organizations, including national universities, are being removed, the need for private institutes as platforms for cooperation and joint utilization of resources is likely to diminish.

2.4 Small share of industry R&D directly financed by the government

In fiscal year 2001, only 1.4 percent of R&D, which was performed in industry was financed by the government. This is a smaller share than in most other large OECD-countries. A major reason for this may be that the system of public procurement of military and other types of equipment in Japan does not seem to include any separate financing of R&D in companies. In reality significant R&D is, however, required by industry in order to meet the requirements specified in the procurement contracts. It is not here possible to estimate the indirect financing of R&D in industry through public procurement contracts. It need to be emphasized that, while 1.4 percent is a small share, in absolute terms it still represented 11.5 billion SEK in 2001, mostly used for highly risky R&D-projects.

Promotion of cooperation between industry, universities and government R&D-organizations is one of the elements in Japanese science and technology policy. This means that a significant part of the R&D funded by the government at universities and research institutes is performed in cooperation with industry. The direct subsidies of industrial R&D is therefore probably not a very good indicator of the magnitude of the R&D-resources actually put at the disposal of industry by the government in Japan. The same is of course also true in a number of other countries.

2.5 20 percent of university project funding from industry

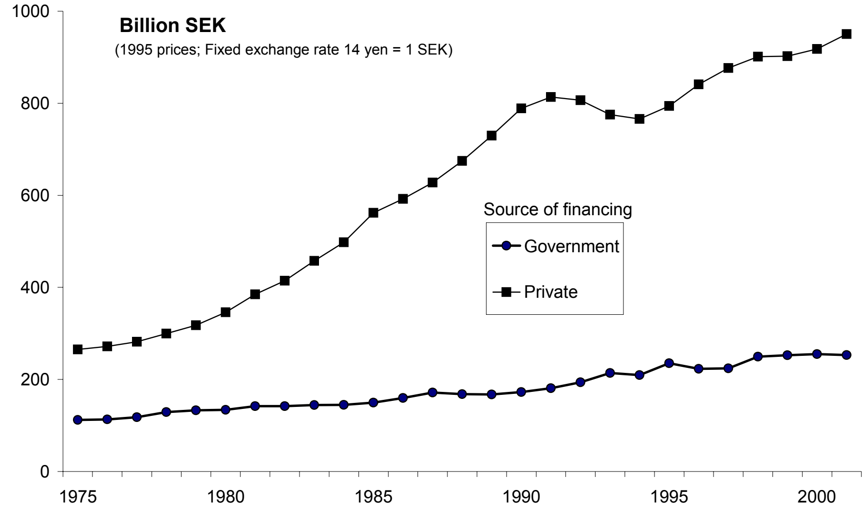
In 2001, industry contributed around 6 billion SEK in research funds to universities. This represented around 2.7 percent of total R&D-expenditure at universities. Looking only at natural sciences and engineering and using OECD estimates of universities' institutional funds for R&D the share would be around 5 percent. More important in judging the significance of industrial funding is, however, that in 2001 only around 30 billion SEK, or 13 percent, of university R&D-expenditure was covered by external project funding. The industry share of project funding was thus around 20 percent. Different from Sweden and many other countries, project funding of research at national universities is rarely used to pay for salaries. Only since the mid 1990:s has it been possible to use project funds to pay for postdoctoral students. Salaries of teaching staff and doctoral students can basically still not be paid from project grants. As national universities are changed into Independent Administrative Institutions (IAI) in April 2004, these regulations are likely to change. There is also a general policy to increase the share of competitive funding in the total government financing of universities.

2.6 Slower growth in industry R&D after bursting of financial bubble

Figure 2-1 and Figure 2-2 show the development of R&D-expenditure by source of financing in Japan during the period 1975-2001 as measured by the annual R&D Survey. During the 1980:s private spending on R&D grew at a remarkably high rate of almost 9 percent per year in real terms. As industry makes up around 90 percent of private R&D spending the development of the latter corresponds more or less to the development of industry financing of R&D.

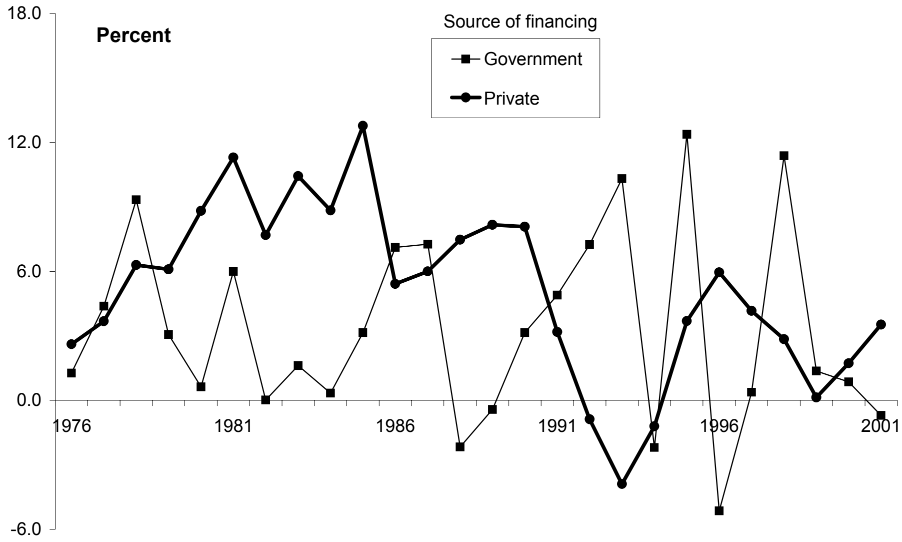
Except for 1992-1994, when industrial R&D spending was reduced following the bursting of the financial bubble built up during the latter half of the 1980:s, industry R&D-financing has grown also during most of the 1990:s but at a much slower pace than during the previous decade.

Figure 2-1 Development of R&D-expenditure in Japan 1975-2001 by source of financing.



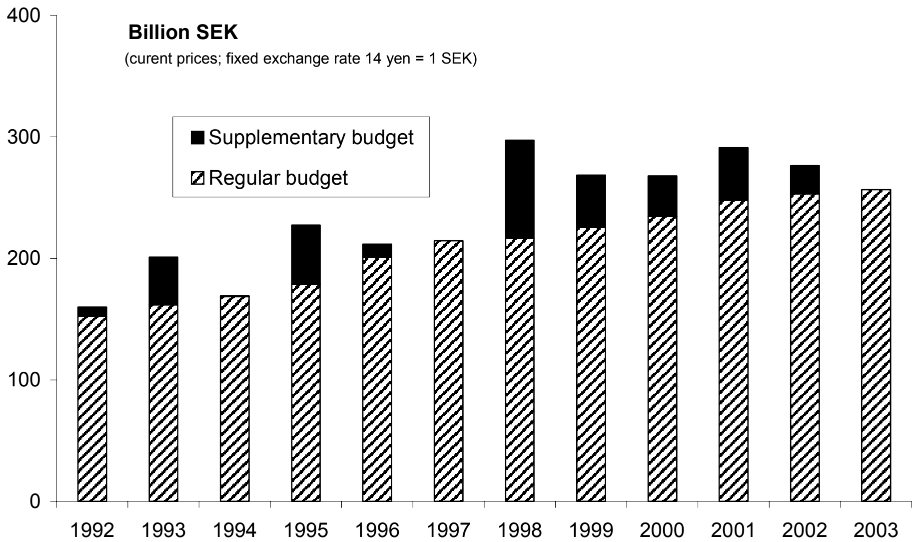
Source: White Paper on Science and Technology 2003. MEXT, June 2003.

Figure 2-2 Estimated real growth in R&D-expenditure from previous year in Japan 1976–2001,



Source: White Paper on Science and Technology 2003. MEXT, June 2003.

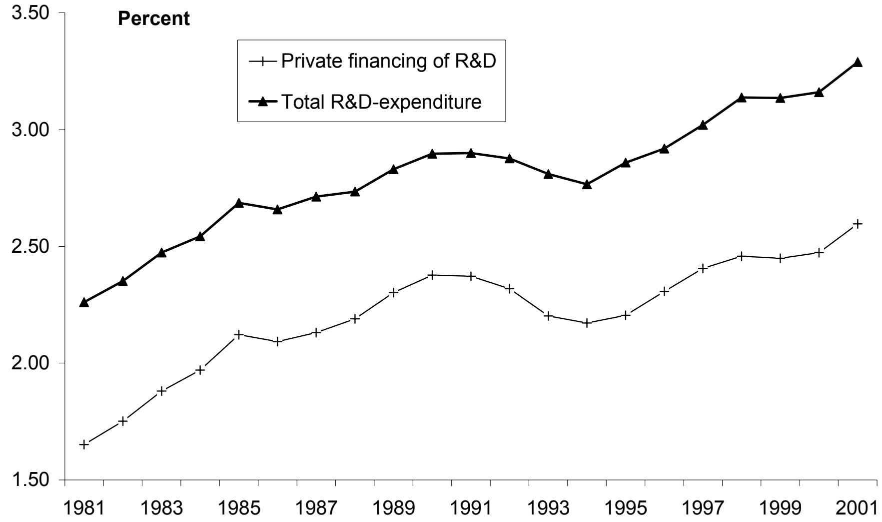
Figure 2-3 Central government financing of R&D in Japan fiscal years 1992–2003



Note: No adjustment has been made for price changes. Using 2001 as the base with price index 100, the "R&D-price level" in 1991 was 100.8 and in 1998 103.2 (prices have decreased during the last few years!). The same exchange rate for converting from yen to SEK has been used for all three years.

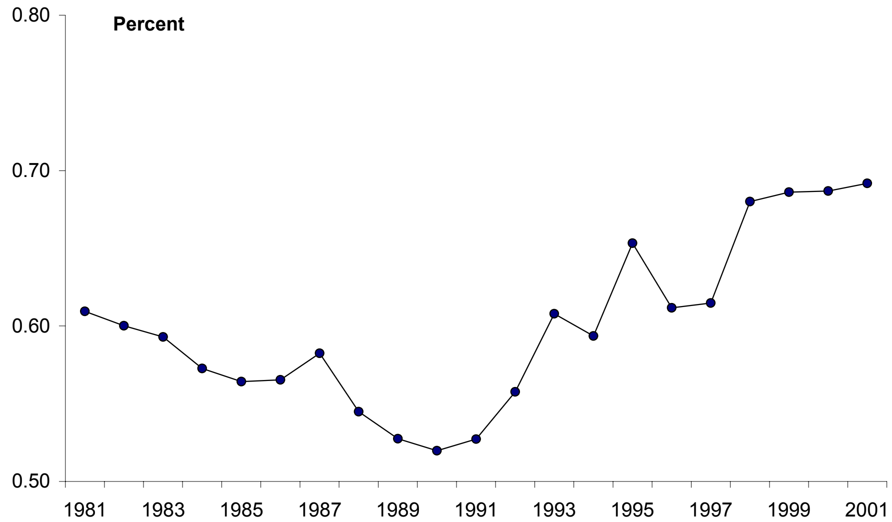
Source: Page 256 in "Trends in Japan's Industrial R&D Activities – Principal Indicators and Survey Data", METI November 2002. Data on supplementary budget for 2002 and regular budget for 2003 taken from page 2 in "Progress of S&T policy based on the Basic S&T Plan for 2001-2005", CSTP 27 May 2003.

Figure 2-4 Total R&D-expenditure and privately financed R&D-expenditure respectively as a percentage of GDP in Japan 1981-2001



Source: White Paper on Science and Technology 2003, MEXT.

Figure 2-5 Government financed R&D-expenditure as a percentage of GDP in Japan 1981-2001



Source: White Paper on Science and Technology 2003, MEXT.

2.7 Supplementary budgets added 81 billion SEK in 1998

Government financing of R&D has shown the reverse pattern of that of industry financing with a higher average growth rate during the 1990:s than during the 1980:s. At the same time the changes from one year to the other, up as well as down, were more pronounced during the 1990:s. The reason for this volatility is explained in Figure 2-3. It shows the development of science and technology related expenditure by the central[3] government 1992-2003 in nominal terms.[4] Most of the large year-to-year variations are due to the difference in size of supplementary budgets between years. Supplementary budgets have been used as a tool by the government to stimulate the economy. In certain years two or three supplementary budgets have been adopted during the same year. While the main part of supplementary budgets has concerned public works expenditure, spending on S&T related items have been quite significant in relation to the regular budget for S&T. During the period 1992-2002, supplementary budgets represented 12.8 percent of total S&T-related budgets. In the single year of 1998, supplementary budgets added 81 billion SEK for S&T related items.

The supplementary budgets for S&T have typically been used for investments in large research facilities, for the acquisition of expensive research equipment or for the carrying out of costly R&D-projects. In many cases the supplementary budgets have been used to speed up investments, which were planned to take much longer to complete using regular budgets. The supplementary budget decided in a certain fiscal year may only partly be reflected in R&D-spending in the same year. A supplementary budget is usually mainly spent during the following year, somewhat depending on when during the year it is decided.

