Investigating the Performance of Japan's Competitive Grant Grants-in-Aid for Scientific Research System

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Abstract

We aim at investigating characteristics of Japan's largest competitive grant Grants-in-Aid for Scientific Research (GASR) system in order to find a desirable research funding system, obtaining more applicants from various academic disciplines, researchers' gender, and ages. Firstly, we briefly describe the Japanese competitive research funding system including the GASR system. Then we investigate the GASR system quantitatively, focusing on its funding, allocation and relationship with the Japanese Science and Technology Basic Plans. Quantitative characteristic analyses are conducted for the GASR system from various perspectives such as type of research projects, academic disciplines, researchers' gender, and ages by investigating the data for applications, acceptances, and budgets allocated in the recent 10 years. Finally, we summarize our findings and conclude the paper by proposing policy recommendations to improve Japan's competitive research funding system.

Keywords: research funding system, competitive grant, grants-in-aid for scientific research, science and technology basic plan, characteristic analysis

1. Introduction

In 2017, 5.5% of the general account budget of Japan, amounting to 5.36 TY(trillion yen, equivalent to 48.29 BUSD (billion US dollars)), was allocated to the Ministry of Education, Culture, Sports, Science and Technology (MEXT). Still, compared to the average annual growth rate of 4.2% of the total general account budget from 20.84 TY in 1975 to 97.45 TY in 2017, the average annual growth rate of MEXT's budget was much smaller. For the same 42-year period, the budget grew only 1.65% on annual average, from 2.70 TY in 1975 to 5.36 TY in 2017, diminishing the share of the budget allocated to MEXT in the general account of the national budget from 12.9% to 5.5% during that period. Until 2000 the MEXT budget was reported as the sum of the budgets for education, culture, sports, science and technology. In 2017 the national government's share of compulsory education expenses was 1.52 TY, or up 28.4% (the largest share of the total MEXT general account budget 5.36 TY. The next largest share went to management expenses grants for national universities, amounting to 1.10 TY or 20.5% of the total, followed by the science and technology promotion fund (STPF) at 864.4 billion yen (BY) or 16.2%. Another major budget item was the government subsidies to private educational institutions, standing at 418.9 BY or 7.82% of the total. The significant cuts in MEXT's budget during the period 2004−2006 were the result of the "trinity reform" conducted by the Koizumi cabinet.

Figure 1 shows the initial budget for general account expenditure and for each sub-budget for the period 1985−2016, an index of 1.0 assigned to budget allocation for 1985. As can be seen in the figure, the initial budget for general account expenditure increased gradually with an overall increase of roughly 50% between 1985 and 2013. Social security spending has been steadily on the rise since 1985, tripling between then and 2013 despite a substantial decrease in 2012 associated with the surge in expenditures related to reconstruction efforts after the Great East Japan Earthquake. From 2012 to 2013, public works spending and education-related spending were on the decline in contrast to increases from 1985 to around 1998; those budget items are currently increasing little, by 0.8 to 0.9 percent. Against that background, we see a rapid increase in the STPF since 1985. The value of the fund tripled in the 18 years from 1985 to 2002 and continued rising thereafter until 2006, when it stabilized at around 3.5 times the 1985 level. The budget for the Science and Technology Basic Plan (STBP) has stabilized since the third basic plan.

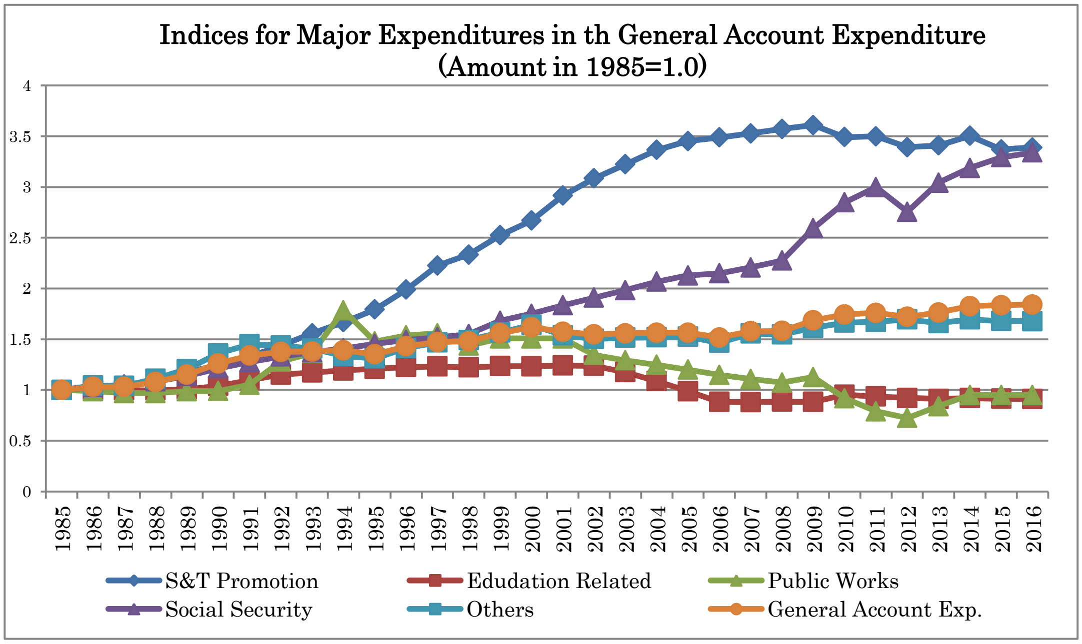

Figure 1. Value of Major Budget Components, 1985−2016 (1985 value = 1.0)

The main causes for the decrease of the education related budget are the reduction in the government's share of compulsory education expenses from approximately 1/2 to 1/3, and the transfer of tax revenue resources to the prefectures as a part of the so-called "trinity reform" promoted by the Koizumi Administration. Taking an integrated approach, the administration overhauled the government subsidies and local grant taxes, and reallocated tax resources, particularly in the form of transfers to the prefectures. A series of discussions preceded the slashing of the government's share of compulsory education expenses, which made up the largest part of government subsidies. The reform resulted in a 1 TY reduction of MEXT's total budget. The education and science-technology promotion fund (ESTPF) has risen gradually from 5.27 TY in 2006 to 5.44 TY in 2014 (an annual growth rate of 0.5%), which we characterize as a stagnant period. The ratio of the ESTPF to the total general account budget declined steadily from 12.5% in 1975 aside from period III when it increased slightly. Then in 2013 it decreased to 5.7% and continued to decrease throughout the period.

Reviewing evaluation research for the funding system and the innovation policy, we find that many researches, focusing on how to distribute public funds, have been done on the funding system in various countries. Lootsma, et al (1990) applied multi-criteria analysis technique in order to design a robust budget reallocation method in long-term research planning. The main objective of the study was to experiment with multi-criteria analysis to be applied to European non-nuclear energy research programs out of energy policy. They gave final scores of the programs to calculate optimal reallocation of the research budget. Geuna & Martin (2003) compared methods for evaluation and funding used across twelve countries in Europe and the Asia-Pacific region. On the basis of this comparison, and focusing in particular on Britain, the paper examined advantages and disadvantages of performance-based funding in comparison with other approaches to funding. Fandel (2007) used data envelopment analysis technique to find a solution for a real process of redistributing funds for teaching and research among the universities in North Rhine-Westphalia in Germany. Anwar & Oyama (2007) investigated the government subsidy system with respect to its allocation process to the private universities in Japan. Psacharopoulos (2008) focused on funding universities in several European countries for efficiency and equity. The author showed that the size of the social returns to investment in education gave an indication regarding the most efficient use of resources, while the difference between the private and the social rates relates to issues of equity. Muscio, et al (2013) used a set of probit and tobit panel data models to show that the government funding to universities complements funding from research contracts and consulting, contributing to increasing universities' collaboration with industry and activating knowledge transfer processes. Vilkkumaa et al (2015) investigated optimal funding decisions depending on evaluation accuracy. Focusing upon the policies maximizing the expected value of the project portfolio, they showed that the optimal policy for funding exceptionally excellent projects was to start a large number of projects and abandon a high proportion of them later. McKinney-Hagedorn (2017) proposed a performance-based funding model for community colleges in Texas, USA.

