Do External Funding Sources Affect Research Productivity?: A Departmental-Level Analysis of Seven Former Imperial Japanese Universities

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Do External Funding Sources Affect Research Productivity?: A Departmental-Level Analysis of Seven Former Imperial Japanese Universities *

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This study examines the research productivity of departments in seven former imperial universities of Japan. We categorize the departments into five academic fields: engineering, health sciences (i.e., medicine, dentistry and pharmaceutical), economics, science, and agriculture. Then, the impact of fundamental and external research funds is examined to see whether they positively affect research productivity—measured by the number of papers accepted in peer-reviewed, international academic journals. Additionally, we investigate whether such external funding sources affect productivity in each of the five fields differently, noting any variation between them.

The estimation results reveal that, first, the increase of fundamental and external funds per faculty member is positively correlated with research productivity in the fields of engineering and health sciences. Second, considering the results of further investigation into the effects of external funding, research funding by the public sector can increase productivity in each of the five academic fields. Third, the results pertaining to private research funds show that research funding provided by firms can increase productivity in engineering and health sciences. However, for economics, the increase in external funding from firms is negatively correlated with research productivity. This result might be because the purpose of industry–university collaboration differs according to the academic field. Regarding economics, the output from the resulting collaboration might not result in the production of an academic paper, but rather make policy recommendations or provide consulting using quantitative analysis.

This study is the first attempt by any Japanese university to analyze research productivity across several departments. The empirical results show that depending on the discipline, the same resources of research funding impact research productivity differently. Nowadays, the Japanese central government has been about the business of reforming resource allocation systems of universities by evaluating their research performance, basing them more on the quantitative indicators such as the key performance indicators (KPI). However, a key result of this study implies that when a relative evaluation of universities is applied, each university's situation must be more carefully considered, especially in terms of what kinds of academic departments it has, and which specialties or segments it features.

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Keywords: financial sources, research productivity, departmental-level analysis, five academic fields

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1. Introduction

For Japan, a mature economy, to realize long-term economic growth, fostering innovation improvements that will raise the level of technology are essential. As a main driver of this movement, universities are expected to play a central role in promoting basic research, along with providing their research findings to industry that can create added value. On the one hand, effectively supporting research in universities has become an urgent and important political agenda for the government, which led to the enhancement and reform of funding by universities in “The 5th Science and Technology Initiative (cabinet decision of January 22, 2016).” To “strengthen the fundamental ability to promote science and technology innovation,” the government plans to maximize both research capabilities and results by promoting reform pertaining to two types of funding: (1) for basic expenses that provide stable and on-going support for university researchers, and (2) for public funding that promotes superior research projects and specific-purpose research.

On the other hand, public funding for higher educational institutions, including universities in Japan, was about 0.5% of GDP in FY 2014—a rather low level compared to the OECD average of 1.1%.[1] Regarding basic expenses needed by national universities, subsidies for operating expenses providing continuous support for research activities are being reduced every year. However, it is to be noted that Japan is shifting from supplying basic expenses for public funds to competitive ones. The ratio of basic expenses and competitive funds was 86:14 in 2001; however, it was 71:29 in 2009 (Maruyama, 2013, p. 61), and this trend has continued down to the present. The aforementioned 5th Science Technology Initiative also clearly states that the enhancement of competitive funding is important to secure a diversity of R&D and to contribute to the formation of a competitive R&D environment. Considering the increase in the competitive fund budget, total research expenses for national universities is, in fact, increasing. For example, Kawamura (2017) pointed out that when adding subsidy expenses such as grants-in-aid for scientific research pertaining to operating expense subsidies, total expenditure—on the basis of financial statements—has increased by about 100 billion JPY between FY 2004 (the point where fiscal years for National Universities were incorporated in Japan) and FY 2014 (Kawamura, 2017, p. 29).

On-going tight financial budgets, couple with a lower growth rate in Japan’s national science and technology budget compared to other countries, and a lower burden of expenditure observed in the ratio of grant-in-aid for scientific research by the government compared to other major countries, as well as a flattening ratio of such expenditure to GDP, have made it difficult to expand public research resources to universities further in terms of both basic expenses and competitive funding. Against this backdrop, there are now expectations for universities to proactively acquire external private funding by cooperating with corporations, thus, strengthening the financial foundation for research and to

[1] This indicates the portion of educational expenditures including public subsidy to households and the other sectors (including R&D as well) as a percentage of GDP（OECD, 2017, Education at a Glance, Indicator B2 Table B2.3）. Note that we should also take various aspects such as financial scale per student and level of tax burden ratio into account when the desirable size of public funding is discussed.

stimulate research activities. More specifically, the government proposed increasing the amount that universities and national R&D agencies receive from corporations for joint research projects during the 5th Science Technology Initiative (FY 2016 to FY 2020) by 50%, and has proposed deliberations on an incentive design in order that universities may proactively promote industry-academia-government collaboration, including prioritizing the allocation of subsidies for operating expenses.

Diversification and strengthening of revenue sources of universities by improving external funding has become an urgent public policy issue; however, one might reasonably wonder if this direction will really lead to the improvement of research productivity of universities. The Ministry of Education, Culture, Sports, Science and Technology points out that the reduction of operating expense subsidies might have caused instability in the employment environment for full-time faculty members, especially its junior ones. It mentions that even if research is financially supported by external funding, it might be difficult to sustain high quality research activities over the medium and long term. While it may be difficult to quantitatively grasp the full gamut of research progress accomplished by universities when measuring their research productivity, it is surely important to quantitatively verify whether the way current funding reform is being conducted will actually maximize the research capabilities and results in a way that is in line with the government's intentions, based on currently obtainable data.

Furthermore, in the third medium-term target and planning period (FY 2016 to FY 2020) for national university corporations, it is required that not only the government, but also the universities themselves, effectively and efficiently allocate their resources to their internal organizations by initiatives through proactively and constantly reviewing their resource allocations, including those available by means of discretionary expenses by university presidents. In discussing the optimum allocation of resources within the university, each university must first objectively grasp as much as possible by themselves, on an internal organization (department) level, their quantitative results and productivity of their research and other activities. These criteria have been strongly recognized recently at Japanese universities through enhanced institutional research (IR) activities. Needless to say, to maintain the persuasiveness of results and the validity of the evaluation process, when evaluating the research productivity of a department, it is a prerequisite that the departments being analyzed be as homogeneous as possible.

Accordingly, this paper analyzes research productivity at a department level for seven former imperial universities situated among Japan's national university corporations, by setting the number of peer-reviewed papers adopted in overseas journals as the index of research results. Specifically, departments were categorized into engineering, health sciences (i.e., medicine, dentistry, and pharmaceutical), economics, science, and agriculture. Then, the difference between internal funding sources (primarily for basic expenses) and external ones (primarily for competitive funding), empirically analyzing their impacts on research productivity. In addition, regarding external funding, we also examined whether different funding sources affects research productivity, noting any variations between the categories and funding sources.

2. Previous Studies

Kanda & Igami (2017) focus on the R&D expenses and R&D human resources related to university research input structures, referencing *The Survey of Research and Development* published by the Ministry of Internal Affairs and Communications, and exhaustively examine the topic using time-series data and analysis. That study provided a detailed analysis of each university for six academic fields (i.e., humanities, social sciences, and four natural sciences), considering data from 2002 to 2015.

Regarding the output structure, such as the number of papers and papers cited, Ban & Kuwahara (2013) conducted an international benchmarking of universities, government departments, corporations, and others with regard to individual indices, such as the number of papers posted on the Web of Science published by Thomson Reuters, as well as its complex measures, such as the relative citation frequency index. The result of the analysis confirmed that the worldwide ranking of the number of papers produced by Japan and the number of those in the top 10% and 1% of highly cited papers have been experiencing a downward trend, and that certain national universities, which are the main players in paper production in Japan, hold a dominant share of published articles and, thus, influence fluctuations in the share of total papers maintained by faculties throughout Japan.

Furthermore, there have also been attempts to quantitatively analyze subjective data sources, e.g., (1) a case study considering whether the relationship between external funding (i.e., consigned research funding and donation revenue) and operating expense subsidies are complementary or substitutional, based on questionnaire data received from faculty members (Fujimura, 2017); (2) a case study that analyzes the relationship between thesis production in foreign languages, internal and external funding, research time, etc. (Ito, 2011); and (3) a case study that verifies the effects of university research promotion policies and environment on research results and motivation (Hayashi et al., 2008). Fujimura (2017) verified that individual research funding serves as a significant coefficient to determine fluctuations in the amount of competitive and external funding received, and also verified that the competitive external funding and individual research funding in the natural sciences, plus competitive external funding and self-evaluation of research capabilities in the humanities and social sciences exhibited a significant, positive impact on the number of peer-reviewed papers generated during the past three years.

Yoneya et al. (2013) conducted an empirical study on paper productivity using input and output data, targeting 142 national, public and private universities that produced more than 50 papers annually (on average) between 2003 and 2011, taking into account the input data (i.e., the number of researchers and research expenses) and output data (i.e., the number of papers) in four natural science fields: science, engineering, agriculture, and health science. The results of his regression analysis showed that universities with more researchers and larger research budgets produced more papers. Moreover, the number of faculties had a positive effect on the number of published papers coming out of national universities, and the amount of research funding (internally used) from external sources had a weak, yet positive, impact on the number of papers for both national and private universities.