R&D-expenditure has been increased during the last decade in spite of a poor performance of the Japanese economy leading to an in increase in the share of GDP spent on R&D from 2.77 percent in 1994 to 3.29 percent in 2001 (Figure 2-4). Government R&D-spending as a share of GDP increased from a low of 0.52 percent in 1992 to 0.69 in 2001 (Figure 2-5). OECD data shows a much slower increase from 0.53 percent in 1991 to 0.57 percent in 2001. The reasons for this discrepancy are not clear as it can only partly be explained by differences in the estimates of university R&D expenditure.

[3] *S&T related expenditure in the regular budgets of local governments in fiscal year 2002 amounted to 512.7 billion yen as compared with 3544.4 billion yen for the central government.*

[4] *Price changes for R&D activities were very small during the period with the price index moving increasing from 99.7 in 1992 to 102.2 in 1997 and then falling to 98.0 in 2001. After that it has probably fallen a bit further.*

2.8 Target of 24 trillion yen in Second Basic Plan for S&T

There is a goal to further significantly increase government spending on R&D. The Second Basic Plan for S&T sets a target for government S&T-related spending of 24 trillion yen for the period 2001-2005. This would raise the S&T-related government budget to 1 percent of GDP at the end of the period, assuming a GDP growth of 3.5 percent per year. This would represent an increase in government S&T-related expenditure of 19 percent compared to the period 1995-2000.[5] It seems, however, likely that neither the assumption of GDP growth nor the target of 1 percent of GDP will be fully realized by 2005.

For comparison it may be mentioned that government S&T-expenditure in 2001 represented 0.91 percent of GDP, around 0.2 percent higher than the estimated share of GDP devoted to R&D-expenditure. The reasons for this large discrepancy are not clear, although part of the reason is that S&T is a broader concept than R&D. In any case the need to be careful in comparing national statistics for S&T and R&D should be obvious.

2.9 Doctoral studies concentrated to national universities

Considering the unreliable nature of R&D-statistics for Japanese universities, other types of data will be used in the following to describe the structure of the Japanese university system.

Japan has a large higher education sector. In 2002, 40.5 percent of high school graduates of that year entered universities. In Japan universities are defined as any higher institution, which awards at least Bachelor's degrees (after four years study). In addition there are also two-year colleges and other institutions for post high school education.

Japanese universities are classified in three groups: private universities, national universities, and other public universities. "Other public universities" are either run by prefectures or by city governments, and are simply labeled "public universities" in this report. Table 2-2 - Table 2-4 provide some basic data on the completion of coursework for different degree levels in 1997 and 2002 by different types of universities by field of study and by sex.

Private universities dominate basic university education with 78 percent of all completed Bachelor's courses, compared with 18 percent for national universities and 3.5 percent for public universities. In the humanities and social sciences the share is close to 90 percent, while in natural sciences and agriculture it is just over 50 percent and in education only 40 percent.

[5] During the latter period central government S&T-related expenditure was 17.65 trillion yen. No data for local government S&T-related expenditure is available for this period. In 2001 the regular budget for S&T-related expenditure of local governments was 0.50 trillion yen. Using this figure for each of the pervious five years would produce a total government related S&T-related expenditure of 20.15 trillion yen.

Reflecting the larger resources allocated by the government to the national universities for research, the latter make up 72 percent of all students who completed Doctor course studies, with even higher shares for natural sciences, agriculture and engineering. Master's courses fall somewhere between the pattern for Doctor's and Bachelor's courses.

Women are still underrepresented in higher education especially in graduate schools, but their share is growing fast.

Graduate course students expanded by about one third between 1997 and 2002while Bachelor's course studies remained almost unchanged.

Table 2-2 Degrees awarded at Japanese universities in 2002 by type of degree, field of study, and type of university

2002

Field of study	Completed Bachelor's courses				Completed Bachelor's courses			
	Total	National U.	Public U.	Private U.	Total	National U.	Public U.	Private U.
Humanities	94 024	7 450	3 561	83 013	100	8	4	88
Social Science	217 838	17 722	6 965	193 151	100	8	3	89
Natural Science	19 369	7 638	902	10 829	100	39	5	56
Engineering	103 682	32 960	2 771	67 952	100	32	3	66
Agriculture	15 440	7 008	555	7 877	100	45	4	51
Medicine	18 236	3 547	2 086	12 603	100	19	11	69
Home Economics	10 766	339	563	9 864	100	3	5	92
Education	31 979	18 776	272	12 931	100	59	1	40
Art & Music	14 913	583	751	13 579	100	4	5	91
Others	10 083	2 369	589	7 125	100	23	6	71
Total	**536 330**	**98 392**	**19 015**	**418 924**	**100**	**18**	**4**	**78**

2002

Field of study	Completed Master's courses				Completed Master's courses			
	Total	National U.	Public U.	Private U.	Total	National U.	Public U.	Private U.
Humanities	4 603	1557	209	2837	100	34	5	62
Social Science	9 382	2724	356	6302	100	29	4	67
Natural Science	5 741	4078	347	1316	100	71	6	23
Engineering	28 538	18366	1121	9051	100	64	4	32
Agriculture	3 515	2937	166	412	100	84	5	12
Medicine	3 116	1495	300	1321	100	48	10	42
Home Economics	430	100	112	218	100	23	26	51
Education	4 737	4182	22	533	100	88	0	11
Art & Music	1 358	334	234	790	100	25	17	58
Others	3 855	2503	178	1174	100	65	5	30
Total	**65 275**	**38276**	**3045**	**23954**	**100**	**59**	**5**	**37**

2002

Field of study	Completed doctor's courses				Completed doctor's courses			
	Total	National U.	Public U.	Private U.	Total	National U.	Public U.	Private U.
Humanities	1 174	461	49	641	100	39	4	55
Social Science	1 026	427	55	520	100	42	5	51
Natural Science	1 607	1 333	93	118	100	83	6	7
Engineering	3 073	2 508	117	399	100	82	4	13
Agriculture	941	818	21	54	100	87	2	6
Medicine	4 141	2 969	286	1 156	100	72	7	28
Home Economics	52	10	11	31	100	19	21	60
Education	288	181	4	82	100	63	1	28
Art & Music	74	27	7	35	100	36	9	47
Others	996	878	9	106	100	88	1	11
Total	**13 372**	**9 612**	**652**	**3 142**	**100**	**72**	**5**	**23**

Source: Basic Research Report on Japanese Schools, Higher Education Volume, MEXT 2003.

Table 2-3 Share of women among graduates from Japanese universities in 2002 by degree, field of study and type of university

2002	Women's share			
Field of study	Completed Bachelor's courses			
	Total	National U.	Public U.	Private U.
Humanities	70,4	62,1	78,3	70,9
Social Science	29	32	42	28
Natural Science	27	27	37	26
Engineering	11	12	16	10
Agriculture	40	42	52	38
Medicine	72	74	87	69
Home Economics	96	100	89	97
Education	61	61	76	61
Art & Music	71	65	72	71
Others	52	58	66	48
Total	**39**	**36**	**54**	**39**

2002	Women's share			
Field of study	Completed Master's courses			
	Total	National U.	Public U.	Private U.
Humanities	56	55	59	57
Social Science	31	33	33	30
Natural Science	22	22	25	18
Engineering	9	9	10	8
Agriculture	34	33	35	37
Medicine	51	52	61	49
Home Economics	88	92	68	97
Education	48	47	45	59
Art & Music	60	59	62	59
Others	36	34	47	37
Total	**26**	**24**	**33**	**28**

2002	Women's share			
Field of study	Completed doctor's courses			
	Total	National U.	Public U.	Private U.
Humanities	48	49	41	48
Social Science	30	26	29	33
Natural Science	15	14	22	11
Engineering	9	9	9	8
Agriculture	24	23	33	26
Medicine	25	23	20	26
Home Economics	77	100	27	87
Education	51	47	75	59
Art & Music	51	52	29	51
Others	31	32	0	30
Total	**24**	**21**	**21**	**31**

Source: Basic Research Report on Japanese Schools, Higher Education Volume, MEXT 2003.

Table 2-4 Percentage growth during the period 1997-2002 in the number of degrees awarded by Japanese universities by degree level, sex, field of study, and type of university

Field of study	Completed Bachelor's courses; growth 1997-2002 (percent)					
	Total	Men	Women	National U.	Public U.	Private U.
Humanities	8	6	9	-1	16	8
Social Science	3	-6	33	-4	12	3
Natural Science	5	2	14	0	28	7
Engineering	2	-1	37	2	44	0
Agriculture	1	-6	15	-3	27	4
Medicine	-26	-58	6	-50	39	-22
Home Economics	8	83	7	4	-21	11
Education	-8	-10	-7	-14	-16	2
Art & Music	8	1	11	1	8	9
Others	62	52	72	105	146	47
Total	2	-5	16	-5	20	4

Field of study	Completed Master's courses; growth 1997-2002 (percent)					
	Total	Men	Women	National U.	Public U.	Private U.
Humanities	24	21	26	36	25	18
Social Science	67	65	72	59	43	73
Natural Science	9	4	29	8	26	8
Engineering	22	18	84	18	48	28
Agriculture	15	1	57	14	48	15
Medicine	53	24	99	56	101	43
Home Economics	20	43	18	22	44	10
Education	14	10	18	11	267	32
Art & Music	38	23	49	1	44	61
Others	104	91	132	113	324	74
Total	29	23	53	23	52	38

Field of study	Completed Doctor's courses; growth 1997-2002 (percent)					
	Total	Men	Women	National U.	Public U.	Private U.
Humanities	28	11	52	27	40	23
Social Science	58	46	94	49	57	59
Natural Science	40	33	108	35	75	12
Engineering	26	22	100	20	105	36
Agriculture	35	21	108	26	200	23
Medicine	20	18	78	37	13	12
Home Economics	63	500	33	0	175	72
Education	60	44	79	26	33	148
Art & Music	100	100	100	-25	*0 in 1997*	3400
Others	219	176	386	192	*0 in 1997*	864
Total	36	28	91	37	46	32

Source: Basic Research Report on Japanese Schools, Higher Education Volume, MEXT 1998 and 2003

Private universities' share of Master's courses increased noticeably while there was a smaller increase in National universities' share of doctor's courses.

The number of students completing Doctor's courses is still rather small in absolute terms at around 13 400 in 2002.

2.10 Eight universities gave out 40 percent of all doctor's degrees

There is a strong hierarchy among Japanese universities. The distribution of Doctor's degrees among universities illustrates this very clearly. In 1999 eight universities each awarded more than 300 doctor's degrees. These were all national universities and except for Tokyo Institute of Technology, they are identical with the seven former imperial universities.[6] Together the eight universities counted 40 percent of all doctor's degrees awarded in 1999 and 53 percent of all doctor's degrees from national universities. Another 9 national universities, one public university, and one private university giving out more than 100 doctor's degrees made up an additional 16 percent of the total number of doctor's degrees.

Comparing the data for 1994 and 1999, the national universities increased their share of doctor's degrees from 60 to 77 percent during this period.[7]

2.11 "Thesis doctorates" loosing in appeal

Figure 2-6 provides some additional perspective on changes in Japanese research degrees. In addition to the regular Doctor's degrees, which are awarded to doctoral students, who enroll in a doctor course program, so called "thesis doctorates" are also awarded based solely on the submission of a doctoral thesis. This has been particularly common in engineering, medicine, and agriculture, where thesis doctorates in 1994 were almost as common as course doctorates. During the expansion of doctor course studies in the 1990s, the granting of thesis doctorates has, however, not kept pace and even decreased in absolute numbers.