Regarding the technology and innovation aspects of the funding system, Kuwahara (1999) concluded that Japanese technology policies were less consistent than is commonly believed and involve an assortment of policy measures and actors/agencies by applying the Japanese Delphi process to the data obtained from every five years survey. Zhao, et al (2015) dealt with regional collaborations and indigenous innovation capabilities in China by applying a multivariate method for the analysis of regional innovation systems. They categorized regional collaborations amongst organizations by means of eight dimensions such as public versus private, innovation capacity versus infrastructures, knowledge production versus dissemination, collaboration, and so on. Paredes & Frigolett (2016) built a multi-criteria decision analysis model of responsible research and innovation (RRI) designed to generate science, technology, and innovation strategy. The model addressed how innovative firms could functionally and organically incorporate broader deliberation processes associated with responsible research and innovation involving actors of the public and private sectors. Staphorst, et al (2016) developed a framework for the structural equation modeling based context sensitive data fusion of technology indicators in order to produce technology forecasting output metrics in the National Research and Education Network. Jeffrey, et al. (2014) presented a detailed analysis of the activities in which ocean energy public funding in the UK and the U.S. has been spent comparing the UK and U.S. He has shown that UK investment in the sector has been relatively sustained and has increased since 2002 spending almost $295 million in total across multiple funding bodies.

Section 2 provides an overview of the background and brief history of Grants-in-Aid for Scientific Research (GASR). This is followed by an analysis of GASR characteristics in terms of type of grant in section 3. Finally, section 4 summarizes the findings and draws some conclusions.

2. The GASR Program in Japan

Figure 2 shows the values of the STPF, GASR and Strategic Creative Research Program (SCRP), respectively, for the period 1985−2017 in the general account budget allocated to the MEXT in Japan. The STPF can be divided into competitive grants and others. The present year (2018) has witnessed an increasing share for the competitive grants. From this Figure 2 we can find that the historical trend of major research funds in Japan such as STPF, GASR and SCRP can be approximated using the so-called “logistic curve”, which is a very common approximate function to express the demand growing process for new manufacturing products and so on. Also it can be seen that the largest growth rates for both estimated and actual values of STPF, GASR and SCRP occur coinciding with the time when the 3rd STBP started,

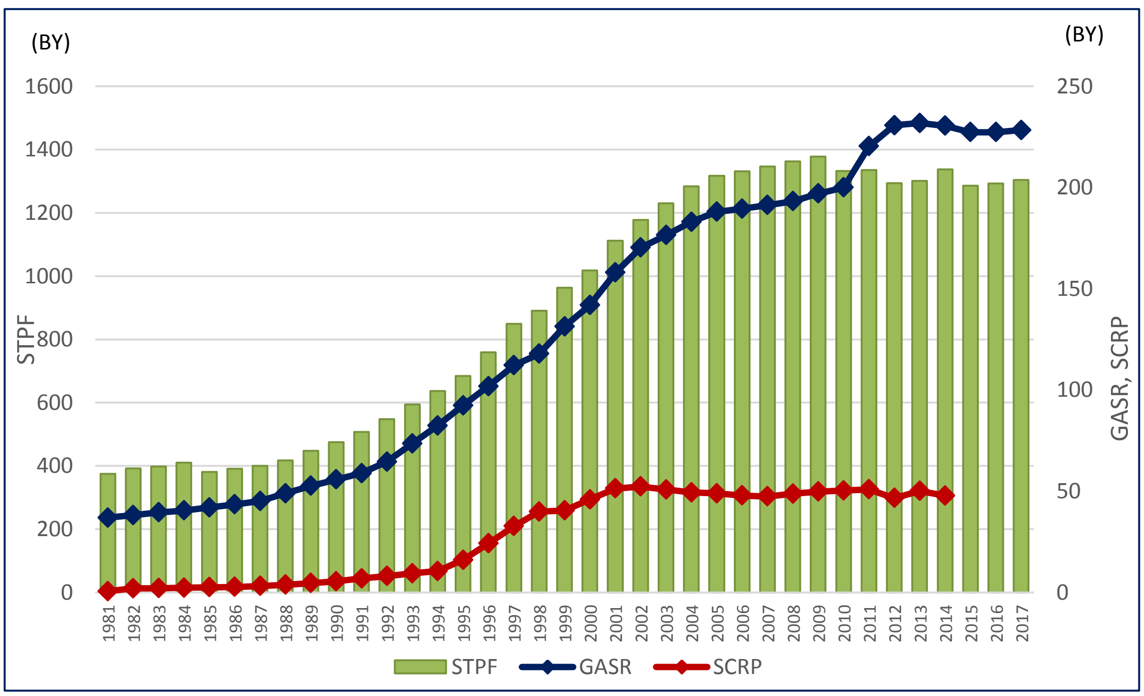

Figure 2. STPF, GASR and SCRP

STBP has been the basic science and technology policy designed in Japan. Brief history of five STBPs follows. The first STBP (1996–2000) was approved by the cabinet in July 1996, where a "competitive grant" was defined for the first time as a research fund provided in a competitive research environment. The plan clearly stated the sizeable expansion of various competitive grant programs including those offered by respective ministries. The expansion of the competitive grant program was clearly stipulated in the second STBP (2001–2005), which was approved by the cabinet in March 2001 and stated the expansion of competitive grants clearly along with a target of doubling the funds granted in the second period learning from the example of the United States, the world leader in effectively applying competitive grant programs. "Indirect expenses" were also defined as the necessary administrative expenditure of the research institutes involved in the research, tentatively set to around 30% of the budget. A particularly sharp rise can be seen in the value of competitive grants, from 296.8 billion yen (BY) in FY2000 to 467.2 BY in FY2005.

In March 2006 cabinet approved the third STBP (2006–2010), in which the plan to expand competitive grants was clearly stated again. The plan stressed the reform of competitive grant programs such as fair and transparent reviewing system, feedback of review results, securing program officer and post doctoral, and other measures such as ensuring diversity and continuity of basic research, creation of a seamless system, development of an attractive research environment for younger and female researchers, boosting high-risk but impressive and original research, reinforcement of the evaluation system, and development of a fair, transparent, and efficient system for allocating and using the fund. The fourth STBP (2011–2015) was approved by the cabinet in August 2011, after the Great East Japan Earthquake, in which the title was changed from "expansion" to "improvement and enrichment" of the competitive grant programs. The fourth STBP emphasized to promote the science, technology and innovation policy. Thus, the plan advocated the importance of the organizational institution to cultivate and train young human resources. From the policy aspects emphasizing point was shifted to problem solving approach from discipline oriented one. The council for Science, Technology and Innovation (CSTI) was established in May, 2014 following the council for Sciences and Technology. Then the current fifth STBP (2011–2015) was approved by the cabinet in 2016, in which policy challenges for creating future industry and reforming the society, i.e., for the so-called super smart society or "society 5.0" were advocated. Also in order to attain the innovation the fifth STBP emphasized cooperation by industry, academics and public administration in addition to human resources, knowledge and budgetary support were necessary and indispensable.

Arguably, competitive grants play a central role in Japan's funding program. Competitive grants were defined in the third STBP as "research and development funds allocated to researchers who proposed research and development projects that were accepted by an agency allocating necessary resources after due evaluation by several individuals including experts." The agencies that allocate such competitive grants are called funding agencies: major examples in Japan include the Japan Science and Technology Agency (JST) and the Japan Science Promotion Society (JSPS). Their American equivalents would be the National Science Foundation (NSF) and the National Institute of Health (NIH). The main roles of funding agencies are: organizing open calls for research and development project proposals; selecting excellent proposals; and allocating research funds to researchers or research institutions to support the performance of their research. The main competitive grant programs offered in Japan are listed in Table 1.

Table 1. Overview of Major Competitive Grant Programs in Japan

Funding Organization	Program	Characteristics	Budget (FY2013, BY) (%)
MEXT/ JSPS	GASR	・facilitates "academic research," ranging from basic to applied, inspired by researchers in the arts and humanities, social sciences, and natural sciences ・screened by peer review ・granted to original and pioneering research	238.1 (58.3)
JST (under supervision of MEXT)	Strategic Basic Research Program	・accelerate the research and development of new technologies ・help achieve important national targets in line with top-down policy ・established to meet socio-economic needs, by establishing a research system.	62.5 (15.3)
MHLW	Health and Labor Sciences Research Grant	・shape a competitive environment for original and pioneering research ・encourage scientific research related to welfare, labor, healthcare, welfare, environmental health, industrial health and safety issues	31.2 (7.6)
JST (under supervision of MEXT)	Promotion System for High Tech-nology Dev-elopment	・encourages innovation through collabor-ation between universities and companies ・commercial application of research findings of universities. ・granted to research and development. projects operated by a single university and a single company.	29.3 (7.2)
Others (16 programs)			47.4 (11.3)
Total			408.5(100)

The first such program, Special Coordination Funds for Promoting Science and Technology, was established in FY1981 to mobilize the research institutes of respective ministries in an all-out effort to accelerate basic research on important cross-cutting issues. In FY2011, the program was reorganized as Strategic Funds for the Promotion of Science and Technology after a budget screening and other discussions under the Democratic Party of Japan administration. A second noteworthy program was Exploratory Research for Advanced Technology (ERATO) aimed at stimulating basic research in a planned and efficient manner by organizing research groups under the leadership of creative and innovative researchers.