Hayashi & Tomizawa (2007) used Japanese paper data from 1982 to 2002 to grasp the characteristics and the background of paper production from the citation frequency and the transition of its share in the paper production sector. They used the following stipulations: (1) the correlation between the number of doctoral students increased due to the stricter selection, and more specialized focus of graduate schools (primarily at previously imperial universities), (2) the total amount of scientific research funding (grant-in-aid for scientific research) typically represents competitive research funding, and (3) the number of top-10% cited papers produced per faculty member is a function of funding received. The study examines the effect of prioritizing research funding looking at the correlation between the research budget and the number of papers at each university. However, in not being able to quantitatively estimate the degree of impact that the variances in the universities' budgets have on the actual number of papers they produce, the correlation analysis method utilized is limited in its use.

There have been studies that factorized changes in the number of papers in Japan according to multiple elements, such as those noted in Aoki & Kimura (2014; 2016). The study used growth accounting with respect to paper productivity within national universities to explain that although research budgets rose between 2005 and 2009, the number of papers did not increase as much due to a reduction in the time allotted for paper production; however, its analysis did not go beyond the university level.

There have been some studies regarding the efficiency of paper production by narrowing down the academic fields considered. For example, analysis on the effectiveness of research production by female researchers and external funding in medical and health science fields has been done (Fukuzawa, 2015).[2] There was measurement of research promoting the effect of research funding programs found in the life sciences, IT, electricity, and electronics fields (Fukuzawa & Ida, 2010), too, and an analysis of the share and number of papers published by Japanese research institutions in six engineering fields (Ohtawa, 1998). Fukuzawa (2015) verified that the higher the external funding proportion was relative to a research institution's own funds, the more efficient the research production became. Mizuta (2014) verified that when a national government or corporation is the external funding source, research results increase. This posits a valuable implication due to the limited number of actual studies on the relationship between research funding sources and research results, but a limitation in his results in that the analysis was confined to the university level.

[2] Ida & Fukuzawa (2011) expanded its analysis into 6 fields (Healthcare, IT and Electricity, Social science, Chemistry and Material, Medicine, Machinery, geology and architect), examined the effect of external funding by conducting DID estimation.

3. The Actual State of Research Funding Sources in the National University Sector

Prior to analyzing research productivity at the department level, first, we will explain the categories and content of each research funding source used in this paper. In addition, we will summarize how the university research funding source and funding size have changed over the past thirty years for the national university sector. We referenced individual data from the university survey sheet in *The Survey of Research and Development (1984 to 2016)*, published by Statistics Bureau, Ministry of Internal Affairs and Communications.

In this survey, university expenditure for research-related work is recorded as "internally used research expenses." Its funding source can be largely divided into "funds accepted from external sources" (hereinafter referred to as "external funding") and "its own, internal funds." Specifically, external funding refers to consigned funds, grants-in-aid for scientific research, subsidies, grants, etc. All other funding besides external funding are regarded as internal funding, including student payments that national universities collect from households in the form of tuition, etc., as well as operating expense subsidies and facility maintenance subsidies received from the national government. Here, in particular, it is difficult to strictly distinguish between the expenditure of student payments and operating expense subsidies used for education and research. Although the amount of research expenditures reported by the representative of each department were used in this survey, we must take note of the possibility that personnel expenses, etc. might be exaggerated, which could inflate the internal funding amount above reality.

In this paper, we obtained the figure for internal funding from the following formula, according to the definition found in the *Survey of Research and Development*: "own, internal funding = internally used research expenses – external funding (used internally)." It is nearly impossible to track or determine the full gamut of sources that comprise internal funding (operating expense subsidies, facility maintenance subsidies, etc.) due to data constraints, but the providers of external funding can be categorized as noted in【Table 1】.

【Table 1】 source categories of “external funds”

categories in this paper		categories in "Survey of Research and Development (Ministry of Internal Affairs and Communications)"		
		1984-2001	2002-2013	2014-2016
(1) the public sector	(a) national government	the national government		
	(b) local governments	local governments		
	(c) national and local public universities	national and local public universitues		
	(d) other public institutions	(a) other public institutions (b) public research institutions (c) government-affiliated research institutions and business enterprises (d) government-affiliated corporations	(a) other public institutions (b) public research institutions (c) governmet-affiliated research institutions and independent administrative agencies (d) government-affiliated research institutions, business enterprises and independent administrative agencies (e) other government-affiliated and	(a) pubic research institutions and independen administrative agencies (b) public business enterprises (c) other public institutions
(2) the private sector	(a) firms	corporations		
	(b) private universities	private universities		
	(c) not-for-profit organizations	(a) private research institutions (b) other private institutins	nonprofit organizations	
(3) foreign countries	foreign countries	foreign countries		(a) corporations (b) universities (c) other institutions

Source: Authers refferd to “Survey of Research and Development” (Ministry of Internal Affairs and Communications) and Kanda and Igami (2017)

During the period under analysis (1984–2016), the external fund provider category in the *Survey of Research and Development* has been revised twice. This paper examines the external funds using three categories: (1) the public sector; (2) the private sector; and (3) foreign countries, based on survey items that were common throughout the period. Furthermore, the public sector is divided into four subcategories: (a) the national government; (b) local governments; (c) national and local public universities; and (d) other public institutions, while the private sector is divided into three subcategories: (a) firms; (b) private universities; and (c) nonprofit organizations.

【Fig. 1】 outlines the transition of internally used research expenses (total research expenses used internally by the universities within the national university sector), as well as those transitions related to internal funding and the external funding that comprise it. The figure also shows the trend of funds allocated to personnel expenses among internally used research expenses.

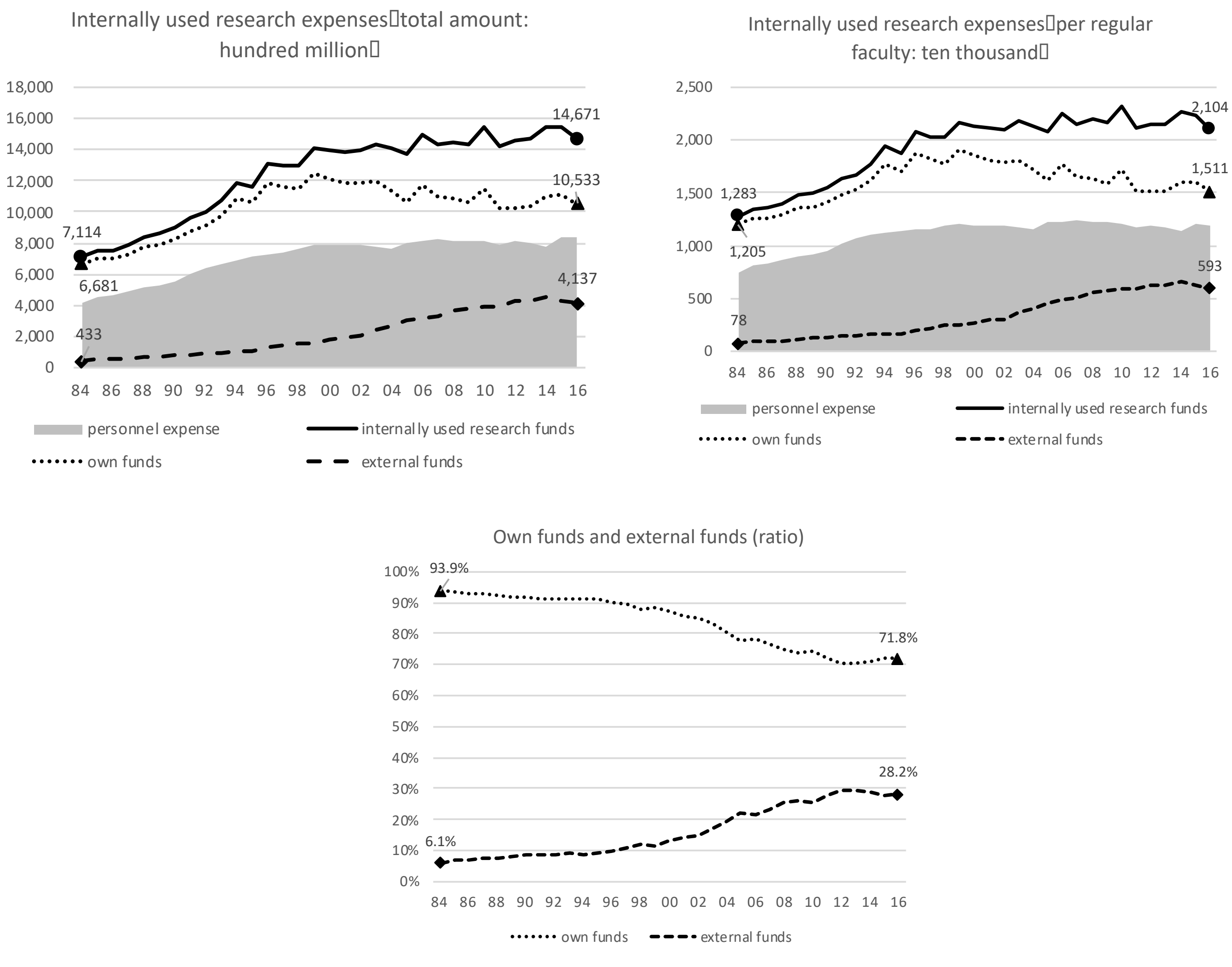
The total amount of internally used research funds in FY 1984 was 711.4 billion JPY (12.83 million JPY per regular faculty member); however, this amount climbed to 1.4671 trillion JPY (21.04 million JPY per regular faculty member) in FY 2016. The number of regular faculty members has increased (net) from roughly 55,000 faculty members in 1984, and although this number declined or flat-lined during the 2000s, it started rising again around 2010, reaching about 69,000 faculty members in 2016. Therefore, the increase in research budget per faculty member was not due to the decrease in their number. About 60% of the internally used research funds were allocated to personnel expenses until the mid-1990s; however, in recent years, the ratio has dipped slightly to around 50%–60%.