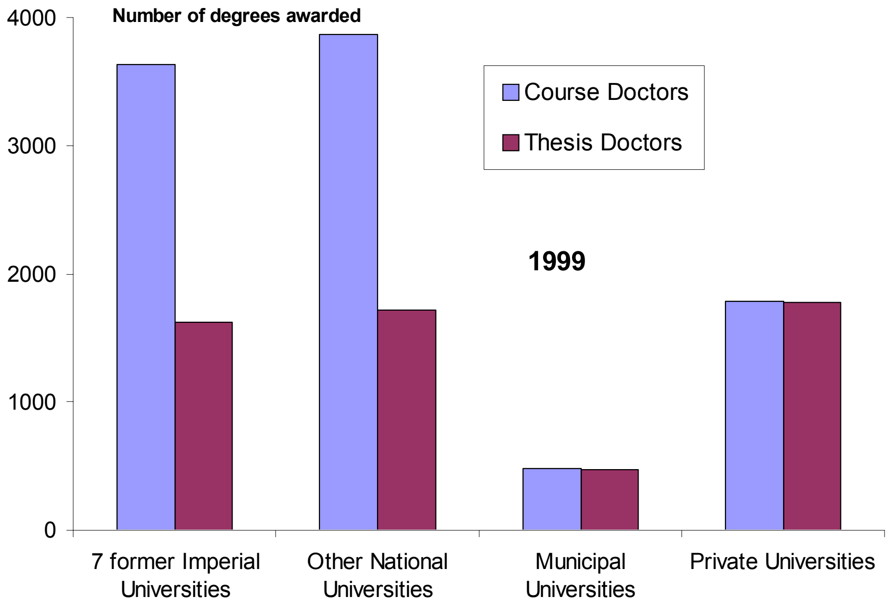
The fact that thesis doctorates have lost ground to course doctorates is a significant phenomena for the Japanese research system. It can be interpreted as an indication that universities are becoming relatively more attractive as research environments compared to alternative research organizations such as companies or hospitals. There is no doubt that conditions for research at Japanese universities have improved during the last decade. At the same time it appears that the opportunities for exploratory research at companies have decreased following the poor performance of many Japanese companies in the wake of the bubble economy of

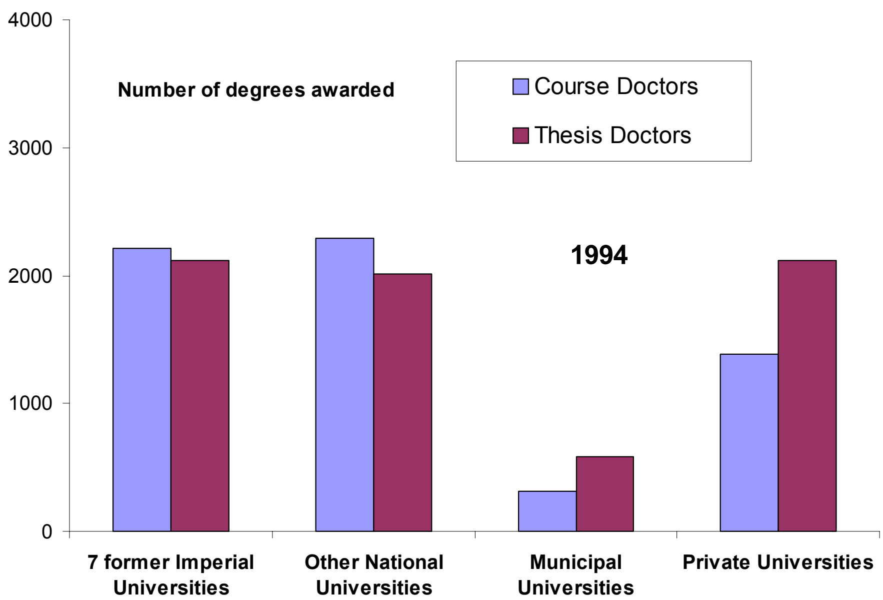
[6] *Listed according to the number of awarded doctorates in 1999, the eight universities were: The University of Tokyo (894), Kyoto University (558), Osaka University (551), Tohoku University (518), Kyushu University (391), Nagoya University (387), Hokkaido University (337), and Tokyo Institute of Technology (337).*

[7] *The share of Doctor's degrees awarded by national universities in 1999 was higher than the national universities' share of completed Doctor's courses. The reason for this may either be that doctoral students at national universities get their dissertations approved faster or to a higher extent than students at other universities or that students who take their courses at private and public universities choose to present their theses at national universities, in which latter case they would normally receive "thesis doctorates".*

the late 1980:s. It must, however, be emphasized that many Japanese companies still carry out highly advanced research on a large scale.

Figure 2-6 Doctor's degrees conferred in Japan in 1994 and 1999 by type of university and type of degree



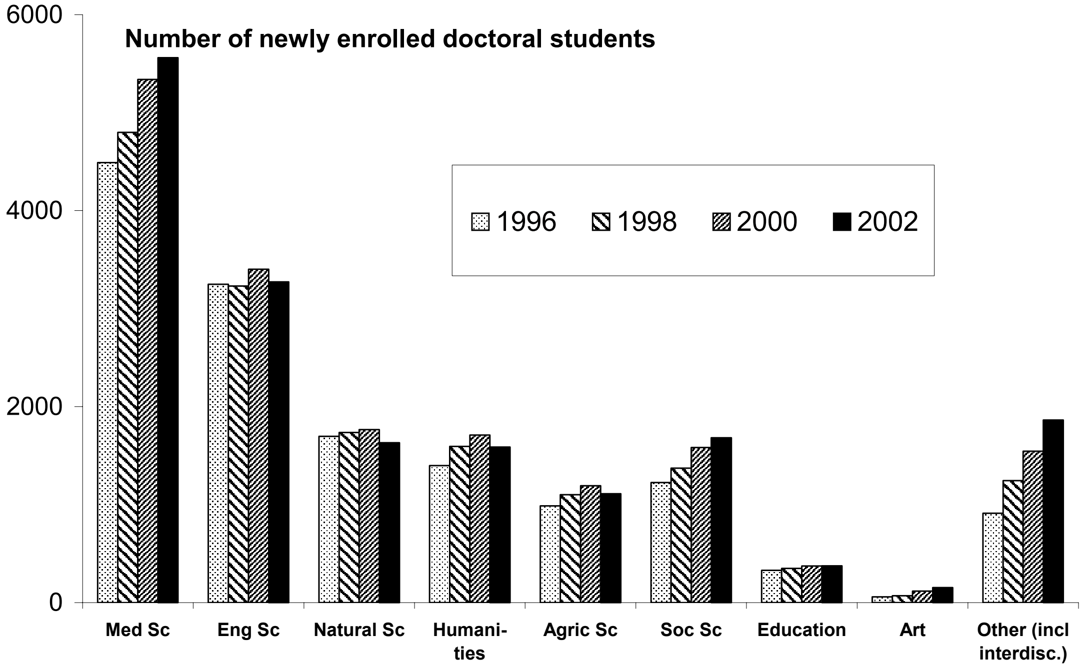


Source: S&T Office compilation based on data in Daigaku Shiryo

According to Figure 2-6 the growth in Doctor's degrees ("course doctorates") was concentrated in the national universities, while there was very little growth in the private and public universities. This picture differs from that of completed Doctors' courses in Table 2-4.[8]

Figure 2-7 shows the development of the enrolment of new doctoral students for different disciplines. Medicine and social sciences shows stronger growth than other disciplines. The fastest growing category is, however, "other fields", which includes interdisciplinary fields.

Figure 2-7 Newly enrolled doctoral students in Japan 1996-2002 by discipline



Source: Basic Research Report on Japanese Schools, Higher Education Volume, MEXT, several editions

[8] *See footnote 8*

3 Trends in Government Funding of Research and Development

3.1 Two thirds of government R&D-funding through MEXT

Almost two thirds of the government budget for science and technology is channeled through the Ministry of Education, Culture, Sports, Science and Technology (MEXT) (Table 3-1).

The role of MEXT is best understood from the fact it was created in 2001 through the merger of the former Ministry of Education (Monbusho) and the Science and Technology Agency (STA). Monbusho, which made up 43 percent of government S&T spending in 2000, was solely concerned with universities and certain institutes considered part of the university system.[9] The STA, which made up 24 percent of government S&T spending in 2000, operated its own research institutes and other R&D-organizations spending most of its resources on areas such as nuclear energy and exploration of space and oceans.[10]

Today the second largest ministry in terms of S&T is the Ministry of Economy Trade and Industry (METI), which controls 17 percent of the S&T budget. Its share has increased from 12 percent a decade ago.

Five other ministries, covering the areas of health, agriculture, telecommunications, environment, and transportation & construction, plus the Defense Agency and the Cabinet Secretariat, each make up between one and four percent of the S&T budget. While they control a small share of the total government resources for S&T, they all play an important role in their respective fields. From a Swedish perspective their resources are still large in absolute terms. The smallest among them, the Ministry of Environment, has an annual S&T budget of more than 2 billion SEK. It is also noteworthy that several of the smaller ministries in S&T terms have increased their share of total government S&T spending significantly during the last decade. This is true for health, telecommunications, construction, and environment, while the share for agriculture has remained stable and that for transportation decreased.

3.2 each ministry still has its own R&D-system

Until recently each ministry has controlled its own R&D-system. This was primarily due to the fact that government funding of universities came solely from Monbusho, either as institutional funds or, to a more limited extent, as project funding in the form of "Grants-in-Aid" administered directly by the ministry. Other

[9] This included 16 large independent "Inter-University Research Institutes" and 20 "Institutes for Joint Use" attached to some of the leading universities.

[10] *The following are some of the organizations, which belonged to STA: The Institute for Chemical and Physical Research (RIKEN), The National Institute of Metals Research (NIMR), the National Space Development Agency of Japan (NASDA), Japan Marine Science and Technology Corporation (JAMSTEC), and the Japan Atomic Energy Research Institute (JAERI).*

ministries used university professors as advisors. To the extent that professors were involved in research projects funded by ministries other than Monbusho, such projects were managed by organizations, often foundations, outside universities. These organizations could then employ research support staff as well as manage other expenses for the research projects. Some of the work has been outsourced to think tanks, of which there is a large number in Japan. Many large-scale surveys in the social sciences, have, for example, been managed in this way. They have benefited from the intellectual input from professors, but otherwise not been part of the university system.

Each ministry has built up its own research institutes or similar R&D-organizations. For most ministries the institutes have been the main way in which they have implemented their S&T policies. In addition they have financed R&D in private companies or in private research institutes. According to the official R&D statistics, financing of R&D in the private sector (excluding private universities) amounted to 26 billion SEK in 2001. As mentioned earlier this number, however, probably does not include R&D done as part of public procurement. Such R&D in private companies may in fact be very sizable considering the large investments made by the Japanese government in satellites, rockets, deep sea vessels, synchrotrons and other high energy physics equipment, supercomputers, and other highly advanced equipment, to say nothing of military equipment.

3.3 Some movement towards common use of universities and research institutes

Since 1995 the role of universities has begun to change and increasingly become a concern for other ministries than Monbusho (today MEXT). This takes different forms. One is for ministries or their agencies to provide funding for researchers at universities, sometimes for projects performed in cooperation with companies or with research institutes. Such funding from ministries other than Monbusho/MEXT has undoubtedly been increasing, but still makes up a small part of total project funding to universities. In certain fields it plays a bigger role, however. One such field is telecommunications, for which there is a special R&D-funding agency, the Telecommunications Advancement Organization (TAO), belonging to the Ministry of Public Management, Home Affairs, Posts and Telecommunications (MPHPT).

Another development has been to offer part time positions for university professors at research institutes in order to lead research at the institutes. As the research institutes often are extremely well equipped, they are attractive places to do research. Double appointment of the key research leaders also gives the research institutes more flexibility in changing the direction of their research.

In general, room has recently opened up for experimentation with new forms of cooperation between universities and research institutes as well as between these organizations and industry. The transformation of national research institutes and national universities into IAI:s is one of several factors that drastically is changing the conditions for such cooperation.. The experimentation process is still at an early stage and it is therefore too early to identify any clear trends.

Table 3-1 Government regular budget for S&T in Japan by ministry for 1992, 1997, 2000, and 2002

	billion SEK			
	FY 1992	**FY 1997**	**FY 2000**	**FY 2002**
Ministry of Education, Culture, Sports, Science and Technology (MEXT)	110,3	144,5	153,8	161,8
Ministry of Economy, Trade and Industry (METI)	18,5	33,7	37,8	42,9
Defence Agency	9,1	12,5	9,7	10,2
Ministry of Health, Labor and Welfare	4,7	6,8	8,3	9,1
Ministry of Agriculture, Forestry, Fisheries (MAFF)	5,4	7,2	8,3	8,7
Ministry of Land, Infrastructure and Transport (MLIT)	2,1	4,5	5,0	5,9
Ministry of Public Mgmt, Home Affairs, Posts and Telecommunications	2,5	4,2	6,2	5,6
Cabinet Secretariat	0,0	0,0	3,7	5,3
Ministry of the Environment (MOE)	0,8	1,3	2,0	2,2
Other ministries	1,0	1,6	1,6	1,3
Total	**154,4**	**216,3**	**236,4**	**253,1**
	Percent of GDP			
	FY 1992	FY 1997	FY 2000	FY 2002
Ministry of Education, Culture, Sports, Science and Technology (MEXT)	0,32	0,39	0,42	0,45
Ministry of Economy, Trade and Industry (METI)	0,05	0,09	0,10	0,12
Defence Agency	0,03	0,03	0,03	0,03
Ministry of Health, Labor and Welfare	0,01	0,02	0,02	0,03
Ministry of Agriculture, Forestry, Fisheries (MAFF)	0,02	0,02	0,02	0,02
Ministry of Land, Infrastructure and Transport (MLIT)	0,01	0,01	0,01	0,02
Ministry of Public Mgmt, Home Affairs, Posts and Telecommunications	0,01	0,01	0,02	0,02
Cabinet Secretariat	0,00	0,00	0,01	0,01
Ministry of the Environment (MOE)	0,00	0,00	0,01	0,01
Other ministries	0,00	0,00	0,00	0,00
Total	**0,45**	**0,58**	**0,64**	**0,71**
	Percent of S&T Budget			
	FY 1992	FY 1997	FY 2000	FY 2002
Ministry of Education, Culture, Sports, Science and Technology (MEXT)	71,4	66,8	65,1	63,9
Ministry of Economy, Trade and Industry (METI)	12,0	15,6	16,0	17,0
Defence Agency	5,9	5,8	4,1	4,0
Ministry of Health, Labor and Welfare	3,0	3,2	3,5	3,6
Ministry of Agriculture, Forestry, Fisheries (MAFF)	3,5	3,3	3,5	3,4
Ministry of Land, Infrastructure and Transport (MLIT)	1,4	2,1	2,1	2,3
Ministry of Public Mgmt, Home Affairs, Posts and Telecommunications	1,6	1,9	2,6	2,2
Cabinet Secretariat	0,0	0,0	1,6	2,1
Ministry of the Environment (MOE)	0,5	0,6	0,8	0,9
Other ministries	0,7	0,7	0,7	0,5
Total	**100,0**	**100,0**	**100,0**	**100,0**

Source: White Papers for Science and Technology

3.4 S&T policy tools

Each ministry has more or less the same main instruments for implementing its S&T policy:

- Institutional funds directly to its own research organizations
- Funding of targeted R&D-projects/programs directly by the ministry to meet strategic objectives
- Funding of targeted R&D-projects/programs oriented towards strategic objectives through an agency attached to the ministry
- Research council type funding managed directly by the ministry
- Research council type funding through an agency attached to the ministry

Project funding, be it from the ministries directly or through agencies, may go to the ministry's own research institute(s), research institutes of other ministries (so far rare), universities, companies or private research institutes. There is no statistics available that shows the relative importance of the different flows for each ministry. In the following we will try to describe major features for some of the ministries and point to new trends in the funding mechanisms.