It seems that no laws or regulations clearly defining the objectives and characteristics of the GASR program. Meanwhile, limitations on funding programs and on the research items eligible for funding have been modified or abolished in keeping with the changing times and the social situation since the 1980s. In the 1990s, the government drew up the Basic Act on Science and Technology and developed the notion of STBP. In the early 2000s, a doubling of the value of competitive grants was planned in the second STBP. In 2010, the programs were subject to evaluation for the government's budget screening. The budget of the GASR program for FY2013 amounted to 238.1 BY (almost a 60% share of all the competitive grants offered by all ministries). In addition to the GASR, strategic funds for the promotion of science and technology and health and labor sciences research grants are also major elements of the national competitive grant program. The budget of these three programs amounted to 238.1 BY, 62.5 BY, and 31.2 BY, respectively for FY2013, which accounted for nearly 80% of the total competitive grants (408.5 BY) offered by all ministries.

3. Characteristics Analysis of the GASR by Type of Research Projects

The research items supported by GASR can be divided into two types: research mainly conducted by individual researchers on their own initiative; and team-based research aimed at pioneering advances in new areas of research. This section focuses on the former type of research, i.e. own-initiative research items, which are more in line with the original purpose of the grant, to support creative and pioneering research by individual researchers.

Table 2 summarizes the major GASR programs in Japan, consisting of Grant-in-Aid for Specially Promoted Research (GASPR), Grant-in-Aid for Scientific Research on Priority Areas (GASRA), Grant-in-Aid for Scientific Research on Innovative Areas (GASIA), Basic Research (BASCR) (S). (A), (B), and (C), Grant-in-Aid for Challenging Exploratory Research (GACER), and Grant-in-Aid for Young Scientists (GAYNS). GASPR has the largest budget, 200 to 500 MY (million yen) per project, and is intended only for small teams of distinguished and selected researchers.

Table 2. Major GASR Programs in Japan

Type	Contents
GASPR	Outstanding and distinctive research conducted by one or a small number of researchers expected to achieve remarkably excellent research results. Period: 3 to 5 years. Budget: 200 to 500 MY per project.
GASRA	Globally and socially required research leading to high-level advanced research evaluation. Period: 3 to 6 years. Budget: 200 to 600 MY
GASIA	Fostering research in novel areas leading to the development and heightening of Japan’s research level, conducted as collective research efforts. Period: 5 years. Budget: 10 to 300 MY per proposed area.
BASCR(S)	Creative/pioneering research conducted by one or a relatively small number of researchers. Period: 5 years. Budget: 50MY to 200MY.
BASCR (A, B, C)	Creative/pioneering research conducted by one researcher or jointly by multiple researchers. Period: 3 to 5 years, Budget: (A) 20 MY to 50 MY, (B) 5 MY to 20 MY, (C) 5 MY or less
GACER	Early-stage research conducted by one or more researchers which sets a high and challenging goal. Period: 1 to 3 years. Budget: 5 MY.
GACRP	Research conducted by a single or multiple researchers radically transforming an existing research framework, Budget: (Pioneering) 3 to 6 years, 5 to 20 MY, (Exploratory) 2 to 3 years.: (Pioneering) 5 MY or less.
GAYNS	(A), (B): Research conducted individually by a researcher of age 39 or younger. Period, Budget: (A) 2 to 4 years, 5 to 30 MY, (Exploratory) (A) 2 to 4 years, (B) 5 MY or less

3.1 GASR Funding by Research Projects

Examining number of accepted projects over time, amount of allocated budget, and the relationship the two, we identify the characteristic properties in order to improve the current funding system for obtaining an appropriate and desirable one. Appendix A presents the number of newly accepted projects and allocated budgets by research subject. Iida (2007) described the history of the Japanese GASR system. Kobayashi (1993) investigated methods for estimating university funding system with its related problems. Nishizawa et al (2005) utilized the database and list of selected research from 1985 to 2002 so as to determine the GASR project selection, then Nishizawa et al (2006) utilized the database of scientific papers and research budgets to develop an application software to elucidate variations in terms of the research organizations and researchers. Nishizawa et al (2008) also described the research cooperation system in Japan and visualized GASR related data using the data base on academic papers published in Japan. Hirota (2003) proposed a competitive fund allocation with its current situation and problems. In a study of private research systems, Kato (1991) summarized the states of the research fund system in Japan and identified related issues.

Figure 3 presents the relationship between the number of newly accepted projects and the total budget allocated for those projects. It can be seen that the yearly budgets for GASPR projects, GAYNS projects and BASCR projects (C) increased with increasing number of projects. However, the average fund for each project did not vary significantly, as the curves in Figure 3 located mostly pass through the origin with slope indicating 1.5 MY (13.39 TUS$) per program during the period 2000–2014. Thus, it can be said that the increase in total budget for those research projects reflects the increase in total number of newly accepted proposals. Budget allocations to specific area research and BASCR (B) decreased in relation to both number of newly accepted proposals and amount of allocated budgets. This implies that the number of specific area research projects, which were designed with much higher budgets by the government to promote research projects, and that for BASCR (B), the number of accepted proposals did not change substantially while the total budget decreased. This suggests that financial sources for BASCR (B) were shifted in part to BASCR (C).

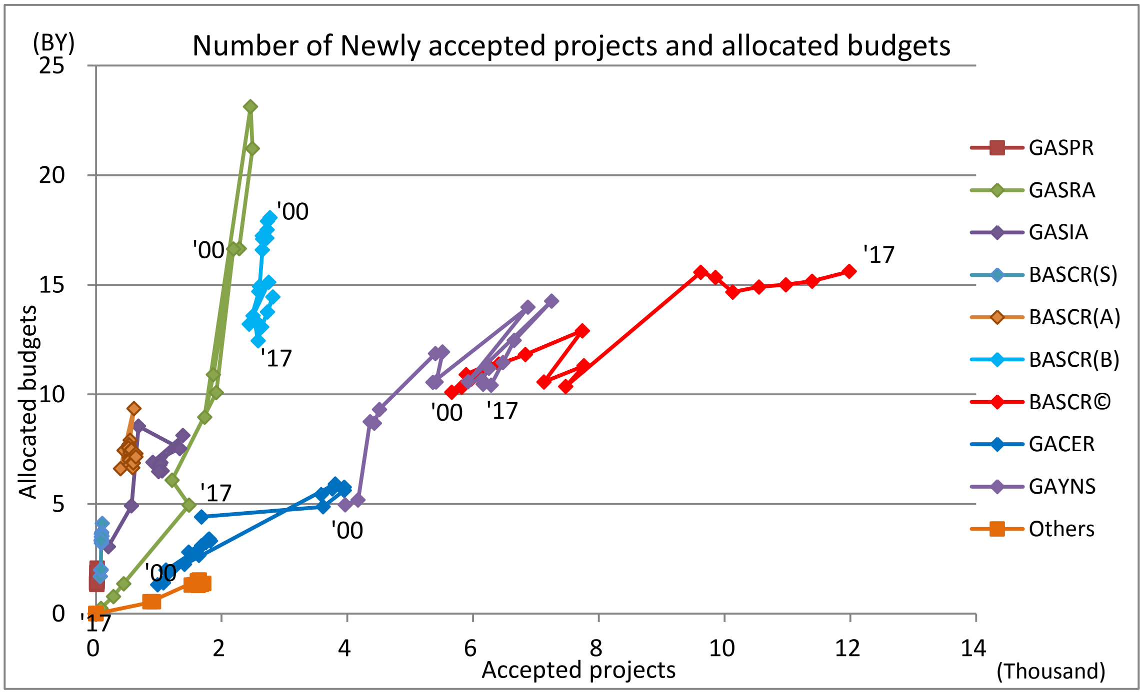

Figure 3. Number of Newly Accepted Proposals and Allocated Budgets

Figure 4 presents ratio of budget allocation to each type of research projects (sum of newly accepted proposals and continuing ones) from 2000 to 2014. It can be seen in Figure 4 that the budget for research projects with larger budget allocation such as GASPR, GASRA, and GACER ranged between 15% and 30% of total budget. However, those ratios varied with time, e.g. in the 2nd STBP period, announcements emphasized four focal fields (life science, IT, environment, Nano technology and materials) supporting social needs. In the 3rd STBP promotion and diversification of basic research were emphasized, and project type shifted toward multidisciplinary, interdisciplinary, and fusion research fields. In 2010, it was oriented to separate competitive research funds into two separate areas, needs-driven and seed-driven. Subsequently, in 2010–2011, that trend became more marked.