As of 1984, the universities’ own, internal funding accounted for 93.9% (total amount: about 668.1 billion JPY; 12.5 million JPY per regular faculty member member) of total research funding, and as of

2016, it accounted for 71.8% (total: about 1.533 trillion JPY; about 15.11 million JPY per regular faculty member member). As of 1984, the external funding accounted for 6.1% (total amount: JPY 43.3 billion JPY; 780,000 JPY per regular faculty member member) of total research funding, and as of 2016, it accounted for 28.2% (total: about 413.7 billion JPY; about 5.93 million JPY per regular faculty member).

Total external funding received has increased tenfold over the past thirty years—per faculty member nearly eightfold—and the rate of acceptance has been increasing especially after FY 2000. Internal funding (net) increased until around 1994, but has been transitioning ever since, showing a net decrease annually. As mentioned previously, the small fluctuations might be due to hardware maintenance costs, as internal funding includes facility maintenance subsidies. In any case, both internal and external funding has clearly been on a declining trend since around 2014. For an institution's own, internal funding, it is consistent with the period when a large sum of facility maintenance budget was instituted in 2014, as part of an emergency economic measure.

【Fig. 1】Trend of internally used research funds (own funds + external funds)



Source: Author

【Fig. 2】 shows the transition in external funds based on the following financiers: (1) the public sector; (2) the private sector; and (3) foreign countries.

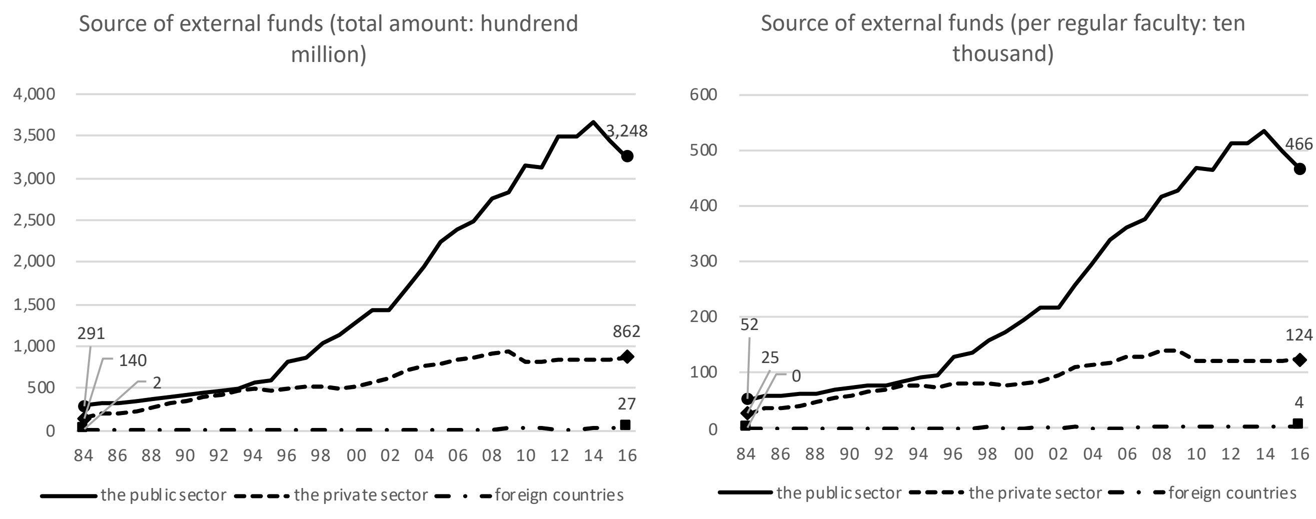
As of 1984, the proportions of financiers were as follows: 67.2% public sector (total: about 29.1 billion JPY; about 520,000 JPY per regular faculty member); 32.4% private sector (total: about 14 billion JPY; about 250,000 JPY per regular faculty member); 0.4% foreign countries (total: about 200 million JPY; about 30 million JPY per regular faculty member). As of 2016, there was 78.5% public sector (total: about 324.8 billion JPY; about 4.66 million JPY per regular faculty member); 32.4% private sector (total: about 86.2 billion JPY; about 1.24 million JPY per regular faculty member); 0.7% foreign countries (total: about 2.7 billion JPY; about 40,000 JPY per regular faculty member).

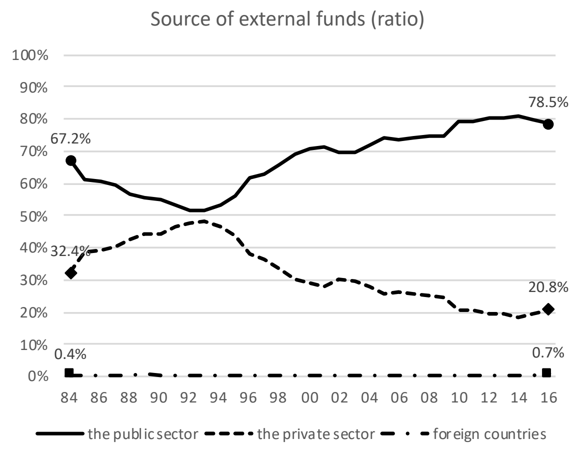
The research funding acceptance rate from the public sector has been on a significantly increasing trend since 1994, and its growth rate has increased further around the time when the national universities were incorporated in 2004.

The increase in the acceptance of research funding from the private sector has been particularly notable since around 2000. However, it started stalling around 2009, and has been nearly flat ever since. This is consistent with the declining trend of R&D expenses of corporations and the industrial sector in 2009—after the world financial crisis of 2008.

Although the overall share of research funds from foreign countries is minuscule, it has been increasing steadily in the past thirty years. Both the total amount and research budget per regular faculty member have increased thirteenfold.

【Fig. 2】Trend of source of external funds





Source: Author

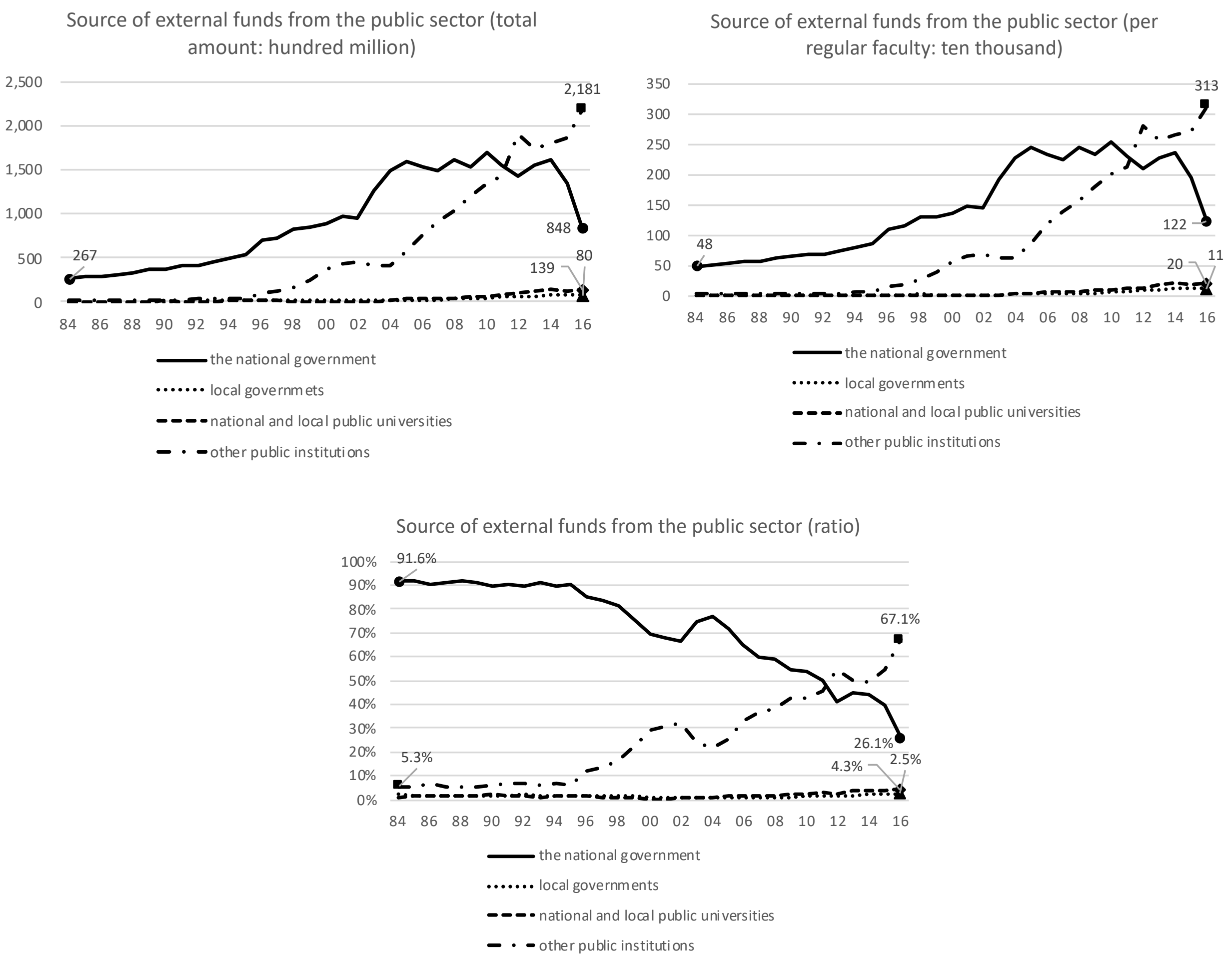
【Fig. 3】 breaks down the source of research funding from the public sector: (a) the national government; (b) local governments; (c) national/public universities; and (d) other public institutions.