3.5 METI, AIST, and NEDO

The Ministry of Economy, Trade and Industry (METI) has one major research institute, the National Institute of Advanced Industrial Science and Technology (AIST) and one large R&D-funding agency, the New Energy and Industrial Development Organization (NEDO).

In 2002 AIST had a budget of around 9 billion SEK per year and a total staff of around 5700 of whom 2400 AIST's own research staff, 800 administrative staff, and 2500 visiting researchers.[11] NEDO had a budget of around 18 billion SEK in 2002 and a staff of almost 800. Industry receives the largest part of NEDO's funding. Considering that METI:s total regular budget for S&T in 2002 was around 43 billion SEK, at least 16 billion SEK were distributed via other routes than AIST or NEDO, most of it probably directly from METI's internal bureaus to the private sector.[12] An increasing but still fairly small part of NEDO's or METI's direct project funding goes to universities. Between 1997 and 2002 NEDO increased its budget by 83 percent.[13] Some part of this increase reflects the fact that funding that was previously handled directly by METI/MITI has been transferred to NEDO.

[11] *Other data, which include graduate students and technical staff on short-term contracts, suggest that in total almost 8000 persons work at AIST during a year.*

[12] *The numbers given are very approximate. No adjustments have been made for supplementary budgets, the fact that some of the project funding from NEDO and METI goes to AIST, or the fact that AIST receives some funding from other ministries. Such adjustments are not expected to change the broad picture.*

[13] *Due to the impact of supplementary budgets NEDO's budget shows large variations from year to year. The budget in 2001 was 15 percent higher than the budget for 2002.*

Both AIST and NEDO cover very diverse fields of science and technology. A proper account of their activities is outside the scope of this report, but some examples will be given later. The priorities of both organizations follow government S&T policies, and more specifically the S&T policies of METI. Before AIST became an IAI in 2001, it consisted of 16 separate institutes, each highly independent. When the new AIST was created these institutes were integrated into one institute under unified management. A regrouping of the research units was undertaken to create a more dynamic organization and adapt the organization better to high priority and growing fields. In total there are today 53 research units. 30 Research Centers, 21 Research Institutes, 10 Research Initiatives and 2 Special Divisions. The Research Centers are set up for a limited time (5-7 years) and given high priority in resource allocation. World leading Japanese scientists in their respective fields have in several cases been recruited as Center Directors. The Research Institutes are more long-term organizations and the research is to a large extent based on the ideas and initiatives of the individual researchers. Research Initiatives is a form for flexibly organizing research in promising, often interdisciplinary, areas during a limited time period before their appropriate long term priority or form of organization can be determined.

NEDO was in October 2003 transformed into an IAI. Its role has gradually changed over the years, partly reflecting a change in the style in which METI (and earlier MITI) has defined national projects. The distribution of R&D-funds among companies and other organizations participating in a national project was in the past usually decided already at the outset of a project based on contacts and negotiations between MITI/METI and the individual companies. This method, although still used not only by METI but by other ministries as well, has to some extent been replaced by open call for proposals and decisions based on evaluation of the received proposals. NEDO's role has changed from one of administrating already more or less decided R&D-projects to one of managing R&D-programs, including the selection of projects. It is not clear to what extent NEDO also plays an active part in defining the themes of the programs it funds.

One of the fields, which has recently been given special emphasis by NEDO is nanotechnology. In this field, universities, AIST, companies and other research organizations all appear to be well represented. The same seems to be the case for projects funded directly by METI aiming at combining expertise and technology in biotechnology, nanotechnology and IT.

3.6 Aiming at NIH-like research organization

During the last 10 years the Ministry of Health, Labor and Welfare (MHLW) has doubled its budget for S&T. Since 1997 the increase has been primarily for "Health and Labor Sciences Research Grants" awarded through an open competition for funding. Only a small part concerns 'labor science". The budget for research grants has increased from less than 1 billion SEK in 1996 to around 3 billion SEK in 2003. As a share of MHLW's budget for S&T this corresponds to an increase from 17 percent to 33 percent. The share spent as institutional funds for the research institutes belonging to MHLW has decreased correspondingly, although in absolute terms also the institutes have seen their funding increase. In 2003, universities received 53 percent of total value of MHLW's research grants. It remains, however, unclear if grants to universities have increased at the same rate as the total budget for research grants.

Different from other ministries, MHLW has chosen to keep most of its research institutes as national research institutes rather than transform them into IAI:s. According to some reports, MHLW is aiming at developing some of their research institutes into a system similar to that of the NIH Institutes in the USA. Each institute would then assume the role both as a performer of research and as a funding agency for extramural research at universities and in other organizations.

A similar development is occurring in the telecommunications area as the Ministry of Public Management, Home Affairs, Posts and Telecommunications (MPHPT) is planning to merge the Telecommunications Advancement Organization (TAO), and the Communications Research Laboratories (CRL). The CRL was turned into an IAI in 2001.

3.7 Sector-oriented R&D financed by other ministries

In their respective fields, the Ministry of Agriculture, Forestry and Fisheries (MAFF), the Ministry of Land, Infrastructure and Transport (MLIT), and the Ministry of Environment (MOE), are playing a central role. Together they make up almost 7 percent of government S&T-spending in Japan. In the Swedish system, their responsibility overlaps to a large extent with that of Formas. A big difference is, however, that the Japanese ministries rely primarily on their own research institutes.

MAFF operates a large number of research institutes concentrated in the Tokyo area and experimental stations for agriculture and fishery all over Japan with more than 5 000 employees in total.

The Ministry of Environment (MOE) operates one big research institute, the National Institute for Environmental Studies (NIES), which has a key role in environmental research as well as in providing input to the development of environmental policy. Around half of MOE's budget is used to finance NIES, while 15 percent, or around 360 million SEK, are used for three research programs providing research grants. The largest program deals with global environment problems and grants are distributed to universities and research institutes. A program for waste related R&D is mainly funding projects in companies. Most of the remaining 35 percent are probably used for commissioned R&D aimed at solving specific problems. In the case of MOE the increase in the competitive funding programs occurred in the first half of the 1990:s, while the subsequent growth of the ministry's S&T budget appears to have been concentrated to commissioned R&D.

3.8 Programs for "competitive funding" of research

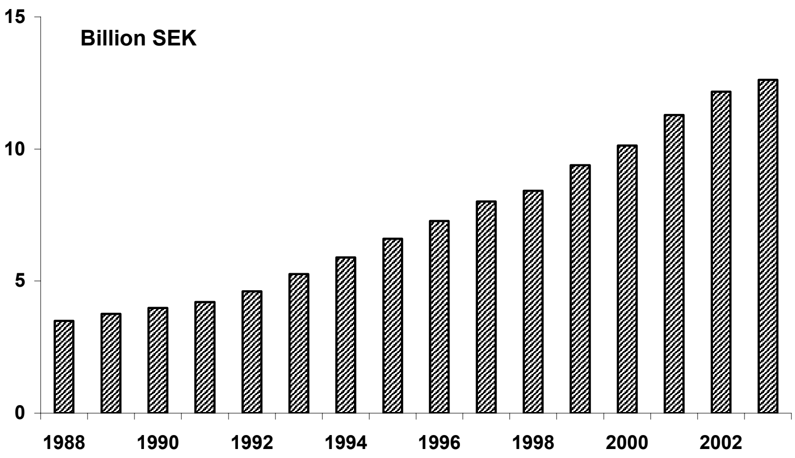
One of the objectives of the Second Basic Plan for S&T is to double the "competitive funding" of research from 2000 to 2005. In 2000 around 21 billion SEK was distributed as competitive funding. The definition of competitive funding limits such funding to "response mode" programs, in which only the general area of research may be defined but no specific targets set and all funding is based on open call for proposals. A large part of government project funding falls outside this definition, e g all except 360 million SEK of the project funding from METI. The major programs meeting this criteria are:

- Grants-in-Aid, administered by MEXT and JSPS (50.6 percent)
- CREST and other programs, administered by JST (12.8 percent)
- Grants for health-related R&D administered by MHLW and the Organization for Pharmaceutical Safety and Research (10.9 percent)
- Special Coordination Funds for Promoting S&T, administered by MEXT under the policy guidance of CSTP (10.8 percent)
- Other programs (14.9 percent)

The Japan Society for the Promotion of Science (JSPS) and the Japan Science and Technology Agency (JST) are both financed by MEXT. Until October 2003, JST was known as the Japan Science and Technology Corporation.

The oldest and largest program for competitive research funding, by far, is the so-called Grants-in-Aid Program financed by MEXT. The administration of this program is today divided between the ministry itself and the Japan Society for the Promotion of Science (JSPS). In 1995 Grants-in-Aid represented around three quarters of all competitive research funding. Since then the sources have become more diversified. While the share of Grants-in-Aid has been reduced, it has experienced a steady growth at an average rate of nearly 10 percent per year during the last 15 years (Figure 1-1).

Figure 3-1 Grants-in-Aid financed by MEXT 1988-2003



Source: MEXT

The Grants-in-Aid Program contains many different types of research grants as shown in Table 3-2 and Table 3-3. Most of the grants are smaller than 1 million SEK (14 million yen) per year, and many much smaller. A sizeable portion of the total budget is, however, allocated to larger projects. When looking at the size of the grants it must be remembered that salaries are usually not paid from the grants, except sometimes for postdoctoral students. Overhead costs are not included in the tables but are paid out at rates that vary dependent on the size and nature of the grants. Smaller grants do not carry any overhead.

Comparing the Grants-in-Aid programs in 1997 and 2002 shows that considerable changes have occurred. More emphasis has been placed on:

- Very large grants (drastic increase of “specially promoted research”; new category “Basic Research (S)”, which offers larger grants than previous categories of Basic Research)
- Priority areas
- Large grants for a select group of young researchers (new program)
- New research areas (new program for “creating new academic fields”; big increase in program for “seed research”)

In 2002, 87 researchers shared 670 million SEK for “specially promoted research”. Each project under this program receives funding under 3-5 years with a maximum of 35 million SEK per project, a limit which may in certain cases be exceeded.

The priority area program funds research according to certain themes. In 2002 there was funding under 140 different themes but new proposals were only funded under 40 themes. The priority areas are seen as deserving special attention either because of a need to strengthen the Japanese scientific community or because of societal demands. In 2001 five new priority areas were started in the fields of life sciences and one in IT as part of the so-called Millenium projects. The funds for these were larger than usual with annual expenditure per area of 75-150 MSEK. These programs represented a big boost for research primarily in genomics. The structure of the funding under the priority areas varies but often 10-20 researchers each receive 1-3 MSEK per year while a larger number of researchers receive funds in the order of a few hundred thousand SEK per year. Each priority area has a coordinator (chairman), who sometimes receives larger funds than the other researchers. There is some cohesiveness to the portfolio of research projects in a priority area and organized communication through gathering of all the project leaders etc.

There is a special program for support of young scientists (age limit 37 years). The grants are given for 2-3 years. Starting in 2002, some of the funds were allocated to large grants. 200 young scientists received these larger type of grants averaging 660 000 SEK per year. Another 8300 received the smaller grants averaging 85 000 SEK per year.

Outside of Grants-in-Aid, JSPS has a separate program for postdoctoral fellowships. Researchers, who receive support under the JSPS program can also apply for research support in a special program “Grants-in-Aid for JSPS Fellows”.

According to data from JSPS, the distribution of Grants-in-Aid between major fields was in 2003, 45.0 percent to “bio-sciences”, 35.8 to “science and engineering”, 17.0 percent to “humanities and socials sciences”, and 2.2 percent to “extensive areas and other”. It is unclear if this refers only to the grants channeled through JSPS or all types of Grants-in-Aid.