Allocations to BASCR (S), (A), (B), and (C) accounted for 60% of total allocations, while allocations to BASCR (B) decreased, and allocations to BASCR (C) showed a tendency to increase. These observations reflect that the fact that a base fund policy for small research projects such as BASCR (C) had been in place since 2011. The impact of the base fund policy can be seen in the increase of allocations for pioneering research projects from 2% of total allocations in 2000 to 8% in 2012. For young fellow research projects (S), (A), (B), and (C), although (S) type projects were abolished in line with project sorting policy, allocations to young research projects increased from 8% of total in 2000 to 19% in 2012. It is said that these increases were suggested in the STBP.

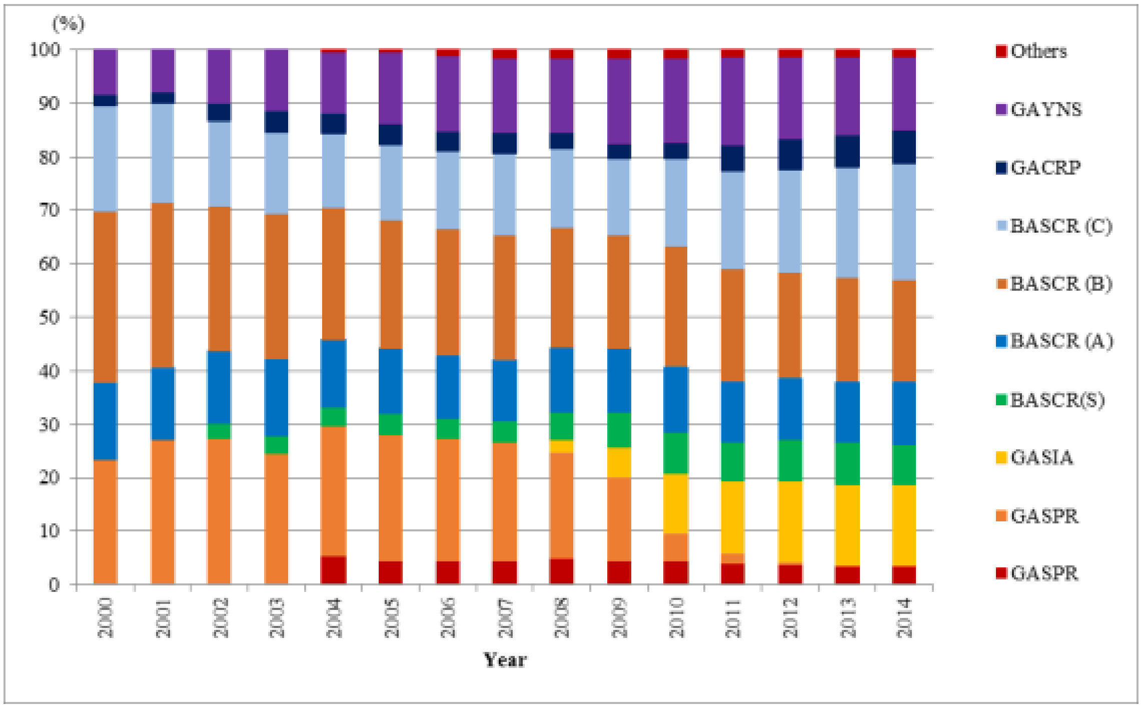

Figure 4. Proportion of Budget Allocation by Type of Research Projects

(sum of newly accepted proposals and continuing ones).

Appendix B presents the number of newly accepted and continuing research projects and budget allocated for those subjects during the period 2000–2017. Figure 5 presents the number of accepted projects (sum of newly accepted and continuing research projects) and the total amount allocated, by subjects. The number of accepted projects increased for Grants-in-Aid for BASCR (C) and GAYNS (S), (A), and (B) during the period 2000–2017. The former increased dramatically during the period from 14.4 to 36.1 thousand projects per year whereas the latter increased from 7.9 to 16.3 thousand projects. Although the number of accepted BASCR (S) projects remained relatively small, increasing from 135 to 425, allocated budget increased from 3.3 to 12.1 BY. The numbers of accepted BASCR (A) and (B) projects increased significantly from 1.5 to 2.2 thousand and from 7.6 to 9.4 thousand, respectively, but allocated budgets changed only slightly, from 13.7 to 18.5 BY and from 20.7 to 33.1 BY, respectively. Meanwhile, the number of GASPR and GASRA saw decreases in both number of accepted projects and amount of allocated budgets. Conversely, GASIA saw substantial increases in both number of accepted projects (from less than 200 in 2008 to 2,640 in 2017) and allocated budget (from 3.1 to 22 BY, an increase of 7.5 times). This reflects the fact that the need for GASPR decreased as GASPR shifted its focus to bottom-up basic research and the GASPR COE (Center of Excellence) was terminated, while at the same time new top-down competitive funds were promoted. Furthermore, special area research was significantly down-sized as research in new academic areas grew in response to policy encouraging more multidisciplinary and interdisciplinary research. As for the total value of newly accepted and continuing projects for each research subject during the period 2000–2014, the average budget allocated for BASCR (S) increased dramatically after 2008 because GAYNS (S) was terminated, and the research fund group in the academic working group of the Academic Councilors declared that since basic research had been major presence in the GASR funding system, attracting the largest number of applications from Japanese universities, the BASCR (S) research period should be extended its research period from 4 to 5 years, with an accompanying need for a further increase in its allocated fund. On the other hand, the allocated budget for BASCR (A) remained unchanged, and the average budget allocation per project decreased as the number of accepted projects increased.

In Figure 5 the slope of each line connecting the origin of the graph with each point corresponds to the amount of budget per project. It can be seen from the viewpoint of budget allocated to each GASR project that there are three large groups; group I, projects with allocated budget of about 1 MY, consisting of BASCR (C), young researchers' research and others; group II, with budget of about 4 MY, consisting of BASCR (B): and group III, with budget of more than 7 MY, consisting of BASCR (S) and (A) projects, including GASPR, GASRA and GASIA. This implies that under the present GASR funding system there would be no reason to further divide each group unless there were a specific reason to do it.