Other elements: (a) The proportion provided by the national government as of 1984: 91.6% (total amount: about 26.7 billion JPY; 480,000 JPY per regular faculty member) of total research funds, and as of 2016, it accounted for 26.1% (total: about 84.8 billion JPY; about 1.22 million JPY per regular faculty member). (b) The proportion provided by local governments as of 1984 was 2%, and about 2.5% in 2016. The statistics for 2016 alone set a low standard: a total of about 8 billion JPY, which was about 110,000 JPY per regular faculty member. (c) The proportion provided by national/public universities is not that high, which was about 4% in 2016. Fund size was about 13.9 billion JPY in total (about 200,000 JPY per regular faculty member). (d) The proportion provided by other public institutions as of 1984: 5.3% (total amount: about 1.5 billion JPY; JPY 30,000 per regular faculty member) of total research funds, and as of 2016, it accounted for 67.1% (total: about 218.1 billion JPY; about 3.13 million JPY per regular faculty member).

Although the fund size has been expanding, the proportion that the national government provides has decreased by as much as 70% during the past thirty years. The figure shows a significant decline, especially from 2014; however, it is important to note that the subsidies provided by the national government had started to be imparted by other public institutions. For example, part of the health and labor sciences research grant has been transferred to the Japanese Agency for Medical Research and Development (AMED), and Grant-in-Aid for Scientific Research by MEXT was transferred to the Japanese Society for the Promotion of Science (JSPS). Hence, there have been changes in the subsidy-implementing entities.

Looking at the flow of research funds from the national government in closer detail, we can confirm that the large increase started around 2002. Possible reasons for this metamorphosis include the reduction in special accounting during the restructuring of government ministries in 2001 that led to an inflating of general accounting figures, as well as the fact that subsidies such as the 21st Century COE program kicked into high gear after the national universities were incorporated.

【Fig. 3】Trend of source of external funds from the public sector



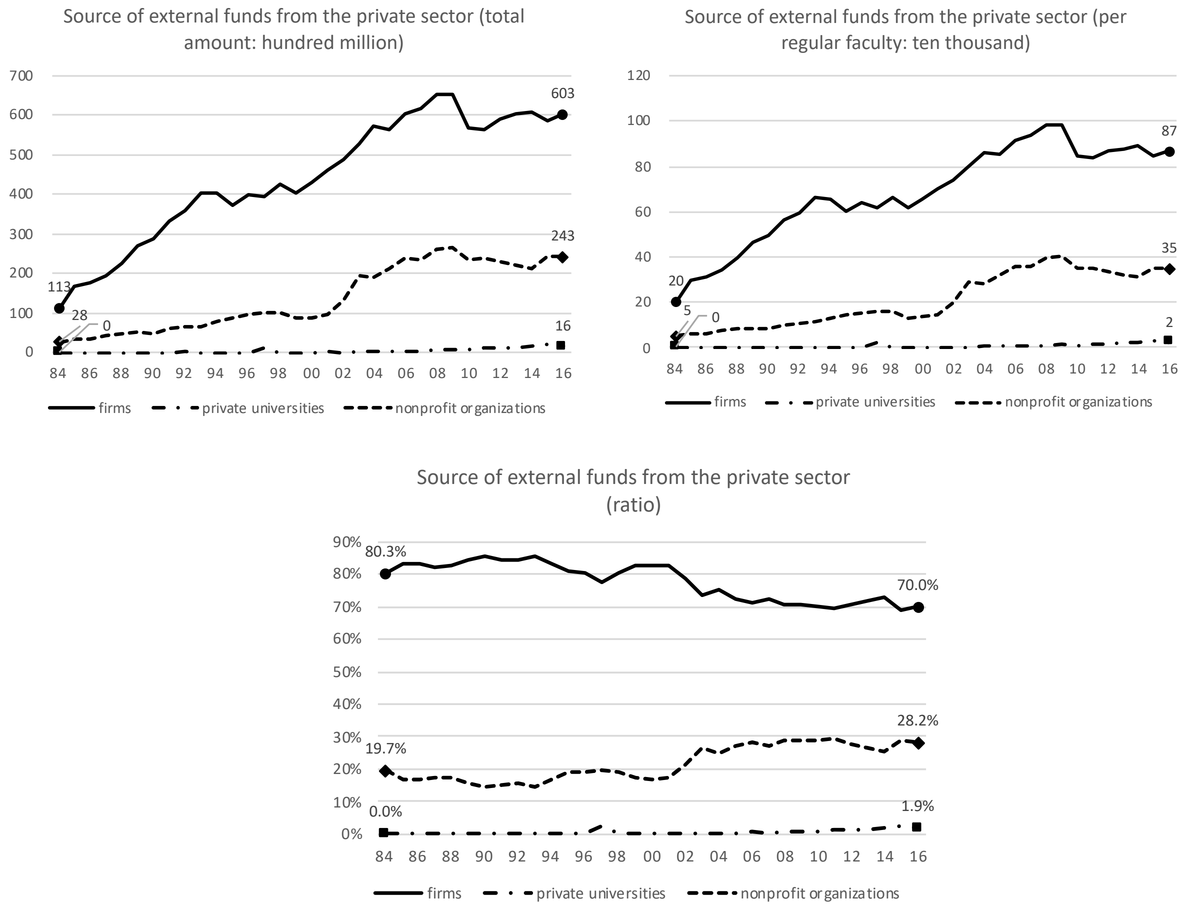
Source: Author

Lastly, 【Fig. 4】 breaks down the source of research funds from the private sector: (a) firms; (b) private universities; and (c) nonprofit organizations.

Other elements: (a) The proportion provided by firms as of 1984 was 80.3% (total amount: about 1.13 billion JPY; about 200,000 JPY per regular faculty member) of total research funding, and as of 2016, it accounted for 70% (total: about 60.3 billion JPY; about 870,000 JPY per regular faculty member). The share itself has been smaller; however, the total amount and amount per faculty member have increased fourfold to fivefold over the past thirty years. (b) The proportion provided by private universities is not too large. (c) However, the proportion provided by nonprofit organizations as of 1984 was 19.7% (total amount: about 2.8 billion JPY; about 50,000 JPY per regular faculty member) of total research funding, and as of 2016, it accounted for 28.2% (total: about 24.3 billion JPY; about 350,000 JPY per regular faculty member). Its share has grown by around 10%, and the amount per faculty member has increased sevenfold.

Since around 2009, the external funding from firms have shrunk by around 16%. This decline is probably because the funds for R&D have been reduced due to the effect of the aforementioned 2008 financial crisis. This trend has been flat since 2009. There is a similar trend in the external funding from firms and not-for-profit organizations; however, we believe that this is because many foundations that provide research grants operate under the management of Japanese firms.

【Fig. 4】Trend of source of external funds from the private sector



Source: Author

4. Actualities of Research Funding Resources and Research Production (i.e., the Number of Published Papers) of the Seven Former Imperial Universities

In this section, we will examine the transition (in time series data) of the financiers of research funding, as well as their funding amounts for the departments by academic field that could serve as subjects of analysis. This paper targeted the departments of seven former imperial universities (Hokkaido University—Tohoku University—University of Tokyo—Nagoya University—Osaka University—Kyoto University—Kyushu University) to analyze research productivity, due to the data restrictions concerning the number of papers published on a department level used mainly for the output index. Here, the department refers to the university's faculty members, graduate school programs, and university-affiliated research laboratories established in accordance with the universities' midterm objectives. In addition, the term *academic field* refers to one of the five fields of economics, science, engineering, agriculture, and the health sciences.

First comes an overview of the actual situations of internally used research funding. The total internally used research funding of departments in the five aforementioned academic fields of the seven former imperial universities have been gradually transitioned from approximately 460 billion JPY to 510 billion JPY. In terms of the composition of research funding, the institutions' own, internal funding has been transitioning on a similar scale to between 260 and 280 billion JPY (except in 2009, when it has skyrocketed to approximately 310 billion JPY), and the external funding from the public sector has generally increased from approximately 120 billion JPY to 200 billion JPY. The ratio of external funds relative to the internally used research funds has climbed more than 10% from 35.6% to 46.8%. In terms of the composition ratio of external funds, those from the public sector have increased by about 5% from 78% to 83%. External funding from private sector hovered around 21% until 2008 but has since remained at around 17%.