Table 3-2 Grants-in-Aid in 2002 by type of grants

2002	Number of projects Applications	Granted	Funding	Funding per grant Average	Highest
	Number		million yen	million yen per project	
Scientific Research Grants	**103181**	**39751**	**130052**	**3,27**	**340,00**
* Specially promoted research	237	87	9366	107,66	340,00
* Priority area research	10519	3777	34256	9,07	112,50
* Basic research (S) (new from	656	135	3274	24,25	61,90
* Basic research (A)	3413	1473	16166	10,98	36,80
* Basic research (B)	16200	7502	32006	4,27	15,80
* Basic research (C)	35366	14688	18889	1,29	3,80
* Exploratory research	14355	2809	3965	1,41	3,90
* Young researchers (A) (new from 2002)	1999	206	1900	9,22	21,80
* Young researchers (B)	17851	8285	10049	1,21	4,30
* Research by school teachers and individual citizens	2585	789	180	0,23	0,27
Regional research cooperation (2002 last year)	**48**	**48**	**516**	**10,76**	**28,10**
Public dissemination of research results	**1515**	**803**	**3047**	**3,80**	**59,80**
Grants-in-Aid for JSPS Fellows	**4179**	**4179**	**4433**	**1,06**	**1,50**
Research for creating new academic fields (new from 2001)	**132**	**55**	**5458**	**99,23**	**300,00**
Total sum	**109055**	**44836**	**143506**	**3,20**	**340,00**

Source: Monbukagakysho. Kagaku Kenkyuuhi Hojoukin. Saitaku Kadai- Koubo Shinsa Youran. Heisei 14 Nendou. Gyousei, Tokyo 2002.

Table 3-3 Grants-in-Aid in 1997 by type of grants

1997	Number of projects Applications	Granted	Funding	Funding per grant Average	Highest
	Number		million yen	million yen per project	
Scientific Research Grants	**93431**	**31726**	**85657**	**2,70**	**204,70**
* Specially promoted research	118	47	2606	55,45	175,00
* Priority area research	10246	3027	19553	6,46	204,70
* Basic research (S) (new from ????)					
* Basic research (A)	4163	2327	13790	5,93	37,20
* Basic research (B)	16063	5371	20201	3,76	15,90
* Basic research (C)	32595	11630	14734	1,27	4,00
* Exploratory research	6631	1943	2200	1,13	2,40
* Young researchers (A) (new from 2002)					
* Young researchers (B)	17815	5396	6980	1,29	2,60
* Research by school teachers and individual citizens	2618	659	133	0,20	0,30
* International research	3182	1326	5460	4,12	18,30
Regional research cooperation (new from ??)					
Public dissemination of research results	**1487**	**995**	**2944**	**2,96**	**38,44**
Grants-in-Aid for JSPS Fellows	**3722**	**3772**	**3501**	**0,93**	**1,50**
Research for creating new academic fields (new from 2001)					
Total sum	**98640**	**36493**	**92102**	**2,52**	**204,70**

Source: Monbukagakysho. Kagaku Kenkyuuhi Hojoukin. Saitaku Kadai- Koubo Shinsa Youran. Heisei 14 Nendou. Gyousei, Tokyo 1997.

3.9 JSPS and JST

The Japan Society for Promotion of Science (JSPS) and the Japan Science and Technology Agency (JST) are two research funding agencies under MEXT. Both are today Independent Administrative Institutions. Before the creation of MEXT, JSPS belonged to Monbusho and JST to STA.

The merger of Monbusho and STA into MEXT has initially raised the question of whether JSPS and JST ought to be merged as well. The division of roles between the two agencies has gradually become clearer. Very broadly JSPS emphasizes bottom-up processes and responds to initiatives from the scientific community, while JST sees its role as implementing government S&T policy priorities. Most of JST's programs, however, are based on open call for proposals. Some reshuffling of programs between the two agencies has occurred. International fellowship programs have been concentrated to JSPS, which established an office in Stockholm in 2001. A large strategic research program, “Research for the Future” administered by JSPS is being phased out and strategic research programs reflecting MEXT priorities in terms of specific fields concentrated to JST. A large part of strategic R&D-projects is, however, still administered directly by MEXT. Until the late 1990s the whole Grants-in-Aid scheme was operated directly by the Monbusho. More recently the administration of a part of the scheme, especially the large number of smaller grants, has been transferred to the Japan Society for the Promotion of Science (JSPS).

JSPS’ budget for 2003 amounts to 8.4 billion SEK (117 billion yen) of which around three quarters for Grants-in-Aid and most of the rest for research fellowships for young scientists. In addition JSPS manages the selection and evaluation of some of the programs funded directly by MEXT. This includes part of Grants-in-Aid and a new 21st Century COE Program.

JST’s budget is similar in size to that of JSPS. In 2002, JST’s total budget was 8.0 billion SEK (111 billion yen). JST has a diverse portfolio of activities. These include the provision of electronic science and technology information services, promotion of technology transfer, promotion of regional science and technology activities, and activities to increase public understanding of science and technology. Information services and technology transfer activities are partly covered by income earned by JST through these activities.

At least 85 percent of the funds provided by the government to JST (in 2002 around 6.6 billion SEK) are used for support of R&D-activities. JST operates seven programs for “Basic Research”. Some of these are described in the following, starting with ERATO, the oldest of JST’s research programs.

3.10 ERATO and RIKEN creating new organizational models

As mentioned above, important targets of systemic reform in Japanese S&T policy has been to increase “mobility of researchers, opportunities for young researchers, cooperation across sector boundaries, competition for funding, concentration of resources, internationalization, etc.” Some of the initiatives taken after 1995 towards reaching these targets have benefited from experiments with new ways of organizing research started during the 1980s. The ERATO (Exploratory Research for Advanced Technology)[14] program (http://www.tokyo.jst.go.jp/erato/), started in 1981 by the Japan Science and Technology Corporation (JST), was one very important such experiment, which broke new ground by offering large grants and a high degree of freedom for five years to research leaders who were judged as having highly innovative research ideas and strong leadership qualities. Each project typically includes 15-20 full time scientists, usually young scientists with a PhD-degree. A significant number of the team members are recruited from abroad

[14] *Although the title of the program makes a reference to “advanced technology”, the emphasis is more on “advanced” than on “technology ”in the traditional sense as can be seen from looking at the content of individual ERATO projects: http://www.tokyo.jst.go.jp/erato/contents.html. The long term ambition i, however, to create a base for new advanced technologies.*

and industry. The project leaders are identified by the JST and selected after discussions between JST and the project leaders of the key concepts and objectives of the research to be pursued. Project leaders may come from any type of research organization, including private companies. After agreeing on the project with JST the project leaders are free to gather research team members, who are employed on a fixed term contract basis, on conditions similar to those applying to postdocs in Europe or the USA.

At the time of the start of ERATO there was no system of postdoctoral fellowships to talk about in Japan, so ERATO essentially introduced this system to Japan. The quality of the project leaders and the highly innovative character of the research have been the main factors attracting young scientists to join ERATO projects, and compensated for the lack of stability in their postdoc employment. The ERATO program has been highly successful in terms of its research results, as a training ground for highly qualified young scientists, and in terms of developing new ways of organizing research in Japan. An ERATO project represents a temporary organization and the teams are normally dissolved after the end of the project. In this sense ERATO projects have served as a means to promote creativity and excellence among Japanese researchers rather than building lasting COEs.

In 1986 The Institute of Physical and Chemical Research (RIKEN) established a new research organization, The Frontier Research System (FRS), with the intention of revitalizing RIKEN and its external contacts with the Japanese and international scientific community. (It needs to be emphasized that the established part of RIKEN was and is a highly regarded research institution). Key elements of the FRS are similar to those introduced by ERATO, namely the recruitment of young scientists from Japan and abroad on fixed term contracts. The emphasis in both ERATO and FRS has been on interdisciplinary research topics. The experience of the FRS has been has been used to build up a large new life science research system as part of RIKEN in a very short time.

3.11 RIKEN's new Life science research centers

In 1997, The RIKEN Brain Science Institute (BSI), was established with Dr. Masao Ito as its first Director. Dr. Ito, one of the leading brain scientists in the world, had been the Director of the FRS since 1991 and inside FRS built up a sizeable research program in the area of brain science. This was moved to the new BSI, where new departments were added during the following years in rapid succession. Today BSI is a unique research institute covering a broad area of brain science, including basic biology, therapy-oriented research as well as research on brain-like computing. There are more than 400 scientists at BSI. It follows a similar organizational model to that of FRS, with fixed-term contracts for almost all of its researchers. Many researchers, including some of the laboratory directors, are recruited from abroad. The system of fixed short-term contracts is said to have played an important role in gaining support from the Ministry of Finance to establish BSI. In terms of organizational models for world-class COEs, the BSI is definitely worth studying. Viewed from a Swedish perspective, it appears, however, that doctoral students play a surprisingly small role. In fact, a general difference between Japan and

Sweden appears is the larger role of doctoral students in research in Sweden than in Japan.

The BSI was established as part of a major push by the Japanese government to strengthen brain science in Japan. Although BSI was the centerpiece of this initiative conceived for a 20 year period, new resources were also allocated, via the CREST Program of JST, towards support of research in universities. The first round of CREST programs in the brain science area, which were started in 1997-1999 are now being phased out as they were planned for 5 years. Although a new program dealing with brain science and education is being started up there is currently some concern that funding for brain science at universities may suffer in the years to come.

The rapid development of the BSI was aided by several supplementary budgets, which allocated funds towards investment in new buildings and equipment for the BSI as part of investments aimed at stimulating the growth of the Japanese economy.

BSI represented a drastic expansion of RIKEN's research in the field of life sciences. BSI then served as a model for the establishment of several more life science related research centers at RIKEN. Most of these (Genomics Sciences Center, Plant Science Center, SNP Research Center, Research Center for Allergy and Immunology) have been located to a new campus in Tsurumi near Yokohama and another to Kobe (Center for Developmental Biology). Together with the BSI these institutes today employ well over 1000 scientists in extremely well equipped research facilities.

3.12 Large scale research facilities

RIKEN and the national research institutes usually have large-scale research facilities, which may be found in only few places in Japan. The same is true of those research institutes, which form part of the university system, including the so-called inter-university and joint-use research institutes. The number of research institutes with large-scale facilities are many too many to mention here. Suffice it mention just a few of the very large-scale facilities:

- **The Kamioka Observatory** belongs to the Institute for Cosmic Ray Research of the University of Tokyo and includes the Kamiokande (Kamioka Nucleon Decay Experiment) and the Super-Kamiokande facilities, the former of which was used by Dr Masatoshi Koshiba for the work that earned him the Nobel Prize in 2002.[15]
- **Spring 8**, the largest third-generation synchrotron radiation facility in the world[16]

[15] *http://www-sk.icrr.u-tokyo.ac.jp/index.html*
[16] *http://www.spring8.or.jp/ENGLISH/*

- **The Earth Simulator** is the world's most powerful supercomputer. About half of its capacity is used for climate modeling at the recently established Yokohama Institute for Earth Sciences (YES). The cost of developing and installing the Earth Simulator was around 450 million USD. [17]

3.13 Centers of Excellence at universities

In 1995, the Ministry of Education and Science (Monbusho), started a special program for Centers of Excellence (COE), aimed at selectively strengthening university research environments to world-class level. Annually around half a dozen new centers were selected each year and awarded a five-year grant. The annual amount has varied quite a lot depending on the nature of the research, with 20 million SEK per year a rather normal figure. As in other cases discussed above, only a small part of the grants have been used for salaries.

In 2002 a new COE Program was started, the "COE Program for the 21st Century", and as a result the old one is being phased out. The focus of the new larger program is to strengthen doctoral programs in universities. The amount per center is 7-35 million SEK per year under five years. The result of the first competition for grants under the new program was announced in September 2002. 113 centers, which had been selected among 464 applications, shared 1.3 billion SEK per year for five years, that is on average 11.5 million SEK per center and year. During the first year the competition was limited to the following fields:

- Life Sciences (other than medicine) (28 grants)
- Chemistry, Materials Science (21 grants)
- Computer Sciences, Electrical, and Electronics Engineering (20 grants)
- Humanities (20 grants)
- Interdisciplinary and New Areas (24 grants)

In the second round in 2003, grants to 133 new centers were offered in the following areas:

- Medical Sciences (24 grants)
- Mathematics, Physics, and Earth Science (21 grants)
- Mechanical, Civil, and Construction Engineering (16 grants)
- Social Sciences (17 grants)
- Interdisciplinary and New Areas (19 grants)

The background of the new program is a perceived need to concentrate research resources at the universities to those that have a potential for achieving world-class level in their research. There are presently more than 600 universities in Japan, around 90 of which are national universities, a few municipal and prefectural and the bulk private universities. The government has very clearly stated that it would like to see a consolidation among the national universities. In June 2001, the Minister of Education, Ms Toyama, made a statement to the effect that Japan should aim at strengthening 30 of its universities so that they would be among the

[17] *http://www.es.jamstec.go.jp/esc/eng/index.html; http://www.jamstec.go.jp/jamstec-e/yokohama/frontier/index.html*

very best in the world. This policy came to be labeled “The Toyama Plan”. The “COE Program for the 21st Century” is so far the clearest example of its implementation. While the initial statements were in terms of whole universities, the new program made the selection at the level of broad subject fields.

The 248 grants awarded during the two years were divided among 85 universities, with a strong concentration to only a few of them. Two thirds of all the grants were divided among 14 universities, which were awarded 4 our more COEs. Among these all but three were national universities with University of Tokyo and Kyoto University receiving 26 and 22 grants respectively. The rest of the national universities receiving at least 4 COE grants were the other former imperial universities (Hokkaido University, Tohoku University, Nagoya University, Osaka University, and Kyushu University) plus Tokyo Institute of Technology, Kobe University, Tsukuba University, and Hiroshima University. The three private universities were Keio University, Waseda University, and Ritsumeikan University, which all have a history of more than 100 years.