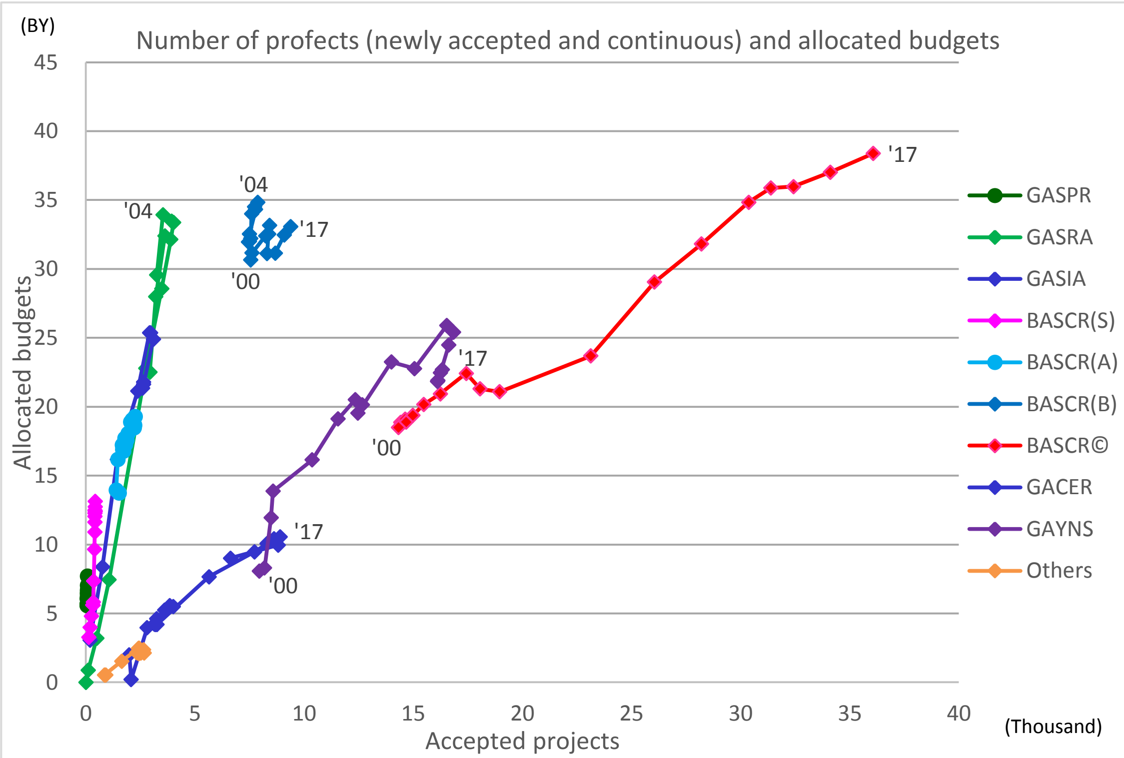

Figure 5. Number of Newly Accepted and Continuing Projects and Allocated Budgets

3.2 GASR Funding by Academic Disciplines

Academic disciplines include general research; general humanities and society; humanities; social sciences; natural sciences and engineering; biology; agriculture; and medical and dental sciences; and pharmacy. Appendix C presents the number of research projects (newly accepted and continuing) accepted and budgets allocated by academic discipline for the period 2008–2017. Figure 6 presents the number of newly accepted and continuing projects, and their corresponding allocated budgets, by academic discipline, during the same period. It can be seen in Figure 6 that both the number of projects accepted and allocated budgets increased for all academic disciplines with around 10% annual growth rate for the former and a few percent less for the latter during the period 2008–2014. In particular, the increase in 2011 is peculiar as the MEXT strongly supported scientific research just after the Great East Japan Earthquake. On the other hand, they show no increase or declining trend for most academic disciplines after 2014 until the present due to the budget cut for higher education area by the MEXT. Specifically, in all academic disciplines the number of projects accepted increased significantly during the above period: i.e., from 6 to 12 thousands in general research, 3.5 to 6 thousands in humanities, 5 to 9 thousands in social sciences, from 11 to 16 thousands in natural sciences and engineering, and dramatically from 13 to 22 thousands in the medical sciences.

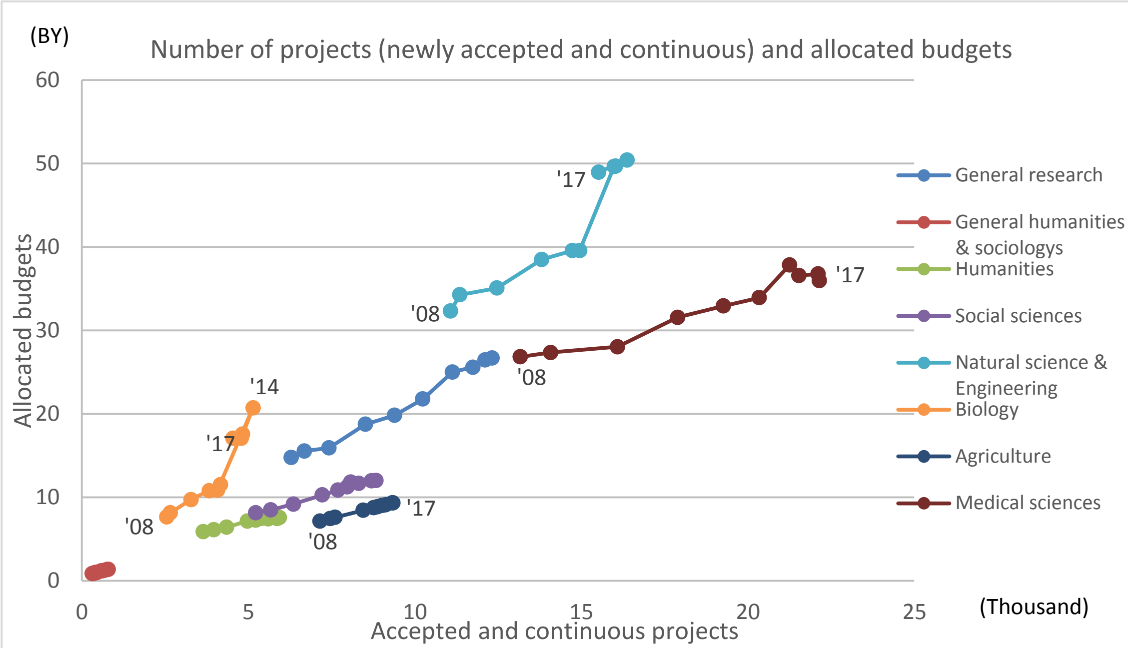

Figure 6. Number of Projects (newly accepted and continuing) and Allocated Budgets, by Academic Disciplines.

Figure 7 shows the share of allocated budget and project acceptance by research area (newly adopted and continuing) during the period 2008–2017. As for adoption rate (defined as the ratio between number of projects accepted and total number of applications) in each academic discipline during the period 2008–2017, it can be seen that the ratios increased within the range 14 to 16% for general research, 0.7 to 1.0% for general humanities and sociology, around 8% for humanities, remained constant around 12% for social sciences, 24.6 to 21.0% for natural sciences and engineering, 5.6 to 6.5% for biology, 5.9 to 5.2% for agriculture, remained constant around 30% for medical sciences, respectively. Regarding the budget allocation ratio, we see that the ratios follow 14 to 17% with increasing trend for the general research, constantly around 0.8% for the general humanities and sociology, 5.7 to 4.8% slightly decreasing for the humanities, constantly around 8% for the social sciences, constantly around 31.0% for the natural science and engineering, 7.3 to 11.0% with slightly increasing trend for the biology, 6.9 to 5.6% with slightly decreasing trend for the agriculture, from 25.9 to 22.7% with slightly decreasing trend for the medical science, respectively.

As for adoption ratio and budget allocation ratio during the period 2008–2017, both ratios changed little for academic fields such as humanities, sociologies, agricultures, and medical and medicine sciences and, but in the case of general research and biology both ratios increased. In particular, the adoption ratio and the budget allocation ratio for the general research increased dramatically from 14.0% and 14.3% in 2008, respectively, to 16.4% and 16.7% in 2017, respectively. During the same period, the adoption ratio for the natural sciences decreased from 24.6% to 21.0% while their allocation rates stayed almost the same at around 32%. Both adoption ratio and budget allocation ratio decreased slightly for the humanities.

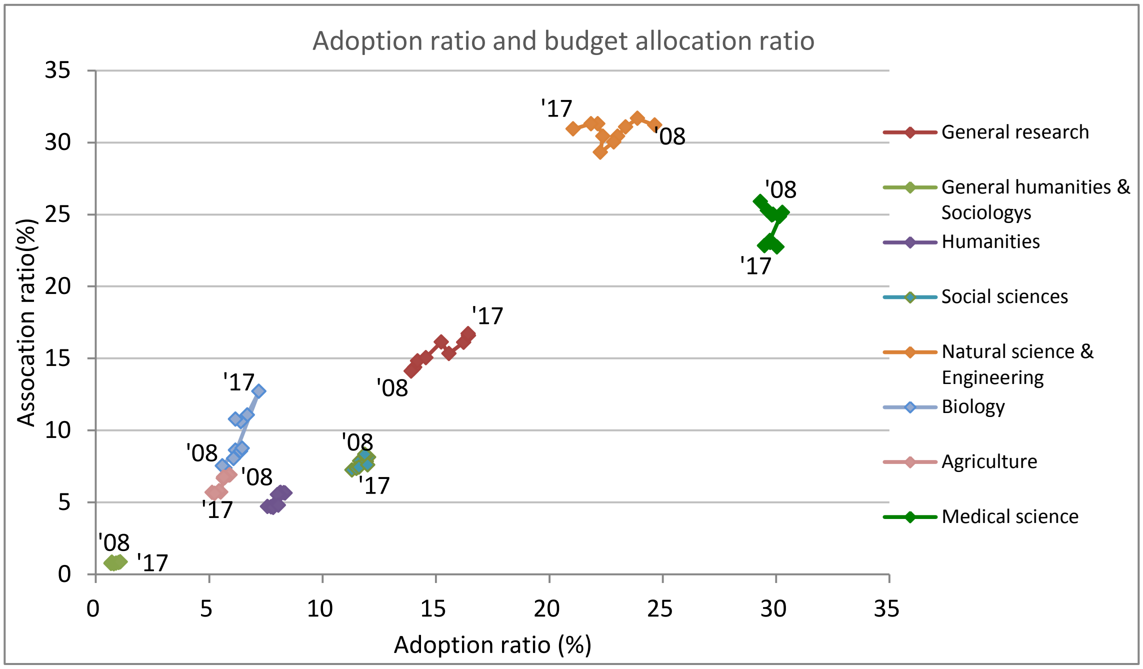

Figure 7. Adoption Ratio and Budget Allocation Ratio

3.3 GASR Funding by Research Subjects, Genders and Ages

Appendices D and E show the total number of applications and the number of accepted projects by age and gender for the period 2006–2017. Figures 8 and 9 show the numbers of applications and selection by age, for male and female applicants in the same period. From these figures we find the followings:

(i) In the period 2006–2017 we see that both male and female applicants show a stable tendency in both the total number of applicants and accepted projects by age and gender. In particular, female group of ages from 35 to 39 years old has shown a large increase in both the total number of applicants and accepted projects.