When analyzing the composition of internally granted research funding according to academic field (see Fig. 5), the largest total amount is in engineering, with the combined figure for the seven former imperial universities hovering around 200 billion JPY. The total figure was largest in 2009 (approximately 210 billion JPY). We believe this is because many universities significantly upgraded their facilities using supplementary budget and appropriation surplus for that year and, thus, expenditures by engineering departments with large-scale facilities significantly increased. The next largest funding target are the health sciences, which increased from approximately 120 billion JPY to 160 billion JPY, and its rate of increase has been the highest for the past ten years at 128%. The next largest overall funding is fixed in the science field, which transitioned from approximately 100 billion JPY to 120 billion JPY. Total research funding in 2009 also increased for the health sciences and science fields. Presumably, a scenario similar to that of the engineering field was at play. During the same ten years, total research funding for the agriculture field transitioned from approximately 36 billion JPY to 41 billion JPY. The amount for economics lingers around 8 billion JPY.

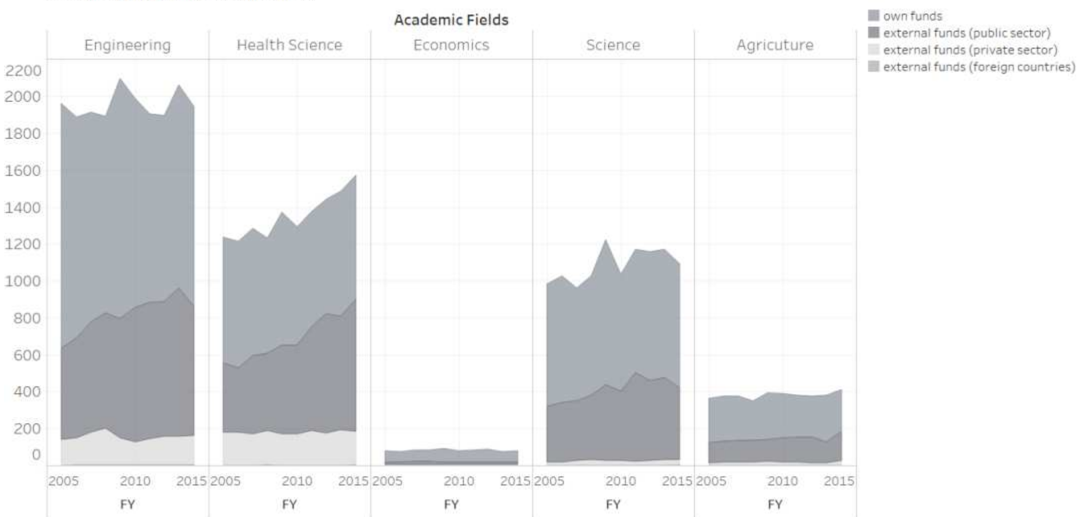
When the composition ratio of research funding is examined, the field with the highest ratio of external funding is health sciences, which became the majority after 2009, and hovers around 57% in recent times. The external fund ratio for Science, Engineering and Agriculture is hovering between low 30% and 40%, and that of Economics is hovering around 20%. When the composition ratio of the external funding by fund source is examined, the field with the highest rate of fund received from public institutions is Science at low 90%. In the health sciences field, the external research fund rate received from private sector has gone down dramatically from 33% to 20%. The list of academic fields from the highest to lowest external fund ratio from private institutions is as follows: Economics (20 to 26%), Engineering (17 to 24%), Agriculture (8 to 12%) and Science (6 to 7%). There has been no significant increase or decrease.

When the transitioning of external funding sources is examined even further, the breakdown of the external funding from the public sector is as follows: in all the academic fields, the proportion of external funding from the national government and other public institutions is high; the sizes of external funding from the national government, local governments and national/public universities are mostly flat; and external funding from local governments, national/public universities is extremely small. It is easily recognized that external funding from other public institutions are on a significantly increasing trend. There was a large difference between the academic fields in terms of the size of external funding from public institutions. Compared with approximately 80 billion JPY and external funding 70 billion JPY in engineering and health sciences, respectively, it remained significantly small for economics at less than JPY 10 billion during the past ten years. When it is considered that external funding from the public sector for engineering and the life sciences during the past ten years has increased by 20–30 billion JPY for each of them, it is clear that the gap is widening. The proportion of external funding from "other public institutions" within the public sector has been on an upward trend, especially for engineering, economics and science. The composition of the public sector's contribution to the aforementioned fields was around 30% in 2005, but climbed to nearly 70% in 2014. The same is true for health sciences and agriculture, which have risen to nearly 50%.

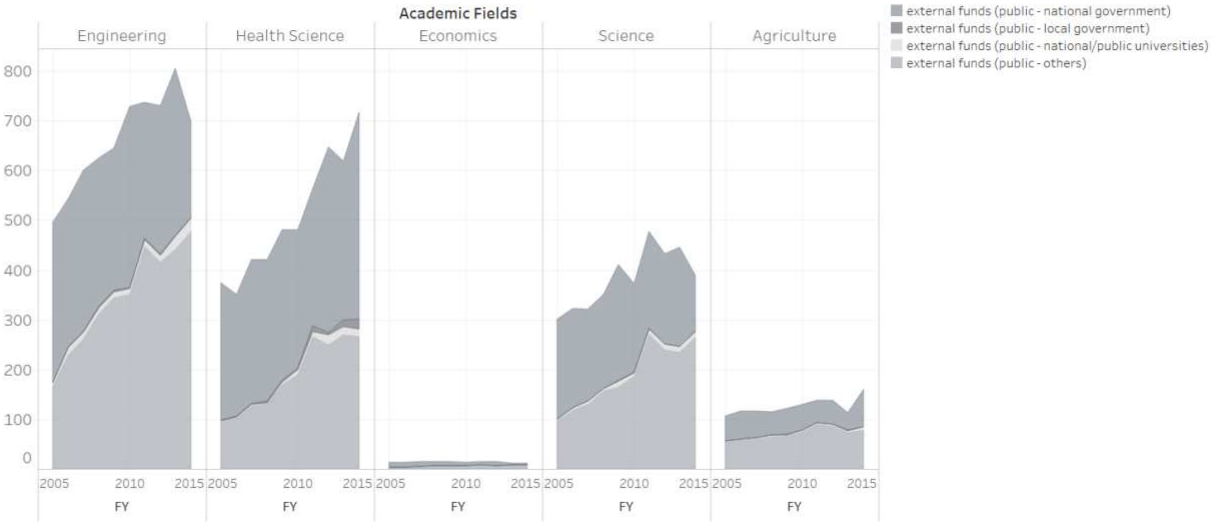
In terms of external funding from the private sector, the size of funding from private universities has been small; funding from nonprofit organizations has been flat with some fluctuations; funding from firms has fluctuated annually. External funding from firms ranged from 15–20 billion JPY for engineering and health sciences, but did not exceed 1 billion JPY for economics. The amounts seem to be fluctuating widely; however, when the transition of ratio of external funding from firms with respect to external funding from the private sector is examined, the fluctuations are not so feral. The external funding proportion for engineering and the health sciences has been suspended around 75% (±5%), and the fluctuations were confirmed to be moving along with external funding from nonprofit organizations.

【Fig. 5】 Total amount of internally used research expenses and composed ratio by academic fields

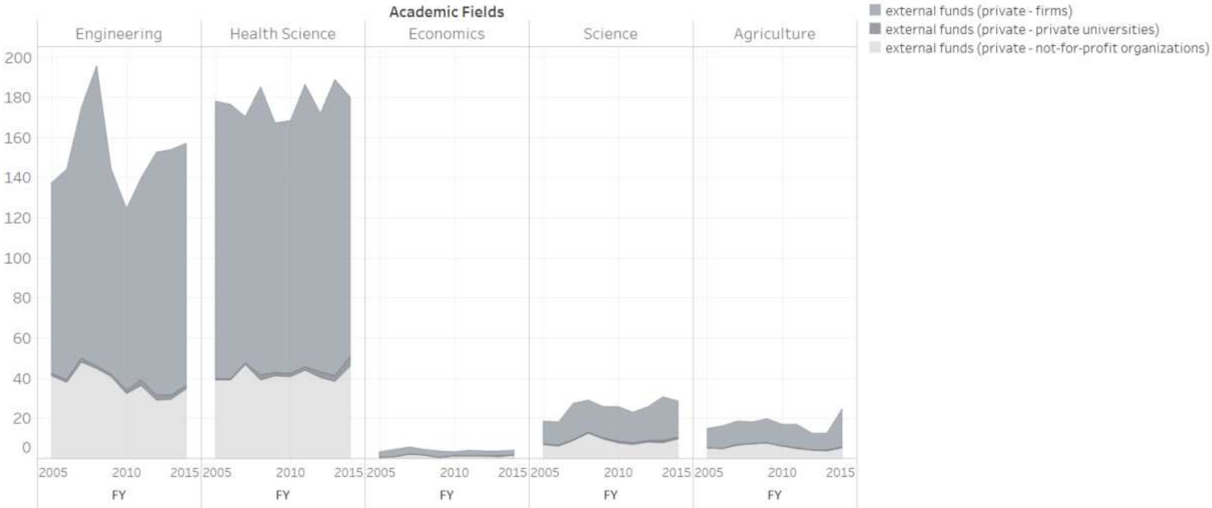
5-1 Total amount of internally used research expenses by academic fields
(Annualised data in hundred million (JPY))