Table 3-4 Distribution of 21 Century COEs selected in 2002 and 2003 by fields and universities

	All fields	Life Sciences	Science & Eng.	Hum & Soc Sc	Interdisc. & New
			Number of COEs		
National Universities	**181**	**45**	**70**	**30**	**36**
The University of Tokyo	26	6	10	7	3
Kyoto University	22	4	8	4	6
Osaka University	14	5	6	2	1
Nagoya University	13	3	8	1	1
Tohoku University	12	2	7	3	
Hokkaido University	10	2	3	2	3
Tokyo Institute of Technology	9	1	7		1
Kyushu University	8	2	5	1	
Kobe University	7	2	2	3	
Tsukuba University	4	1	1		2
Hiroshima University	4	1	1	1	1
Other Natinal Universities	52	16	12	6	18
Private universities	**56**	**15**	**16**	**14**	**11**
Keio University	12	3	4	4	1
Waseda University	9		4	4	1
Ritsumeikan University	4	1	2	1	
Other Private Universities	31	11	6	5	9
Public universities	**9**	**3**	**2**	**2**	**2**
All universities	**246**	**63**	**88**	**46**	**49**

Source: JSPS

4 Four Priority Areas

One of the new elements of Japanese S&T policy is the designation of priority areas. These are national priorities and thus supposed to guide all parts of the government and also to some extent serve as guidance for the private sector.

The designation of four priority areas was decided by the Cabinet as part of the adoption of the Second Basic Plan for Science and Technology, which covers the period 2001-2005. The four areas are:

- Life sciences
- Information and communication technologies (ICT)
- Environment
- Nanotechnology and materials

Another four areas are recognized in the Second Basic Plan as deserving strategic attention, although no increase in allocation of resources is necessarily foreseen for these areas. These four additional fields are:

- Energy
- Manufacturing technology
- Social infrastructure
- Frontier (space and ocean related S&T)

4.1 First attempt at estimating total resources allocated to priority areas

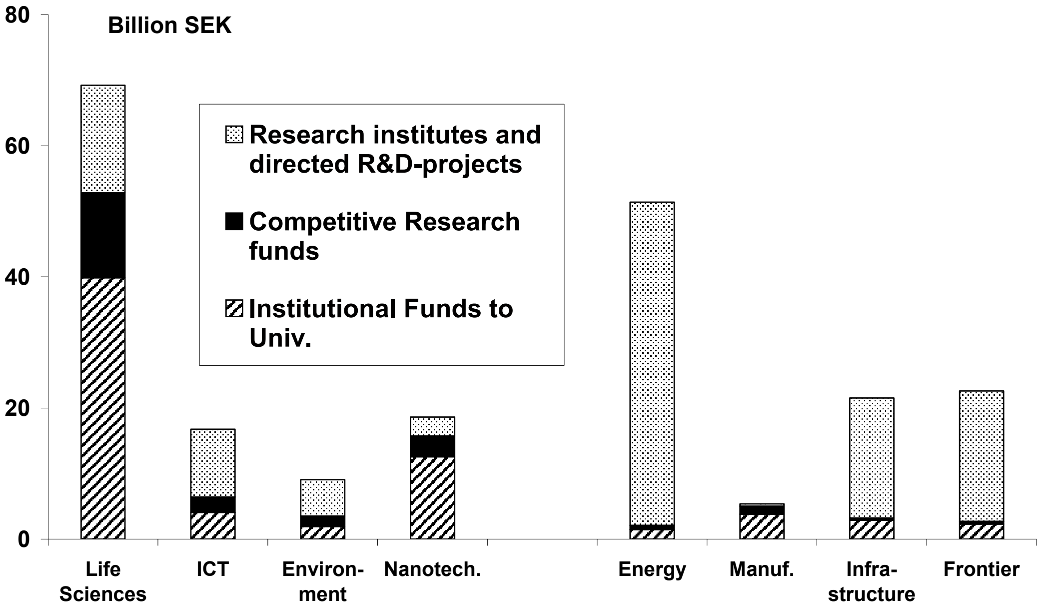
The first attempt to estimate total government funding of S&T in each of the eight areas was published in May 2003 in a midterm (actually only two of five years had passed) review by the CSTP of the progress of the Second Basic Plan for S&T. Three types of funding are identified:

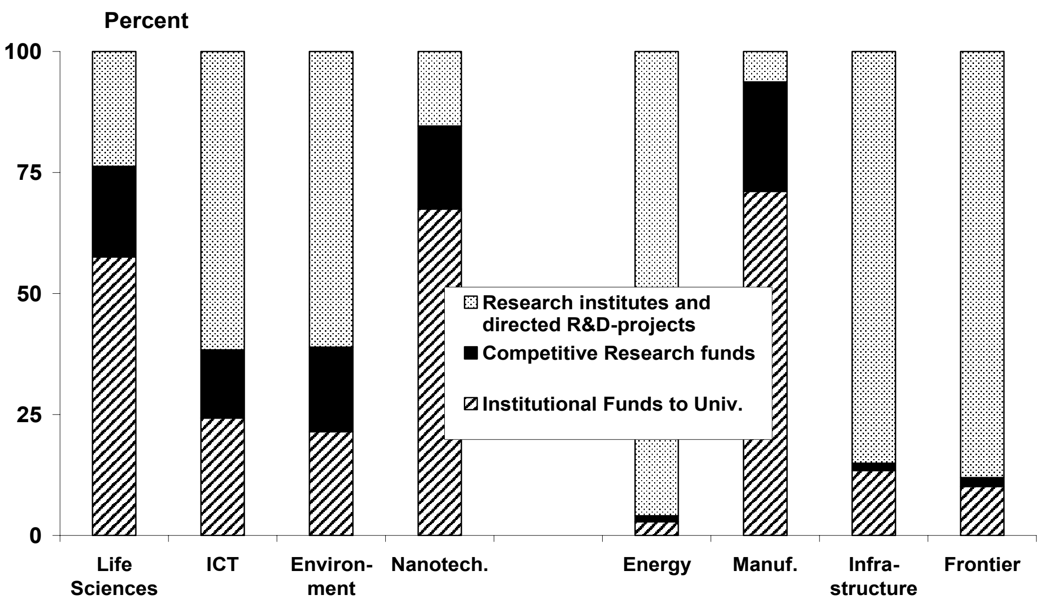
1. Funding of Directed R&D-projects and institutional funds to research institutes and other non-university government research organizations[18]
2. Programs for Competitive research funding (discussed above in Chapter 3)
3. Institutional funds to universities

Estimates of government funding for each area are very difficult to make for all categories except the "Directed R&D-projects" for which the purpose is usually clear and the amount of resources allocated well specified. The institutional funds to universities are the hardest to divide by area. So far, data on the allocation of competitive funds by area seems to have been used as a key to distribute the institutional funds. The result of this exercise are shown in Figure 4-1 and Figure 4-2.

[18] *The mentioned report by CSTP divides this category further into " Independent Administrative Agencies" and S&T-funding, which has the promotion of the area as "Primary Objective". As some of the research institutes are not IAI:s this further break-down is not used in this report.*

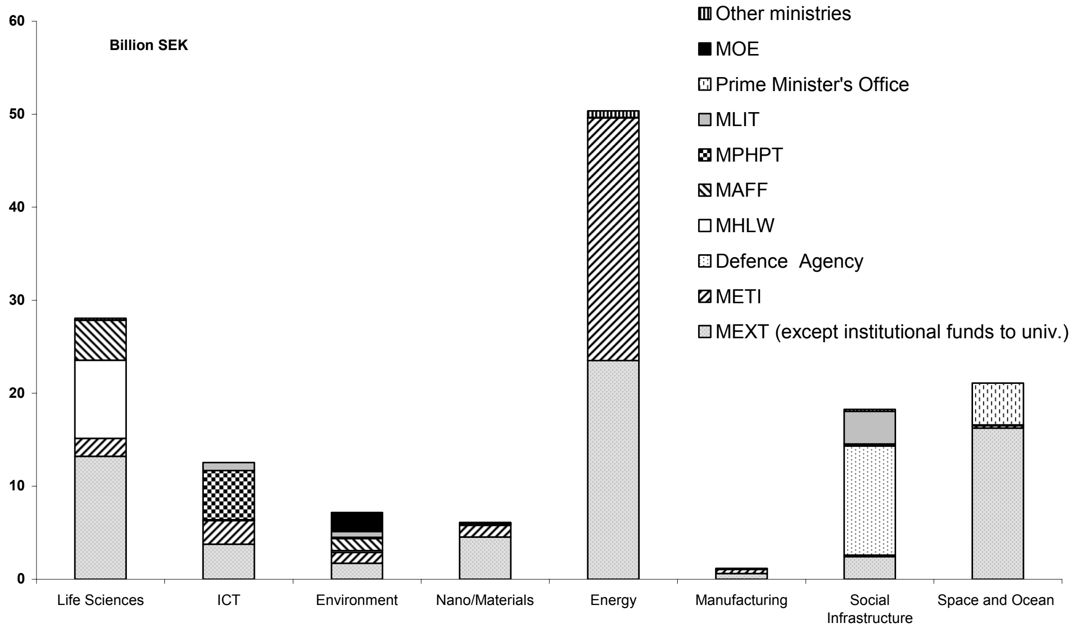
Figure 4-1 Estimated allocation of government S&T-budget for 4 priority and 4 additional fields in f.y. 2002





Source: Midterm follow-up of second basic plan for S&T, CSTP, May 2003

Figure 4-2 Government R&D-funding in Japan f.y. 2002 in 8 fields by ministry (institutional funds to universities not included)



Ministry names and abbreviations

- Ministry of Education, Culture, Sports, Science and Technology (MEXT)
- Ministry of Economy, Trade and Industry (METI)
- Defence Agency
- Ministry of Health, Labor and Welfare (MHLW)
- Ministry of Agriculture, Forestry and Fisheries (MAFF)
- Ministry of Public Management, Home Affairs, Post & Telecommunications (MPHPT)
- Ministry of Land, Infrastructure and Transport (MLIT)
- Prime Minister's Office
- Ministry of Environment (MOE)
- Other ministries

Source: Midterm follow-up of second basic plan for S&T, CSTP, May 2003

4.2 Life sciences and energy dominate government S&T-spending but uses the money very differently

Estimated in the way described, the eight areas cover 84 percent of the total regular government budget for S&T in 2003. Life sciences and energy dominate with respectively 27 and 20 percent of the total budget.

Adding institutional funds to universities and competitive funds most likely gives a fairly good estimate of the total resources allocated to universities. Some of the funds of directed R&D-projects also go to the universities but at the same time some part of the competitive funds go to non-university organizations.

While 75 percent of the budget for Life sciences is spent at universities, the same share is only 4 percent in the energy field. Nanotechnology, and somewhat surprisingly Manufacturing technology, resemble the Life sciences in their high reliance on universities. The high share for universities in manufacturing technology partly reflects the lack of any large government initiatives in the field. In the fields of ICT and Environment, around 40 percent of the budget goes to universities.

Based on the same type of estimates, Figure 4-2 shows the importance of different ministries for each of the eight areas. In Nanotechnology, Energy and Manufacturing technology, MEXT and METI play the dominant role. In Life sciences, ICT and Environment the roles are more evenly distributed between several ministries. It should be noted, however, that Figure 4-2 includes competitive funds for research, most of which fall under MEXT. Looking only at the funds, which are used in a strategic way, the role of MEXT is therefore smaller than suggested by Figure 4-2.

4.3 Strategies for priority fields

Appendix A1 provides a summary of the strategies for the four priority areas as defined by the CSTP in June 2003. These strategies primarily concern “Directed R&D-projects and institutional funds to research institutes and other non-university government research organizations” (Figure 4-1). Societal objectives therefore play an important role in the formulation of the strategies.

The strategy for Life sciences recognizes three main application areas: Health, Food and Environment, the largest resources being devoted to the former. In addition to genomics-based medicine, special attention is given to regenerative medicine, cancer, and brain science under the category of health. Investments in these areas are made primarily by MEXT and MHLW. Most of MAFF’s Life science funding falls under the Food label. Application of biotechnology to the development of industrial processes and materials with good environmental performance is a major thrust of METI’s efforts, although the largest part of METI’s Biotechnology funding is also Health related.

Noteworthy is the emphasis on the fusion of life sciences and engineering sciences, exemplified by such areas as bionanotechnology, bioinformatics, systems biology, bio- and medical imaging, technology and devices for analysis of genes and proteins, brain-like computing etc. Such technology fusion is promoted by several ministries, including MEXT and METI and is considered to offer great promise for Japanese industry, which has a strong base in micro- and nanotechnologies as well as in supercomputer technology.

The strategy for ICT involves both those technologies, which can be developed and put to practical use in the mid-term perspective and radically new technologies such as quantum computing and communication, humanoid robotics, and devices and systems based on biological functions, which are likely to take longer time before they have any significant economic impact. A third area concerns high performance computing. A large part of the strategy concerns the development of hardware technologies, including related materials.