(ii) Both the total number of applications and number of accepted projects were the largest at age group 35 to 39 years old for both male and female applicants. The largest numbers for male applications were at group of 35 to 39 years old and 40 to 44 years old, then the group of 45 to 49 years old was the second, then the group of 50 to 54 years. old follows. In the case of female applications, the largest number of applicants was at group of 30 to 34 years old, then the second was 40 to 44 years old.

(iii) In 2006, the ratio between male and female applicants was about 6.1 times more for male, while it was decreasing afterward. Then in 2017 the ratio became 3.7. We foresee this trend may continue for a while in the near future. There was not significant difference in the adoption rate between male and male, and the rate has been showing an increasing trend ranging in between 20% and 30%.

As mentioned above, it is worthy of note that both total number of applications and number of accepted projects were almost stable for males and females. As there is a limitation the total number of applications by both males and females of ages over 60, we identify a need for policy to increase applications by male applicants of ages less than 25. Furthermore, it can be expected that the proportion of female researchers would increase more than that for males, i.e., the proportion of male to female applicants would decrease current ratio 3.7 in 2017, approaching to the male ratio. Under the circumstances reported here, regarding the question of reducing the male– female ratio, we believe that, for the time being, it would require great efforts to achieve a ratio of 2.0 within the next several years.

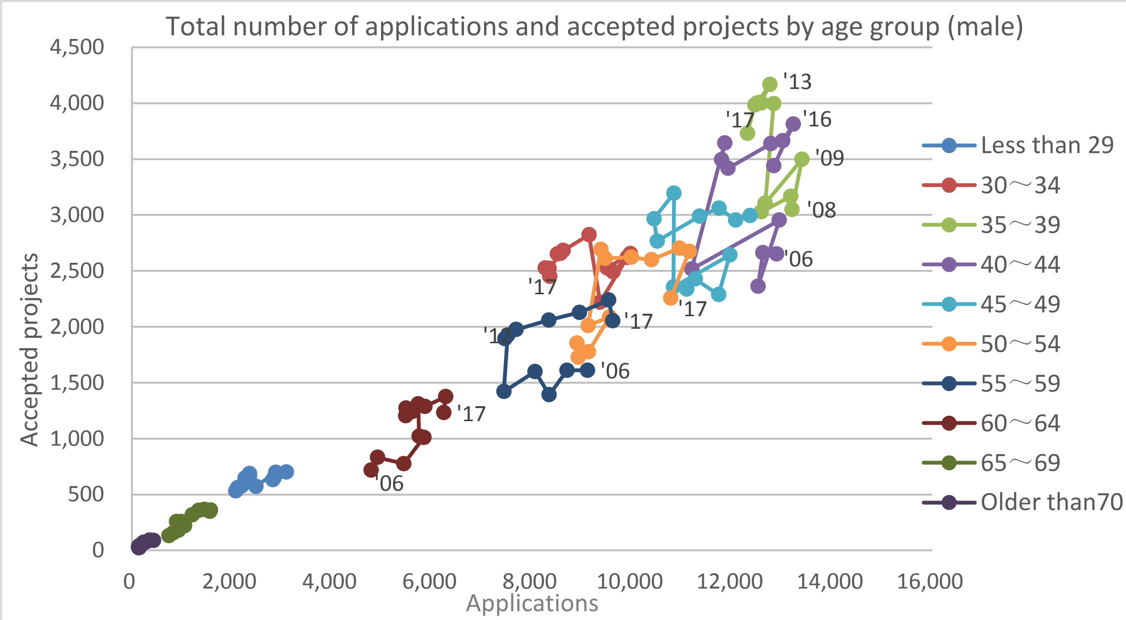

Figure 8. Number of Applications and Selections according to Age Range (male)

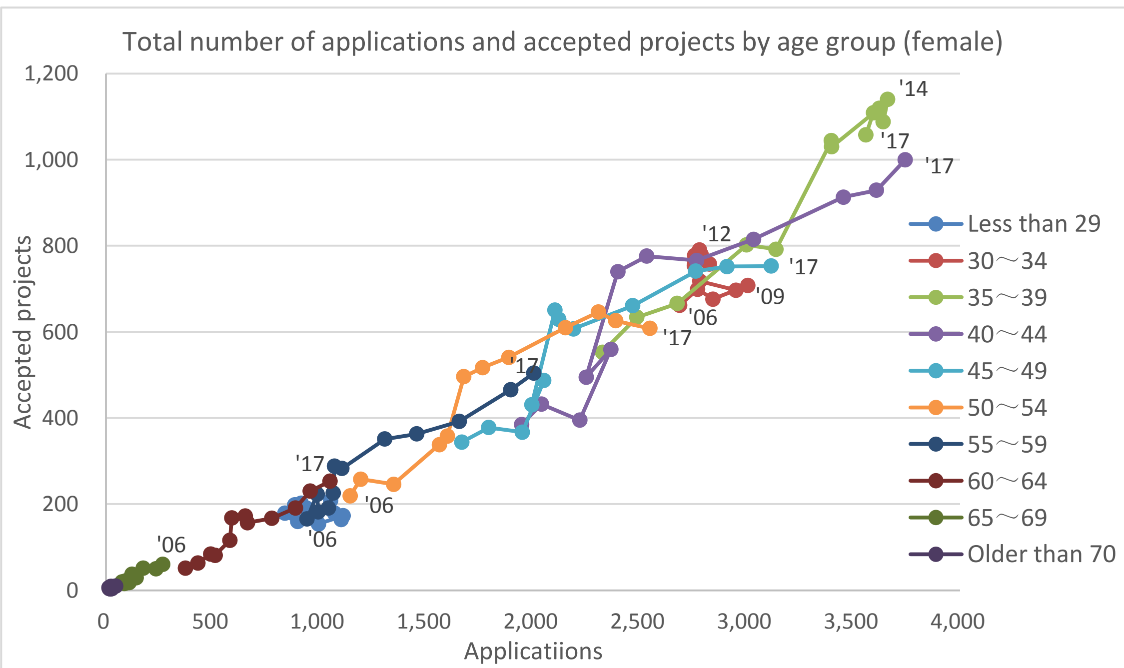

Figure 9. Total Number of Applications and Accepted Projects by Age Group (female)

4. Summary and Conclusion with Policy Suggestions

In addition to the GASR, two other major types of national competitive grants are strategic funds for the promotion of science and technology and health and labor sciences research grants. The FY2013 budgets of these three programs amounted to 238.1 BY, 62.5 BY, and 31.2 BY, accounting for nearly 80% of the competitive funding (408.5 BY) offered by all Japanese ministries.

We have examined here the GASR system, the largest competitive research funding system in Japanese history. We described its behavior from various perspectives, such as its history, and in terms of both quantitative and qualitative characteristics. In addition, we have shown that the GASR system has played a key role in, and has contributed greatly to, scientific research activities and higher education in Japan. In section 2 we briefly described the GASR system including a historical review. In section 3 we examine the GASR system quantitatively using historical data for the last 35 years, focusing on operational data such as the number of projects accepted and number of budgets allocated.

The following is a summary of the above quantitative analysis of the growth of the GASR system, and the results of quantitative characteristic analysis of the data, including the number of accepted projects and the number of budgets allocated for all types of GASR systems, including; BASCR (S), (A), (B) and (C); GASRIA; GACER; and GACR.

i) GASR's share of basic research funding has been increasing recently; the shares of BASCR (S) and (C) have increased; the share of fund (A) has been almost constant; and that of fund (B) has decreased.

ii) All GASR projects have been found to be divisible into three groups, (1) BASCR (C), GAYS, and other; (2) BASCR (B); and (3) BASCR (S), GASPR, GASRIA and GACR. This implies that we could aggregate these projects in each group into one rather than keeping them separately.

iii) As for the number of accepted GASR projects and budgets allocated by research subjects, it can be seen that research (C) and GAYR have been increasing while their budget per project has remained rather constant at around 1 MY. This can be solved by the aggregation procedure we proposed above in ii).

In addition, from the perspective of academic disciplines we can say that funds for the social sciences and natural sciences have been increasing, while that for the medical and medicine sciences has increased dramatically. By applying our statistical data processing approach to examine the structure of the Japanese research funding system, we obtained the following results. The behavior of the science technology promotion fund, the GASR fund and the strategic creation research fund can be expressed as a logistic growth curve. Estimates to be obtained with the so-called approximate "logistic curve" function models indicate that the highest growth periods for these funds correspond to the second and the third STBPs, and the reform period of the GASR, respectively. In particular, the period of fastest growth of the SCRA was around 2003, i.e., almost 3 years before the fastest growth periods of SRPF and GASR. We suggest that the fifth STBP, as we are in the process, we should increase the total GASR fund based upon our forecasting findings with respect to the applicants' gender and ages.