5-2 Total amount of external funds from public sector by academic fields
(Annualised data in hundred million (JPY))



5-3 Total amount of external funds from private sector by academic fields
(Annualised data in hundred million (JPY))

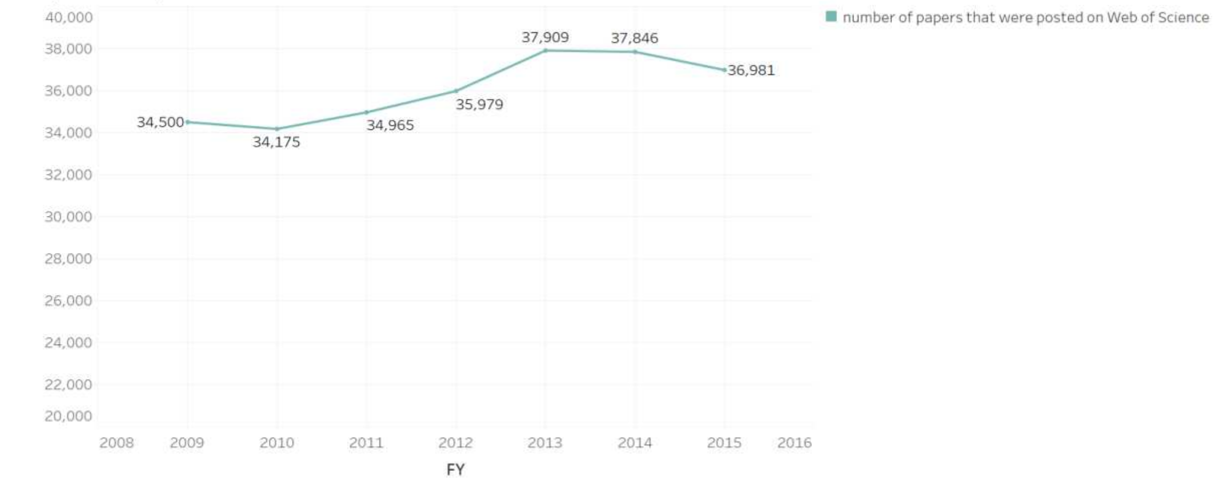


Source: Author

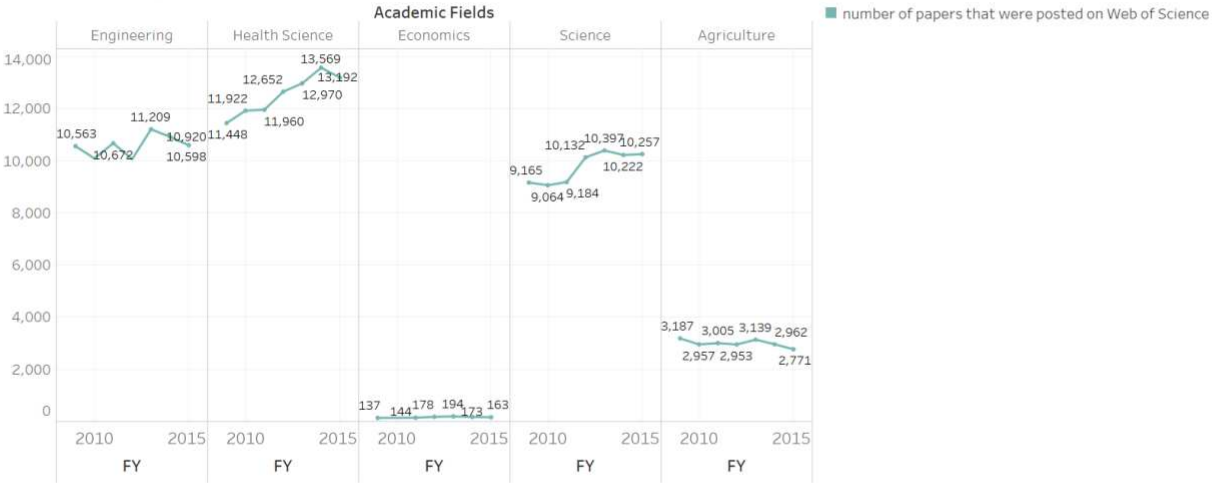
Finally, the transition of number of papers on a department level may be used as an output index. The number of papers produced within the five academic fields by the seven former imperial universities, posted on Web of Science, has increased by 107% over the past ten years, from 34,500 to 36,981. The percentage increase from the year with the lowest paper production (2010) to the one with the highest production (2013) was 10%; however, the production volume steadily declined thereafter. When each academic field was examined, the number of papers produced in health sciences had significantly increased. The number of papers in 2014, the highest production volume in seven years, was 118% of that reached in 2009, and the volume for 2015 was slightly lower than 2014, but still 115% of the figure in 2009. The number of science papers grew 110% from 2011 to 2012; however, it has been mostly flat ever since. The numbers of papers in economics, engineering and agriculture have seen slight fluctuations, but have been mostly flat.

【Fig. 6】 Total number of papers that were posted on Web of Science by academic fields

6-1 Total number of papers that were posted on Web of Science
(Annualised data)



6-2 Total number of papers that were posted on Web of Science by academic fields
(Annualised data)



Source: Author

5. Department Research Productivity Analysis (By Academic Field)

5. 1. Analysis Framework

In this section, we will conduct a regression analysis using the numbers of paper data harvested from Thomson Reuters' Web of Science (WoS) as the explainable variable, and human resources and capital data from the *Survey of Research and Development* as the explanatory variables. Seven years' data were available on the number of papers (from 2009 to 2015). This paper deems the number of papers produced three years after the input of human and physical resources as the output of the research activities, and uses the data between 2006 and 2012 obtained from the *Survey of Research and Development* as input data. 【Table 2】 shows the descriptive statistics of each variable. The outline of each variable is as follows.

Data on papers posted in WoS by each department of the seven former imperial universities used as research output were provided by Professor Takayuki Hayashi of National Graduate Institute for Policy Studies. According to Professor Hayashi, the following methods are used for the identification of departments. First, the following five existing databases were combined to create the Japanese/English name thesaurus on the three levels of university, faculty and department, which were fed into the WoS data to temporarily classify them into departments based on the names of affiliated institutions and postal codes: ① university portrait; ② "Consistency Table for English Names of Universities and Public Institutions" by National Institute of Science and Technology Policy; ③ "Information on Japanese schools (universities, colleges and junior colleges)" from the Japan Student Services Organization; ④ J-Global's "Institution Name Data;" and ⑤ business-type postal code data from the Ministry of Posts and Telecommunications. Then, these classified names of affiliated institutions were added to any English institution names (mainly names on the third hierarchy level that fall under a department level) not listed in the thesaurus so that the thesaurus is made up to date. Unclassified department names are manually classified if their names come up frequently. By repeating the process of updating the thesaurus and manual classification several times, identifications of the departments were undertaken as well as could be expected. The final identification rate of number of papers between 2009 and 2015 published by each university was as follows: Hokkaido University (91.3%), Tohoku University (93.7%), University of Tokyo (91.3%), Nagoya University (90.3%), Osaka University (93.5%), Kyoto University (92.3%) and Kyushu University (90.4%). The papers were counted using the integer method, and when the same department appeared more than once in a single paper, we counted the department as "1" instead of counting each of their appearances.

By merging the WoS paper dataset of the departments obtained via the aforementioned method with the individual dataset found in the *Survey of Research and Development* on a department level, we aligned them with the fiscal years of the input variables to produce an analysis-ready database for 2006–2012. The academic fields of target departments are engineering, health sciences, economics, science, and agriculture, and the number of departments as of 2012 were 37, 26, 10, 28 and 10, respectively. These departments include the university's research laboratories, but not on-campus collaborative educational research facilities, nationwide shared facilities, etc.

In the context of this paper, the university research result index merely refers to the number of papers adopted and published in overseas, peer-reviewed journals, and the term "research productivity" refers to the productivity of papers in them. Of course, a result of university research activity is not limited to paper production, but is expressed in many different ways. By first recognizing that limitation, the analysis and interpretation may proceed.

Explanatory variables in this paper relate to the funds data broken down based on an institution's own, internal funding, external funding and providers of external funding, and we also considered other human resource data as follows. Specifically, the data include the percentage of full-time employees with a Ph.D. degree, the number of doctoral course students per full-time faculty member, and the number of medical staff and other researchers per full-time faculty member.

The percentage of full-time employees with a Ph.D. degree serves as a proxy variable for the quality of the faculties, etc., and is believed to have a positive impact on paper productivity. However, 80% to 90% of full-time department employees outside of the economics departments have Ph.D. degrees, variation in this variable is rarely seen. The number of doctoral course students per full-time faculty can possibly have either positive or negative impact on paper productivity. In the science departments, it is not uncommon for faculties to conduct research activities with doctoral course students in the labs, and doctoral course students contribute to the paper productivity. However, research activities in liberal arts departments such as economics exhibit a strong characteristic of "proprietorship" on the part of the faculties, and the doctoral course students are mainly subjects to be educated. Therefore, having many graduate students may have a negative impact on paper productivity due to the limitation it places on the faculty's research time. In the case of medical staff, the paper production will depend on whether the staff is mainly researching, training or working and, hence, the sign of estimation coefficient can either be positive or negative.