The total government budget for S&T in the field of ICT is around 14 billion SEK in fiscal year 2003. This can be compared with the total R&D-expenditure of the Japanese electronics and other electrotechnical industry, which amounted to around 280 billion SEK in 2001, out of which around 10 billion SEK was reported as "basic research" and around 50 billion SEK as "applied research". Although miniscule in relation to the total R&D-activities, government R&D funding may thus play some role in "basic research" and other more risky types of R&D.

The strategy for Environment related S&T includes five different areas. So far the main emphasis has been on global warming and to a lesser extent on technologies for creating a "recycling-oriented" society. Gradually the other three areas are expected to receive increased attention.

A major objective for the strategy for nanotechnology is to supply new technologies for use in the fields of ICT, Environment and Energy, and Health. The application focus is thus quite strong even in this area. Certain advances in nanotechnology are, however, considered as basic technologies, with potential applications in any number of fields, and treated accordingly. Generally speaking, nanotechnology fits well with the structure of Japanese industry, with its strengths in a wide range of materials, microelectronics, precision machinery, instrumentation, etc.

4.4 Life sciences as an example

In order to give a more concrete picture of the S&T policies of the Japanese government, the example of Life sciences is discussed in more detail in the following. In addition to providing an overview of the budget for fiscal year 2003 for Life science for all the ministries, Table 4-1 also shows a more detailed breakdown of the budget for MEXT and METI. For the latter ministries, the supplementary budget for 2002 is included as well.

Institutional funds to universities make up just under 60 percent of the total government regular budget for Life sciences. Another approximately 20 percent of the regular budget, corresponding to around 14 billion SEK, is used for research at research institutes other than those run by universities. At least 9 billion SEK of these go to institutes under MHLW and MAFF.

According to the table, 2,4 billion SEK are spent on the RIKEN Life Sciences Centers. Additional funds are, however, spent at these Centers from various projects, mainly under MEXT. The largest of these is the Protein 3000 project, the largest part of which is carried out at RIKEN Genomic Sciences Center (GSC). In total the budget for RIKEN's Life Sciences activities is therefore probably at least 3,5 billion SEK, corresponding to 5 percent of the total regular budget for Life sciences. Considering the very high recognition that RIKEN's Life sciences Centers have received internationally this is a surprisingly low share.

The table also shows how the supplementary budget is used to start up policy-driven "leading projects" under MEXT, by providing one-time grants for investments in equipment at the start of five year projects, supplementing the annual grants for operating expenditure, which are provided over the regular budget. In the case of METI the supplementary budget is used for investment in new buildings for expansion of research in the fields of Bio/IT and Clinical Informatics.

Table 4-1 Partial and approximate decomposition of fiscal year 2003 Budget and Fiscal year 2002 Supplementary Budget for Life sciences S&T

	Regular budget, Fiscal year 2003	Supplementary budget, Fiscal year 2002 (spent during f.y. 2003)
	Million SEK	
MEXT	**53 514**	**1 514**
Institutional funds to universities	**39 857**	
Competitive funds (Grants-in-Aid, CREST, etc)	**8 457**	
Institutional funds to RIKEN Life Science Centers	**2 400**	
* Brain Science	722	
* Genomics Sciences	509	
* Developmental Biology	381	
* Immunology and Allergy	370	
* Single Nucleotide Polymorphism (SNP) Research	156	
* Bioinformatics (no single center)	144	
* Plant Science	118	
National projects	**1 168**	
* Protein 3000	679	
* Bioresource project	286	
* 21 Century innovative lIfe science technology	203	
Leading projects	**340**	**1 514**
* Tailor-made medicine (5 year project)	154	593
* Regenerative medicine (10 year project)	93	500
* Cell simulation (5 year project)	57	286
* Photonics & cell measurement (5 year project)	36	64
* Nurturing of new industry based on Glyco-chain function		71
Human Frontier Science Program	**171**	
Life science in International Space Station	**791**	
Other funds	**330**	
MHLW	**8 686**	**n.a.**
*** Competitive funds**	**2 971**	
*** Other funds (incl own institutes)**	**5 714**	
MAFF	**4 443**	**n.a.**
METI	**2 007**	**2 207**
Health related	**1 095**	
* Postgenomic research	471	79
* Nurturing of Bioindustry based on development of Bio-tools	492	86
- Equipment based on fusion of Bio and IT	*155*	*86*
- Nanobiotechnology	*171*	
- Medical equipment for diagnosis and therapy	*136*	
- Assistive equipment for elderly and disabled	*30*	
* Bioinformatics	124	
* Protection of genetic information for individuals, safety, ethic	7	
Use of biological functions in recycling-oriented industry	**271**	
* Basic technologies for Bioprocesses	213	
* Genetic resources for microbes	36	
* Risk management in the use of genetic modification	23	
Basic biotechnology research and other measures	**460**	
* Basic biotechnology research	144	
* Depository of patented microorganisms	39	
* Large scale fixation of CO2	21	
* Biomass Energy	214	
* Other projects and measures	41	
Human Frontier Science Program	**100**	
Faciltities for Industry-Univ.-Government Cooperation		**1 993**
* Facility for research on Bio/IT (AIST in Odaiba)		1786
* Clinical Informatics Research Center (Tsukuba)		186
* Center for technology for industry supporting clinical trials		21
Bioventure Support		**4**
Human resource development for Entrpreneurial activities		**50**
Biotechnology projects in "horisontal programs"	**n.a.**	
OTHER MINISTRIES	**271**	**n.a.**
Total for all Ministries	**68 921**	**3 721**

5 Lessons and benefits for Sweden

5.1 Why look at Japan?

There are many reasons for Sweden to pay more attention to the development of scientific research and industrial innovation in Japan than has so far been the case, for example the following:

- To learn about opportunities and conditions for cooperation between actors in Sweden and Japan
- To discover and understand new trends in science and technology, which will form the future competition environment for Swedish researchers, firms, and government policy
- To understand how changes in science and technology interact with broad social and economic changes, including the emergence of new markets and industries as well as changes in corporate innovation management, research organization, government policies, and patterns of cooperation
- To find inspiration from a different model of cooperation between politics, government S&T administration, industry and academia
- To find a reference against which to evaluate when and how limited scale of resources is an obstacle to effective research and innovation in Sweden

Of course all scientific fields, technologies and industries are not equally well represented in Japan. In most fields where Japanese researchers and companies are active there will also be activities in the USA and often on a larger scale. The developmental logic does, however, in many cases differ between the USA and Japan as a consequence of big differences in the industrial structure, the character of the domestic market, societal values, government policies, regulations and promotion measures, scientific culture and organization, modes of cooperation and competition, etc. The current strong emphasis in much of Japanese industry on raising the environmental quality of its products as viewed from a life cycle perspective illustrates the point. A concrete example is the development and commercial launch of hybrid cars by Japanese automobile companies, which is not matched by any other companies.

As the point of gravity in the world economy is gradually shifting towards Asia and especially East Asia with China as the fastest growing market, the global impact of Japanese science and technology is likely to grow.

5.2 Japan is creating new industries

The technological strength of Japanese industry is still a major reason to monitor research and innovation in Japan. Slow growth of the domestic market and growing competition from companies in both the USA and EU and in neighboring countries in East Asia, such as Korea and Taiwan, have put Japanese industry under strong pressure during the last decade and forced many Japanese companies to change their business practices. The general consensus has been that Japanese industry must focus on innovation and high value added products and services, including the creation of entirely new industries.

Whether new industries can actually be created fast enough to make up any significant share of the economy remains to be seen. If, however, there is any place where new manufacturing industries may be created on a significant scale it is probably in Japan. The reference to manufacturing industry implies that the development of new "physical products" will be an important component of the new industry. Many Japanese manufacturing firms are increasingly combining innovative physical products with high-quality services and information in their development of new businesses. The borderline between manufacturing and services thus is becoming increasingly difficult to maintain in Japan as elsewhere.

Manufacturing still occupies a very central role in the consciousness of Japanese industry and to a much higher degree than in for example Sweden. High technology manufacturing epitomized by the semiconductor and precision machinery industry and suppliers to these industries makes up an important part of Japanese industry. The development of nano-technology offers an opportunity for these and similar industries to move up to a qualitatively new level of manufacturing technology and Japanese industry is well positioned to take advantage of this opportunity. IT-related industries, already well represented in Japan, will account for a large part of the uptake of nanotechnology. Mass production of carbon nanotubes and fullerenes, which already is underway in Japan, are examples of new materials industries with products of extremely high value per weight.

An opportunity for qualitative transformation of existing industries comes from the need to raise the environmental quality of industrial activity. Today this challenge is defined as reducing the environmental impact of products during their whole life cycle. This of course includes the manufacturing processes but often the major environmental load is associated with the utilization and disposal of a product. Many Japanese companies have today adopted this perspective in earnest and are in the process of extending it to their supply chains. Considering the high quality and nearly "complete cluster" of Japanese engineering and related materials industries and the strong tradition of quality control in Japan, there are good reasons to believe that Japan will indeed lead the way towards transforming traditional industries to a condition of ecological sustainability.

Stricter environmental requirements also create openings for new industries, such as industries for fuel cells and solar cells. Japanese companies already dominate the world market for solar cells and several are planning commercial launch of compact fuel cells for use in mobile phones and portable PCs, with at least one company using nanotechnology in the form of carbon nanohorns.

Japan's ability to create new industries based on life sciences and biotechnology is more difficult to assess. Commercial success by Japanese industry worldwide has so far been unimpressive, mainly because of the earlier failure to nurture new bio-ventures and the domestic orientation of most of its many pharmaceutical companies. The situation is rapidly changing on both fronts. Maybe as importantly, many companies in electronics, instruments, materials, chemicals and food industries are strengthening their business development in bio-related fields. Combined with an increasingly active government science and technology policy in life sciences, it seems increasingly likely that Japan will build a strong position in at least some of the bio-industries, such as regenerative medicine and devices based on bionanotechnology.

Comparative analysis of innovation in Japan and the US, has concluded that the US has its particular strength in the case of breakthrough innovations based on a single technology, while innovations which are based on technologies from more than one industry have a better chance in Japan.[19] Mechatronics, the combination of electronics and mechanical technology, is one example of a field based on technologies from several industries and in which Japan has excelled, robotics being one field of application. As robotics moves beyond stationary industrial robots to other types of robots, such as rescue, service and entertainment robots, the number of technologies, which need to be used and integrated is increasing to the extent that robotics is becoming one of the most complex fields of engineering. Japan is leading the way in developing the industry for non-industrial robots.

5.3 New industries linked to societal change

As has previously been mentioned, discussions about nurturing new industries in Japan usually make explicit reference to needs stemming from the desirable future development of Japanese society and sometimes even the needs of humanity at large as for example in the case of measures to abate global warming.

Also in Swedish research policy there are sometimes similar connections between research priorities and needs in Swedish society. In some fields, for example biomass energy, Sweden has indeed shown the capacity to develop the technologies needed to meet a national objective.

When it comes to pursuing research and innovation in high technology, it is, however, much more of a rare case that R&D-priorities in Sweden are linked meaningfully to meeting social needs. This may be unavoidable as Sweden's high

[19] *Source: Article by Professor Leonard H. Lynn, Case Western Reserve University (not been possible to locate article)*

technology industry is simply too small and too narrow to be a major source of innovations, for satisfying complex social needs.

This difference beween Sweden and Japan is significant and deserves to be further analyzed. It needs to be said that it is by no means clear that the attempts in Japan to set objectives for R&D, which are derived from perceived social needs, are well conceived or will be successful. It is simply too early to tell. Considering the history of industrial innovation in Sweden, which until a couple of decades ago was strongly linked to public procurement, the present conditions under which the link between R&D-priorities and societal changes has been severely weakened should be some cause for concern.

For Sweden, the only solution may be to reintegrate the connection between its R&D-activities and the meeting of social objectives on an international level. The EU may offer a framework for this, but other international link-ups may also be useful, including with Japan. Not too surprisingly there is in many cases an explicit link between R&D and social objectives in the European R&D-programs.

Most of the societal changes emphasized in Japanese S&T-policy, such as ageing society, protection of the environment, and the creation of an information society are very relevant in Sweden as in large parts of the rest of Europe. In other parts of the world, including North America, the first theme has much less relevance. The strong emphasis on environmental objectives, seem to carry special weight in Japan and Northern Europe.

Naturally there are many concerns of Japanese society, which influence S&T-policies, but which have no or little counterpart in Swedish society. Infrastructure technology associated with super-large and super-dense urban agglomerations is one such area and construction and rescue technology preventing against damage from earthquakes is another. One should note, however, that there are other fields of construction technology, for example wooden housing, where there are clearly common interests.

5.4 Scientific research beginning to match the high level of industry

Increasingly scientific research in Japan is becoming a strong force in its own right on par with the impressive technological innovation capacity of Japanese industry. As before some of the most advanced research is still performed in industry. Compared to the situation fifteen years ago, the research strength of universities has grown dramatically as a result of larger and more concentrated competitive funding. Their performance is likely to improve further as a result of the "corporatization" of national universities and the deregulation associated with this change. The future role for the national research institutes remains unclear and will partly depend on how the university sector evolves and partly how successful the institutes are in utilizing their new freedom as Independent Administrative Institutions.