We have examined the Japanese GASR system quantitatively and comparatively using recent data. The results reveal that the Japanese research funding system is in need of further reform and improvement if the Japanese research funding system is to improve. We believe that the results of our analysis will be of use for determining our future strategic research direction towards reforming the Japanese funding system, and .that a drastic and innovative reform may be required.

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Appendix A. Number of newly accepted projects and allocated budgets by research subjects

	GASPR		GASRA		GASIA		BASCR(S)		BASCR(A)	
	No.	ALB.	No.	ALB.	No.	ALB.	No.	ALB.	No.	ALB.
2000			2,278	16,643.6					394	6,609.4
2001			2,490	21,221.1					450	7,441.5
2002			2,460	23,132.6			74	1,995.7	604	9,354.3
2003			1,728	8,962.6			69	1,692.8	544	7,906.4
2004	19	1,693.5	1,868	10,903.6			65	1,694.8	509	7,586.2
2005	20	1,596.2	2,186	16,632.0			74	1,992.8	526	7,711.0
2006	18	1,950.7	1,916	10,086.0			82	1,976.0	520	7,567.9
2007	20	2,072.9	1,210	6,086.5			81	2,025.3	543	7,437.2
2008	19	1,907.8	1,481	4,953.0	198	3,051.3	85	3,329.4	545	7,307.0
2009	12	1,389.1	442	1,365.5	567	4,919.3	100	4,120.7	567	7,440.7
2010	15	1,538.5	279	778.6	678	8,552.2	89	3,716.1	536	7,110.1
2011	15	1,352.2	80	239.6	1,334	7,536.7	90	3,382.3	565	7,478.0
2012	18	1,462.0	9	25.4	905	6,907.9	87	3,508.3	535	6,985.5
2013	15	1,890.8	2	6.0	1,385	8,124.4	87	3,641.2	541	6,787.1
2014	14	1,331.5			1,035	6,883.6	87	3,207.0	583	6,656.3
2015	14	1,435.2			1,016	6,793.5	87	3,296.1	597	6,870.9
2016	14	1,384.2			1,051	6,508.7	95	3,537.3	634	7,299.5
2017	13	1,387.91,			996	6,782.5	81	3,343.2	636	7,157.3

	BASCR(B)		BASCR(C)		GACER		GAYNS		OTHRS	
	No.	ALB.	No.	ALB.	No.	ALB.	No.	ALB.	No.	ALB.
2000	2,645	17,239.2	5,887	10,903.8	980	1,315.1	3,966	4,970.7	0	0.0
2001	2,726	17,905.2	6,229	11,344.6	1,074	1,411.2	4,170	5,180.2	0	0.0
2002	2,718	17,125.7	5,662	10,097.7	1,750	3,243.6	4,361	8,754.4	0	0.0
2003	2,661	17,224.0	5,816	10,329.6	1,478	2,813.1	4,430	8,684.8	0	0.0
2004	2,769	18,070.0	5,973	10,694.4	1,779	3,360.4	4,508	9,313.3	914	540.0
2005	2,654	17,090.4	6,410	11,380.4	1,801	3,397.4	5,402	11,869.6	861	540.0
2006	2,725	17,510.6	6,829	11,816.9	1,677	3,099.7	5,515	11,931.5	1,643	1,538.7
2007	2,649	16,592.2	7,736	12,902.4	1,820	3,319.0	5,411	10,563.3	1,616	1,513.1
2008	2,601	14,924.2	7,128	10,570.9	1,117	1,983.0	5,361	10,557.2	1,612	1,494.5
2009	2,749	15,116.2	7,764	11,303.3	1,640	2,660.8	6,872	13,973.4	1,715	1,372.9
2010	2,498	13,585.3	7,471	10,361.6	1,412	2,250.9	5,921	10,581.1	1,562	1,314.2
2011	2,592	14,688.9	9,620	15,564.5	3,809	5,916.1	7,246	14,256.1	1,519	1,310.6
2012	2,440	13,200.8	9,857	15,332.5	3,759	5,692.8	6,654	12,456.6	1,561	1,316.8
2013	2,523	13,400.4	10,127	14,669.3	3,582	5,426.1	6,473	11,453.3	1,620	1,297.1
2014	2,580	12,446.7	10,549	14,905.5	3,950	5,762.1	6,285	10,422.6	1,631	1,290.8
2015	2,638	13,078.8	10,975	15,003.8	3,952	5,628.1	6,160	10,459.9	1,652	1,362.9
2016	2,813	14,441.4	11,392	15,166.2	3,613	4,871.4	6,139	10,652.3	1,662	1,364.4
2017	2,729	13,757.1	11,983	15,608.3	1,680	4,413.7	6,250	11,191.3	1,677	1,326.3

(Unit: MY)

GASPR: Grant-in-Aid for Specially Promoted Research, GASRA: Grant-in-Aid for Scientific Research on Priority Areas, GASIA: Grant-in-Aid for Scientific Research on Innovative Areas, BASCR: Basic Research, GACER: Grant-in-Aid for Challenging Exploratory Research, GAYNS: Grant-in-Aid for Young Scientists, OTHRS: Others.

No.: Number of projects, ALB.: Allocated budgets

Appendix B. Number of newly accepted and continuing projects and allocated budgets by research subjects

	GASPR		GASRA		GASIA		BASCR(S)		BASCR(A)	
	No.	ALB.	No.	ALB.	No.	No.	No..	ALB.	No..	ALB.
2000			2,937	22,506.7					1,537	13,733.8
2001			3,207	28,001.1					1,397	13,954.6
2002			3,623	32,411.3			135	3,273.8	1,473	16,166.5
2003			3,252	29,558.7			198	3,979.9	1,672	17,212.2
2004	80	7,702.5	3,537	33,937.9			257	4,796.4	1,798	17,714.7
2005	84	6,445.6	3,943	33,469.9			316	5,618.5	1,771	17,349.2
2006	81	6,350.4	4,018	33,369.7			336	5,588.4	1,695	16,899.3
2007	85	6,595.0	3,895	32,142.1			344	5,813.7	1,731	16,782.3
2008	86	7,031.2	3,477	28,559.0	198	3,051.3	363	7,351.4	1,767	17,206.7
2009	81	6,714.2	2,756	22,799.4	765	8,366.2	398	9,655.2	1,822	17,267.2
2010	80	6,465.2	1,064	7,436.8	1,438	16,168.9	417	10,913.1	1,878	17,582.8
2011	79	6,244.1	501	3,206.6	2,378	21,138.9	425	11,625.4	1,940	18,059.8
2012	77	6,033.6	117	882.5	2,925	25,356.4	435	12,737.6	2,054	18,888.8
2013	73	6,066.5	2	6.0	2,969	25,366.5	435	13,122.5	2,127	19,041.5
2014	74	5,677.8			3,100	24,909.2	419	12,486.9	2,266	19,291.8
2015	74	5,646.8			2,604	21,359.5	620	12,279.5	2,230	18,672.3
2016	73	5,585.1			2,654	21,624.4	431	12,407.5	2,233	18,613.0
2017	68	5,558.2			2,643	21,799.8	425	12,050.1	2,220	18,471.7