The flow of our analysis is as follows. First, we will analyze how the size of the organization's own, internal funding (mainly covering basic expenses) and external funding (mainly dealing with competitive funding) impacts paper productivity (Model 1). Next, we will categorize the providers of external funding into the public sector, the private sector and foreign countries, and verify their relationship with paper productivity (Model 2). We will further setup Model 3 (dividing public sector into four categories: the national government, local governments, national and public universities, and other public institutions) and Model 4 (dividing private sector into three categories: corporations, private universities, nonprofit organizations), and verify their individual relationship with paper productivity.

The analysis uses seven years' worth of pooling data. This paper simply applies and explores multiple regression analysis to examine how and to what degree various types of funds affect paper productivity per faculty member. Among the target departments, agriculture and science departments in particular are highly interdisciplinary. For example, there are various subfields that researchers in agricultural departments can engage in, such as fields that primarily study biology and chemistry that can relatively easily lead to papers being published in overseas journals. There are also fundamental fields such as genetics, breeding, cultivation, crops, soil, etc., and there are other fields including biotechnology, the ecosystem, marketing, weather, etc. Therefore, they are varied, and each field seeks different outputs and thus entails different results. Examples include studies that focus on experiments, fieldwork, engineering, civil engineering, etc., and fields that require certain number of papers to be posted in overseas journal as results, etc. Hence, the fields of engineering, health sciences and economics are the main focus, in which the number of papers are relatively commonly regarded as research output, in order to properly conduct the analysis. For reference, estimations on cases that integrate all academic disciplines are also made.

【Table 2】Descriptive statistics

Variables	Obs.	Mean	St.Dev	Min	Max
Dependent Variable					
the number of paper per full-time faculty	1,210	2.8	7.0	0.0	194.0
Independent Variables					
The ratio of full-time employees with a Ph. D. degree	1,317	0.9	0.2	0.0	1.0
The number of doctoral course students per full-time faculty	1,297	0.6	0.7	0.0	5.1
The number of medical staffs and other reseachers per full-time faculty	1,297	0.4	0.7	0.0	13.0
Own funds	1,297	32.8	58.6	0.0	1,236.9
External funds	1,297	13.8	26.3	0.0	758.4
External funds from the public sector	1,297	11.4	24.6	0.0	737.6
External finds from the private sector	1,297	2.3	5.5	0.0	99.5
External funds from abroad	1,297	0.0	0.2	0.0	5.2
External funds from the public sector					
from the central government	1,297	5.9	10.7	0.0	133.1
from local governments	1,297	0.0	0.2	0.0	5.6
from national and local public universties	1,297	0.2	0.7	0.0	12.3
from other public organizations	1,297	5.3	18.5	0.0	612.4
External finds from the private sector					
from firms	1,297	1.7	4.2	0.0	74.1
from private universities	1,297	0.0	0.3	0.0	6.7
from non-profit organizations	1,297	0.6	2.1	0.0	66.5

* financial data is standerlized per full-time faculty.
** The unit of financial data is million yen.

Source: Author

5. 2. Analysis Results and Interpretation

【Table 3】 illustrates the estimation results of Model 1 through Model 4. First, we will examine the estimated coefficients of explanatory variables of research funding source that we have explored in this paper, primarily in cases (2) through (4) of engineering, health sciences and economics. The estimation result of Model 1 clearly shows that an increase in an organization's own, internal funding per faculty member significantly and positively increases the number of papers published per faculty member, in all the said fields. Similar results were seen for external funding for engineering and the health sciences departments, but not for economics.

When examining the impact of external funding by financiers from the estimation results of Model 2, the external funding from the public sector, which accounts for about 80% of external funding, are positively significant in all cases (engineering, health sciences, economics). For engineering and the health sciences, the increase in research funding from the private sector heightens paper productivity. In the previous section, we outlined that at present, the ratio of external funding received from foreign corporations and universities is extremely low, and that in many cases, its impact on paper productivity cannot be verified. As an exception, the data shows some negative significance in the health sciences; however, the primary objective of international joint studies is not always paper productivity. Since there are university hospitals and the medical/research centers, their primary results may simply be clinical research in some cases.

The estimation result of Model 3 and Model 4 (cases that categorized public institutions and private institutions in more detail) show that external funding, the majority of which comes from the national government, positively and significantly affected all academic fields. Similar results were seen for other public institutions, except in the health sciences. Yet, as explained in section 1, this outcome is partly because subsidies that were conventionally provided by the national government started to be made by other public institutions. Hence, we must take note of the changes in subsidy-implementing entities. In economics, collaboration with other national universities significantly heightens paper productivity. However, external funding from local governments exhibited a significantly negative impact on the number of papers per faculty member in engineering and economics. The results of such research activities funded by subsidies from local governments are not always in the form of papers being submitted to overseas journals due to the possibility that the main objective might be to resolve social challenges of local economies and to try to revitalize them.

Lastly, the private sector's external funding from firms was positively significant in engineering and health sciences, while it was negatively significant in economics. The industry-academia collaboration in the economics field are often seen in the United States, for example, in corporate marketing strategies that take advantage of the theories and demonstrations of experimental economics and behavioral economics. This can be regarded as a benefit for the university that likewise increase its published paper production. However, in Japan, it is doubtful whether such industry-academia collaboration would lead to a paper. Presently, universities prioritize providing reports of their achievements, advice on application and utilization of the findings, etc. to firms. In engineering and the health sciences, collaboration with private universities was positively significant. In the health sciences and economics, collaboration with nonprofit organizations such as private foundations and medical corporations was, too.

The estimation results of the human resources variables showed that the coefficient of the percentage of Ph.D. holders among faculties, medical staff, etc., which is a proxy variable representing the quality of the researchers, was mostly positively significant in engineering and economics. However, in the health sciences, certain variables that were significant in one area proved to be negative in others. In this field, there is a possibility that the motivation to produce a paper is higher before acquiring a Ph.D. than afterwards. It suggests that doctoral students complement paper production of faculties in the health sciences field. In engineering and economics, it was non-significant, and neither complementary nor substitutional. Increasing researchers (other than medical staff) and faculty members increased paper production in engineering and economics, whereas it negatively affected those produced in the health sciences. Since medical staff are not employed in engineering and economics departments, full-time researchers other than faculty members are considered to contribute to their paper productivity. Yet, in the health sciences field, the role of medical staff is not necessary to partake in studies, but rather, primarily, for clinical trials, training, etc. Hence, the results of their activities may be considered as a tradeoff to paper productivity.

【Table. 3】estimation results

Dependent Variable: the number of paper per full-time faculty	(1) All the fields		(2) Engineering		(3) Healthcare		(4) Economics		(5) Science		(6) Agriculture	
full-time employees with a Ph. D. degree / full-time employees	2.806	***	1.882	**	−0.934	*	0.499	**	3.251	**	−0.755	
	(0.394)		(0.739)		(0.488)		(0.236)		(1.321)		(0.839)	
doctoral course students / full-time faculty	0.107	*	0.086		0.087		−0.002		0.350	***	0.448	***
	(0.056)		(0.100)		(0.092)		(0.027)		(0.112)		(0.134)	
medical staffs and other reseachers / full-time faculty	1.759	***	1.111	***	−0.840	**	1.020	***	2.318	***	0.566	**
	(0.302)		(0.356)		(0.330)		(0.243)		(0.553)		(0.260)	
own funds	0.024	***	0.036	***	0.029	***	0.025	**	0.033	***	0.006	
	(0.005)		(0.008)		(0.010)		(0.012)		(0.011)		(0.007)	
external funds	0.017	**	0.038	***	0.042	***	0.0222		−0.020	*	0.065	***
	(0.008)		(0.010)		(0.007)		(0.013)		(0.010)		(0.011)	
constant	−1.331	***	−1.081		2.512	***	−0.555		−1.639		1.551	*
	(0.380)		(0.747)		(0.432)		(0.374)		(1.289)		(0.785)	
year effect	○		○		○		○		○		○	
obsevations	745		234		177		69		195		70	
R-squared	0.323		0.394		0.353		0.599		0.250		0.634	

Note1: Robust standard error in parentheses。

Note2: ***, **, * indicate that each coefficient is statistically significant at 1%, 5% and 10% respectively.