Cooperation between industry on the one hand and universities and research institutes on the other has so far been severely hindered by a variety of regulations as well as by negative attitudes among many of the parties involved. The potential of such research cooperation has thereby largely remained unutilized in Japan. The drastic changes now taking place in Japan aiming at facilitating and actively encouraging research cooperation between industry, universities, and government research institutes should be a very important stimulus for all parties involved. Although the emphasis is often on how such cooperation can help renew and strengthen industry, the positive effects on scientific research may be just as strong, especially considering the many high technology companies already existing in Japan.

Whether the recent emphasis on establishing new spin-off companies from technology seeds generated in universities and research institutes will make any real contribution to the creation of new industry of Japanese only the future can tell. The phenomena is still so new that it is not yet possible to see how these research spin-outs will be able to compete or cooperate with established firms. The modes of interaction may well turn out to be quite different from those found in the US.

5.5 Japanese actors positive to cooperation with Sweden

There is little doubt that Sweden, its scientific community as well as its industry and maybe also public institutions, would benefit from closer contacts with Japan in the form of R&D-cooperation and other forms of knowledge exchange. For the cooperation to be sustainable it has of course to be perceived as beneficial by both sides.

The author’s experience is that there is a surprisingly large interest among many Japanese individuals and organizations in engaging in exchange with Sweden. Swedish science and industry have a good reputation in Japan, the former not least due to the Nobel Prize. Even if the cultures show important differences, many of the basic values and basic norms of social behavior harmonize well. The creativity of Swedish scientists and the many unique technologies developed by industry and others in Sweden attract Japanese interest once real contact has been established. The informality and the freedom from hierarchies in Swedish organizations are appreciated by young Japanese scientists.

More than the specifics of science and technology, the deepest interest for Sweden in Japan, even among scientists, often concerns the organization and institutions of Swedish society, focusing on softer aspects such as pension system, elderly care, child care, gender equality and environmental policies and how it has been possible to combine a high degree of “caring” in these regards with Sweden as a society of advanced science and industry. The image of the Nordic countries as a group (“hokuou”) is similar.

Recently the Nordic countries, Sweden included, have begun to receive a reputation in Japan as representing a special model for nurturing advanced knowledge-based societies, which Japan might benefit from studying closer. The high ranking of especially Sweden and Finland on many scoreboards for information and knowledge-based societies has probably contributed somewhat, but there may be other factors. The initial choice of the US as the model for reforming Japanese institutions, including the research and innovation system, is being questioned at least in some quarters and in taking a closer look at Europe, the Nordic countries appear as one relevant model to study, although in the field of science and technology it may in fact represent several rather different models.

A strong indication of the interest in developing cooperation with Sweden on the part of the Japanese government research administration was the decision by the Society for the Promotion of Science (JSPS) to establish an office for the Baltic region in Stockholm in 2001. The budget for this had to be approved by the then Ministry of Education and Science.

The signing of an official government agreement for cooperation in science and technology by Japan and Sweden in January 1999, although being only an umbrella agreement with no provisions of funding or commitments to cooperation in specific areas, seems to have to have contributed to the recent growth in exchange. One important reason may have been that the signing of the agreement synchronized a temporary increase in mutual attention and created a positive climate for new initiatives on both sides. A positive spiral of increasing exchange and mutual understanding seems to have been created, while the number of concrete collaborative projects still remains low.

Although there has recently been some increase in the contacts between scientists in Sweden and Japan, the communication between the research communities in the two countries is still quite limited. Very few Swedish scientists have any experience of working in Japan. This is in sharp contrast to the otherwise very high international mobility of Swedish scientists.

In the field of industrial technology, the contacts between Sweden and Japan seem to be somewhat more developed than in scientific research. As few Swedish companies perform R&D in Japan there are, however, few Swedish engineers, who have worked in Japan. An important exception is the many engineers dispatched from Sweden to Japan by the Ericsson company as part of its efforts to develop infrastructure equipment for the highly advance Japanese market for mobile communication services.

Needless to say most Japanese scientists still have little if any contacts with Sweden and very few engage in active research collaboration with Swedish colleagues. Many more Japanese researchers have, however, worked in Sweden than Swedish researchers in Japan.

In order for R&D-cooperation between Sweden and Japan to enter into a virtuous circle of self-sustained growth, a significant increase in the number of Swedish scientists and engineers working in Japanese R&D-environments therefore appears as one of the important factors.

5.6 Areas for cooperation of particular interest to Sweden

If viewed from the Swedish side, some of the large and unique research facilities and research programs, which have been established in Japan would seem to be obvious attraction points for Swedish scientists. The new RIKEN life science research centers and programs for robotics research are just two examples.

Large Japanese high tech companies should also in principle be very attractive partners for Swedish scientists in fields such as microelectronics, nanotechnology and materials science as well as for new Swedish high tech companies in the same fields. Although Japanese bio-industry is still not a major player internationally, it nevertheless offers openings for Swedish life scientists and biotech companies, as illustrated by the big investment done by Sumitomo Pharmaceuticals in a center for Alzheimer's research at Karolinska Institutet in Huddinge.

Also in more traditional fields there are interesting opportunities for R&D-cooperation. From almost zero 15 years ago, Swedish export of wood products to Japan has grown to a level of around 2 billion SEK per year and the potential for further growth is very large. To sustain a continued growth, the development of research cooperation on wood materials and wood building technology is highly desirable.

In fields such as elderly care and environmental protection, where Sweden has a high reputation in Japan, R&D-cooperation between the two countries could utilize their complementary strengths for common benefit. The same holds for knowledge and technologies needed for realizing advanced information societies to which both countries aspire, and have much to contribute.

5.7 The effect of scale

Sweden scores very high on many indicators relating to knowledge production. Most, if not all, such measures are relative numbers. When competing internationally Swedish scientists and companies can, however, not hide behind relative numbers. They compete with their opposite numbers in other countries on the same terms, regardless of the size of their home countries. Swedish industry has already adjusted to the small size of the Swedish economy on the world stage by a high degree of specialization and internationalization and in recent years by becoming part of global companies, an increasing number of which now have their head-quarters in other countries. Similar processes in the Swedish research system have barely started.

When Swedish scientists visit Japan today, the large scale of research facilities and research projects is often the strongest impression. Sometimes the much larger resources spent on a particular project in Japan as compared with similar ones in Sweden, even makes the Japanese project look wasteful in Swedish eyes. Many of the large projects encountered in Japan simply have no meaningful counterpart in Sweden. The difference in scale of resources is probably the most important difference between Sweden and Japan, and where Sweden may be able to learn most about its own system by studying Japan and possibly also vice versa.

One relevant question is whether the larger projects in Japan achieve something qualitatively different from their counterpart projects in the same field in Sweden, in terms of the quality of the science and/or in the practical relevance and effects of the results.

Some of the most striking examples of large projects in Japan are found in research institutes so to some extent the question of scale is also related to the question of whether Sweden needs to create research institutes (inside or outside universities) in order to create competitive research environments. In Japanese research institutes, some of which are part of universities, the relative importance of doctoral students among the researchers is much smaller than in Swedish universities. The effect of this is another question, which merits further study.

To what extent can Swedish scientists compensate for their small resources in absolute terms by networking with other researchers in Sweden and internationally? To what extent is it necessary to concentrate resources for research to fewer and larger projects in Sweden? These questions cannot be answered in the present report, but more detailed comparisons with Japan would probably be helpful in doing so.

Appendix: Main focus of priority areas

Extracted from “Plan for Resource Allocation of Budget and Human Resources related to S&T in fiscal year 2004”, CSTP, 5 June 2003 (provisional translation by S&T Office)

A.1 Life Sciences

(i) Development of technologies for prevention, diagnosis and treatment of diseases to realize an active long-life society, which is safe and secure.

- Analysis of structure & function of genome, proteins, glyco-conjugates, and the net-works which they form; establishment of basic databases required for the mentioned analysis; based on this knowledge, tailor-made medicine and drug discovery corresponding to the unique characteristics of individuals.
- New medical treatments centered around regenerative medicine and gene therapy
- Prevention, diagnosis and treatment of cancer; prevention, diagnosis and therapy for allergic diseases; diagnosis and treatment of “prion-diseases” and newly emerging infectious diseases; measures against bio-terrorism
- Basic research on cognitive development and the brain; research concerning mental disorders and the influence of education on brain functions; prevention, diagnosis and treatment of CNS diseases such as Alzheimer syndrome.

(ii) Development of food science & technology to contribute to an increase in the food supply and an improvement in eating habits; development of technology for the production of useful materials and for environmental applications.

- Post-genome research on rice plants and the securing of food safety and stable food supply; development of functional foods.
- Development of the production of useful substances from microorganisms and from animal/plants and technology for their environmental applications.

(iii) Research and development of advanced technology, which is just emerging and represents a fusion of different fields; promotion of research, which can effectively return benefits of advanced research to society; establishment of systems and infrastructure.

- Fusion of life sciences with ICT and nano-technology; Bio-informatics; cell simulation technology; systems biology; bio-imaging; diagnostic imaging technology; medical equipment; technology and devices for analysis of genes and proteins
- Translational research from basic research to clinical applications and clinical trials.
- Research on risk assessment of medicines, medical treatments, medical equipment, foods, and genetically manipulated living creatures.
- Preparation of biological genetic resources, which can be used as a base for R&D.

A.2 Information and Communication Technologies (ICT)

(i) Technologies for Ubiquitous Network Society

- Technologies to connect and operate a wide variety and huge number of equipments and terminals, e.g., networked electronic home appliances, and technologies for realizing an ultra-high speed mobile Internet system by means of optics and radio
- Highly functional and low power consumption semiconductors, flat panel displays, etc.
- Security technology, technologies to improve reliability and productivity of software, technologies against information (digital) divide, e.g., Human Interface, information storage and search technologies, contents technologies, and distributed computing technologies for business use

(ii) Information and Communication Technologies representing break-throughs for next generation technologies and seeds of new industries

- Utilization of technologies based on new principles and technologies such as quantum engineering technologies and biological functions
- Fields characterized by fusion of technologies such as robots' coexistence with humans, nano-technologies, life science, and space communication

(iii) Research and Development of Infrastructure ("Base") Technologies

- Computer network systems enabling connection of distributed computer resources with high-speed lines in order to ensure high computation power
- Technologies for shortening the calculation time of computer simulation of natural phenomenon, such as molecular motion

A.3 Environment

(i) Global Warming Research

- Energy conservation (especially in transportation and daily life of citizens); new energy technologies; technologies for absorption, separation, collection, and sequestration of carbon dioxide and technologies for fixation of carbon dioxide in forests and other ecosystems
- Observation and monitoring of global warming; advancement of global change prediction technologies; assessment of policies for limiting global warming; research information system

(ii) Waste-Free, Resource Recycling Technologies

- Scenario for how to promote the creation of a recycling-oriented society; circular material flows from a global point of view; research information system

(iii) Symbiotic Regeneration of Urban and Riverside Areas

- Relationship between water, heat and material circulation at riverside environments and human activities; technology for integrated management of data from monitoring, diagnosis and evaluation of the environment
- Technologies for reduction of physical, chemical and biological environmental impact of urban and riverside areas; regeneration scenario

(iv) General Risk Management of Chemical Substances

- Collection of information concerning toxicity, exposure, and the existing quantities of substances and their movement in the environment; construction of databases

- Assessment of impact on the ecosystem; risk evaluation and management methods relating to sensitivity on a individual level; integrated risk managemant methods; technologies to reduce risk and methods for evaluating technologies

(v) Water Circulation Changes on the Global Scale

- Observation of global water circulation; increasing the accuracy of predictions and evaluation of their reliability; evaluation of the impact on food, water resources, ecosystem and society caused by changes in water circulation, research information system

- Development of technologies for optimal water management and their evaluation

A.4 Nanotechnology/Materials

(i) Nanodevices and materials for next generation information and communication systems

- R&D on semiconductor micro-processing technology, on omponents and devices for use in communication, and on related materials

- R&D on single electron devices, super-conducting devices, electron spin devices, nano-tube devices, devices based on new principles and molecular elements, devices for quantum computing & communication, and related materials

(ii) High performance materials for environmental protection and energy use

- R&D on materials and catalysts for use in new energy and energy saving, which pay attention to the environmental load during the whole life cycle

- R&D on technologies for monitoring and removing harmful substances

(iii) Ultra-small systems for use in medicine and nanobiology

- R&D on medical therapy using nanotechnology in drug delivery systems (DDS) and in equipment for diagnosis and therapy
- R&D concerning measurement and analysis of the structure of biomolecules and nanobiology which applies the principles of their behavior to semiconducting devices and materials

(iv) Basic technologies for measurement, evaluation, processing and quantitative analysis and simulation

- R&D of technology for analyzing, evaluating, processing and fabricating any type of material on nanoscale
- R&D on micro-machine technology, including micro-electro-mechanical systems (MEMS)
- Increase in the number of R&D-sites, which have access to technology for computer-aided design of materials and processes

(v) Materials technology aimed at innovative materials and functions

- Comprehensive search for materials with innovative functions, e.g. nano-carbons
- R&D on materials with innovative structures and advanced composites, which have highly controlled structure and composition

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