	BASCR(B)		BASCR(C)		GACER		GAYNS		OTHRS	
	No.	ALB.	No.	ALB.	No.	ALB.	No..	ALB.	No..	ALB.
2000	7,556	30,656.6	14,435	18,867.0	1,992	1,999.3	7,957	8,080.3	0	0.0
2001	7,454	31,953.0	14,638	19,105.7	2,081	2,099.4	8,194	8,297.9	0	0.0
2002	7,502	32,006.2	14,688	18,889.2	2,809	3,965.2	8,491	11,948.5	0	0.0
2003	7,500	32,548.8	14,330	18,488.9	3,246	4,607.4	8,579	13,866.7	0	0.0
2004	7,877	34,846.3	14,993	19,382.1	3,610	5,250.0	10,376	16,149.0	914	540.0
2005	7,770	34,318.9	15,487	20,156.4	3,855	5,558.0	11,561	19,119.9	861	540.0
2006	7,740	34,506.7	16,248	20,943.3	4,014	5,507.6	12,350	20,507.3	1,643	1,538.7
2007	7,598	34,011.0	17,432	22,424.1	3,879	5,506.1	12,672	20,146.9	2,406	2,455.5
2008	7,559	32,224.7	18,068	21,301.6	3,196	4,208.0	12,471	19,550.3	2,439	2,468.4
2009	7,619	31,160.1	18,966	21,088.4	3,138	4,210.7	14,000	23,243.4	2,648	2,370.8
2010	8,246	32,402.2	23,142	23,686.8	3,265	4,203.8	15,066	22,774.6	2,583	2,213.4
2011	8,421	33,172.7	26,062	29,057.0	5,651	7,666.0	16,546	25,900.6	2,340	2,149.8
2012	8,358	32,515.8	28,211	31,815.4	7,735	9,476.7	16,848	25,403.6	2,352	2,147.0
2013	8,378	32,543.9	30,377	34,848.5	8,309	10,064.9	16,634	24,489.1	2,451	2,133.5
2014	8,311	31,119.6	31,389	35,879.0	8,629	10,420.6	16,256	22,468.8	2,529	2,122.6
2015	8,682	31,150.7	32,432	35,975.6	8,904	10,546.0	16,129	21,896.4	2,430	2,088.2
2016	9,102	32,475.4	34,121	37,028.2	8,821	9,963.9	16,116	21,829.1	2,674	2,135.1
2017	9,393	33,080.5	36,081	38,384.1	6,629	9,004.1	16,334	22,702.4	2,502	2,124.0

(Unit: MY)

GASPR: Grant-in-Aid for Specially Promoted Research, GASRA: Grant-in-Aid for Scientific Research and Priority Areas, BASCR: Basic Research, GASIA: Grant-in-Aid for Scientific Research on Innovative Areas, GACER: Grant-in-Aid for Challenging Exploratory Research, GAYNS: Grant-in-Aid for Young Scientists, OTHRS: Others

No.: Number of projects, ALB.: Allocated budgets

Appendix C. Number of newly accepted and continuing projects and allocated budgets by research areas (New and continuing)

	General research		General humanities and sociologies		Humanities		Social sciences	
	No.	ALB.	No.	ALB.	No.	ALB.	No.	ALB.
2008	6.291	14,779.3	0.318	860.4	3.645	5,871.7	5.227	8,152.1
2009	6.681	15,545.4	0.341	863.4	3.963	6,111.2	5.670	8,486.5
2010	7.422	15,912.4	0.368	894.5	4.348	6,418.2	6.355	9,184.6
2011	8.516	18,752.5	0.405	1,003.1	4.973	7,161.6	7.221	10,289.1
2012	9.387	19,817.1	0.430	999.5	5.227	7,250.1	7.691	10,860.5
2013	10.240	21,779.7	0.466	1,030.4	5.380	7,448.0	7.966	11,243.5
2014	11.133	25,010.1	0.572	1,178.2	5.411	7,680.1	8.079	11,812.9
2015	11.747	25,588.2	0.644	1,219.8	5.595	7,422.1	8.320	11,676.5
2016	12.322	26,702.3	0.749	1,322.9	5.862	7,470.2	8.705	11,979.7
2017	12.111	26,442.0	0.794	1,361.1	5.938	7,594.1	8.834	12,015.2

	Natural sciences		Biology		Agriculture		Medical science	
	No.	ALB.	No.	ALB.	No.	ALB.	No.	ALB.
2008	11.073	32,331.9	2.554	7,644.4	2.656	7,155.2	13.166	26,834.9
2009	11.352	34,258.4	2.654	8,135.8	2.795	7,460.1	14.077	27,341.8
2010	12.462	35,064.9	3.281	9,721.4	3.036	7,601.3	16.088	28,047.4
2011	13.812	38,488.9	3.829	10,806.5	3.401	8,445.6	17.897	31,566.8
2012	14.728	39,548.9	4.163	11,525.5	3.622	8,765.7	19.263	32,921.3
2013	14.951	39,558.0	4.079	10,854.7	3.787	9,120.8	20.343	33,923.4
2014	15.988	49,637.6	5.143	20,724.0	3.944	9,325.2	21.260	37,836.7
2015	16.027	49,682.1	4.833	17,562.1	3.710	9,019.2	21.536	36,581.1
2016	16.372	50,395.2	4.795	17,061.0	4.073	9,341.4	22.111	36,757.7
2017	15.522	48,956.6	4.543	17,066.3	3.858	8,883.0	22.147	35,969.3

（Unit: MY）

Appendix D. Total number of applications and accepted projects by age (male)

Age		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
~25	APP	3,090	2,855	2,822	2,877	2,483	2,194	2,115	2,079	2,316	2,356	2,264	2,350
	ACC	700	655	631	698	572	576	561	532	659	686	647	664
30~34	APP	9,965	9,501	9,617	9,902	9,357	9,139	8,507	8,569	8,619	8,338	8,264	8,353
	ACC	2,654	2,525	2,490	2,620	2,219	2,822	2,652	2,656	2,681	2,521	2,525	2,452
35~39	APP	12,582	13,170	13,192	13,393	12,657	12,829	12,497	12,752	12,573	12,580	12,452	12,304
	ACC	3,027	3,166	3,049	3,498	3,104	3,994	4,000	4,166	4,007	4,000	3,983	3,730
40~44	APP	12,885	12,613	12,515	12,941	11,190	11,848	11,787	11,912	12,769	13,009	13,221	12,831
	ACC	2,650	2,663	2,361	2,953	2,515	3,643	3,493	3,416	3,636	3,663	3,811	3,439
45~49	APP	11,091	11,260	11,729	11,951	10,827	10,837	10,435	10,500	11,344	11,734	12,066	12,359
	ACC	2,335	2,427	2,287	2,642	2,355	3,195	2,966	2,766	2,987	3,060	2,955	2,995
50~54	APP	8,924	8,897	9,125	9,547	9,119	9,377	9,456	9,986	10,385	10,941	11,141	10,771
	ACC	1,726	1,853	1,775	2,086	2,011	2,691	2,612	2,622	2,599	2,703	2,673	2,257
55~59	APP	9,107	8,698	8,340	8,059	7,435	7,514	7,458	7,682	8,331	8,949	9,532	9,613
	ACC	1,611	1,611	1,392	1,599	1,420	1,923	1,892	1,975	2,059	2,128	2,238	2,053
60~64	APP	4,783	4,912	5,439	5,838	5,741	5,725	5,482	5,477	5,605	5,858	6,271	6,234
	ACC	717	831	775	1,010	1,022	1,311	1,271	1,203	1,242	1,288	1,374	1,231
65~69	APP	742	830	934	1,056	996	893	984	1,210	1,337	1,448	1,571	1,559
	ACC	131	158	179	220	217	257	256	318	357	365	361	348
70~	APP	136	143	150	137	149	168	205	239	278	357	358	432
	ACC	31	28	26	24	41	40	58	72	73	88	92	89

APP: Applications, ACC: Accepted

Appendix E. Total number of applications and accepted projects by age (female)

Age		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
~25	APP	1,102	1,052	1,071	1,110	995	898	885	838	869	883	915	939
	ACC	164	209	179	173	154	160	198	179	180	197	202	191
30~34	APP	2,687	2,771	2,842	3,006	2,950	2,781	2,780	2,755	2,826	2,757	2,787	2,757
	ACC	662	699	676	708	697	718	790	754	758	778	780	766
35~39	APP	2,325	2,486	2,675	3,000	3,138	3,397	3,399	3,621	3,661	3,640	3,594	3,559
	ACC	553	634	666	802	792	1,044	1,030	1,119	1,140	1,088	1,109	1,058
40~44	APP	1,946	2,040	2,219	2,364	2,249	2,397	2,533	2,766	3,032	3,453	3,608	3,743
	ACC	385	432	395	559	495	740	776	766	815	913	929	1,000
45~49	APP	1,667	1,793	1,950	2,050	1,994	2,103	2,121	2,189	2,467	2,762	2,908	3,115
	ACC	344	378	367	487	431	651	629	607	661	741	752	753
50~54	APP	1,143	1,193	1,347	1,561	1,599	1,676	1,764	1,886	2,152	2,306	2,387	2,548
	ACC	219	258	246	338	358	496	517	541	610	646	626	608
55~59	APP	942	989	994	1,042	1,065	1,071	1,105	1,306	1,455	1,654	1,896	2,003
	ACC	166	223	182	191	226	288	283	351	363	392	466	504
60~64	APP	372	431	490	511	581	589	652	663	776	888	956	1,049
	ACC	51	63	84	81	116	168	172	157	167	191	230	253
65~69	APP	75	95	86	109	94	89	97	122	141	175	234	266
	ACC	19	21	16	18	17	21	22	37	29	51	50	60
70~	APP	14	15	20	23	19	21	28	28	22	25	32	45
	ACC	6	4	4	9	4	3	8	4	4	8	7	10