Dependent Variable: the number of paper per full-time faculty	(1) All the fields		(2) Engineering		(3) Healthcare		(4) Economics		(5) Science		(6) Agriculture	
full-time employees with a Ph. D. degree / full-time employees	3.002	***	1.715	**	-0.292		0.418	**	3.265	**	-0.859	
	(0.390)		(0.719)		(0.518)		(0.205)		(1.350)		(0.805)	
doctoral course students / full-time faculty	0.135	**	0.069		0.215	**	-0.004		0.341	***	0.424	***
	(0.058)		(0.102)		(0.089)		(0.025)		(0.121)		(0.134)	
medical staffs and other reseachers / full-time faculty	1.760	***	0.872	**	-0.692	**	0.967	***	2.306	***	0.735	**
	(0.298)		(0.380)		(0.299)		(0.218)		(0.587)		(0.290)	
own funds	0.026	***	0.033	***	0.032	***	0.019	*	0.033	***	0.007	
	(0.006)		(0.008)		(0.010)		(0.010)		(0.010)		(0.007)	
external funds (the public sector)	0.010		0.033	***	0.031	***	0.047	***	-0.021	**	0.065	***
	(0.008)		(0.010)		(0.007)		(0.016)		(0.010)		(0.010)	
external funds (the private sector)	0.106	***	0.112	***	0.233	***	-0.046		0.007		-0.081	
	(0.025)		(0.028)		(0.044)		(0.028)		(0.104)		(0.078)	
external funds (abroad)	0.070		-0.032		-0.963	*	-2.338		0.038		0.090	
	(0.310)		(0.585)		(0.554)		(2.197)		(0.504)		(1.327)	
constant	-1.644	***	-0.934		1.339	**	-0.422		-1.647		1.792	**
	(0.382)		(0.729)		(0.519)		(0.309)		(1.324)		(0.782)	
year effect	○		○		○		○		○		○	
observations	745		234		177		69		195		70	
R-squared	0.337		0.41		0.472		0.664		0.250		0.66	

Note1: Robust standard error in parentheses。

Note2: ***, **, * indicate that each coefficient is statistically significant at 1%, 5% and 10% respectively.

Dependent Variable: the number of paper per full-time faculty	(1) All the fields		(2) Engineering		(3) Healthcare		(4) Economics		(5) Science		(6) Agriculture	
full-time employees with a Ph. D. degree / full-time employees	2.959	***	1.453	**	−0.194		0.232		2.971	**	−1.107	
	(0.390)		(0.681)		(0.513)		(0.218)		(1.383)		(0.777)	
doctoral course students / full-time faculty	0.133	**	0.077		0.231	**	−0.003		0.373	***	0.467	***
	(0.058)		(0.100)		(0.090)		(0.022)		(0.121)		(0.136)	
medical staffs and other reseachers / full-time faculty	1.747	***	0.704	*	−0.597	**	0.918	***	2.286	***	0.595	**
	(0.294)		(0.386)		(0.281)		(0.223)		(0.604)		(0.270)	
own funds	0.027	***	0.040	***	0.026	***	0.007		0.034	***	0.005	
	(0.005)		(0.009)		(0.009)		(0.008)		(0.011)		(0.008)	
central government	0.027	***	0.029	**	0.063	***	0.042	***	−0.039		0.060	***
	(0.009)		(0.013)		(0.014)		(0.015)		(0.029)		(0.017)	
local governments	−0.451		−0.957	**	0.437		−0.833	**	−0.972	*	−2.196	**
	(0.283)		(0.429)		(0.518)		(0.390)		(0.548)		(0.893)	
national and local public universities	−0.033		−0.002		0.047		0.647	*	0.005		−0.021	
	(0.047)		(0.036)		(0.151)		(0.336)		(0.157)		(0.262)	
other public organizations	0.001		0.047	***	0.012		0.152	***	−0.016	*	0.076	***
	(0.009)		(0.015)		(0.011)		(0.023)		(0.008)		(0.024)	
external funds (the private sector)	0.098	***	0.103	***	0.212	***	−0.082	***	0.051		−0.038	
	(0.024)		(0.030)		(0.044)		(0.024)		(0.120)		(0.080)	
external funds (abroad)	−0.109		0.015		−1.334	**	−3.976	*	0.101		−0.058	
	(0.309)		(0.593)		(0.544)		(2.094)		(0.520)		(1.446)	
constant	−1.678	***	−0.803		1.173	**	−0.140		−1.331		2.072	***
	(0.384)		(0.680)		(0.523)		(0.300)		(1.359)		(0.744)	
year effect	○		○		○		○		○		○	
observations	745		234		177		69		195		70	
R-squared	0.343		0.428		0.495		0.761		0.262		0.695	

Note1: Robust standard error in parentheses。

Note2: ***, **, * indicate that each coefficient is statistically significant at 1%, 5% and 10% respectively.

Dependent Variable: the number of paper per full-time faculty	(1) All the fields		(2) Engineering		(3) Healthcare		(4) Economics		(5) Science		(6) Agriculture	
full-time employees with a Ph. D. degree / full-time employees	3.026	***	1.702	**	-0.113		0.552	***	2.286	*	-0.993	
	(0.390)		(0.713)		(0.516)		(0.201)		(1.275)		(0.947)	
doctoral course students / full-time faculty	0.137	**	0.058		0.231	**	-0.015		0.174		0.402	***
	(0.058)		(0.104)		(0.090)		(0.022)		(0.118)		(0.137)	
medical staffs and other reseachers / full-time faculty	1.735	***	0.839	**	-0.666	**	0.919	***	1.905	***	0.629	*
	(0.293)		(0.385)		(0.289)		(0.223)		(0.569)		(0.318)	
own funds	0.026	***	0.033	***	0.033	***	0.024	**	0.025	**	0.006	
	(0.005)		(0.008)		(0.010)		(0.009)		(0.010)		(0.007)	
firms	0.126	***	0.137	***	0.287	***	-0.077	***	-0.047		-0.026	
	(0.032)		(0.046)		(0.051)		(0.024)		(0.240)		(0.092)	
private universities	0.752	*	0.472	***	1.759	**	-0.600		9.206	***	0.686	
	(0.439)		(0.078)		(0.725)		(0.688)		(2.246)		(1.630)	
non-profit organizations	0.059		0.066		0.137	*	0.269	**	0.171		-0.125	
	(0.051)		(0.075)		(0.077)		(0.115)		(0.230)		(0.101)	
external funds (the public sector)	0.010		0.029	***	0.029	***	0.042	**	-0.015		0.064	***
	(0.008)		(0.011)		(0.006)		(0.017)		(0.009)		(0.010)	
external funds (abroad)	0.134		0.050		-0.615		-12.810	***	0.441		0.290	
	(0.298)		(0.584)		(0.494)		(3.924)		(0.543)		(1.372)	
constant	-1.671	***	-0.895		1.077	**	-0.584	**	-0.535		1.953	**
	(0.381)		(0.728)		(0.506)		(0.284)		(1.214)		(0.911)	
year effect	○		○		○		○		○		○	
observations	745		234		177		69		195		70	
R-squared	0.342		0.417		0.49		0.701		0.341		0.666	

Note1: Robust standard error in parentheses。

Note2: ***, **, * indicate that each coefficient is statistically significant at 1%, 5% and 10% respectively.

Source: Author

6. Summary

This study focused on funding sources of an institution’s own, internal funding and external funding, and conducted an empirical analysis on a department level on the effect of each provider of external funding on research productivity, especially focusing on three academic fields: engineering, health sciences and economics. The analysis shows that, first, the increase in the organization’s own, internal funding and external funding per faculty member has a positive impact on paper productivity in engineering and health sciences, but only the increase in its own, internal funding positively impacted the paper productivity in economics.

Second, further analysis on the impact of each provider of external funding shows that, in all academic fields, an increase in research funds from the public sector, which accounts for about 80% of external funding, was positively significant. Most research funds received from the public sector consist of competitive funds from the national government (primarily the grant-in-aid for scientific research), and these research funds can be empirically verified to have contributed to paper productivity.

Third, for engineering and the health sciences, the increase in research funding from the private sector was verified to have increased paper productivity. Nevertheless, the positive effect of an increase in research funding from the private sector was non-significant in economics. Furthermore, the private sector subdivision analysis showed that an increase in research funding received from firms negatively impacted research productivity in economics. This finding contrasted with the positive effect research funding accepted from firms had on the productivity in both engineering and the health sciences. One possible explanation for this disparity is that the objective of joint research with corporations might be different depending on the academic field. For example, in economics, their final output might merely provide a policy recommendation, consulting service, etc. to the partnering firm through research and analysis, rather than the university’s (or department’s) production of papers.

This paper’s analysis quantitatively suggests that the effect on research output is different for each academic field, even if the research funding source is the same. Currently, there are some considerations being made to construct a system that evaluates a university’s performance via key performance indicators (KPI) to reflect on funding allocations. However, when conducting a relative evaluation of universities, it is important to pay particular attention to the kinds of departments in each academic field wherein universities operate, and the scale of each department.

Lastly, some future challenges should be mentioned. The first challenge is the limitation of the explanatory variables. We only used a limited quantitative index of the number of papers that were posted in overseas journals due to constraints on data acquisition. Needless to say, the outputs of a university’s research activities are diverse, including those that cannot be visualized. In future studies, it is necessary to develop performance indicators that take qualitative factors into consideration at the department level, too.

The second challenge is the difficulty in interpreting the productivity of the humanities and social sciences. In economics, a field analyzed in this paper, it is relatively common for an academic paper to be the sole research output among all the liberal arts departments. However, in the humanities in general, or in law, politics, etc., it would be difficult to conduct an analysis in the same context as found in this study. Furthermore, in recent years, interdisciplinary and integrated research has become especially popular. Hence, the papers produced from researchers within the same academic field, or produced from joint or international studies are expected to be positioned differently. With the difficulty in interpreting the results, comes a challenge in analyzing each academic field, too. The third challenge is that although this paper focused on research funding sources, it is also important to analyze the relationship between the usage of acquired research funds and the research productivity.

[References]

Akai, N., K. Suetomi, W. Senoh, and K. Mizuta (2014) "Analyses of Resource Allocation in Educational Finance (Governance of Educational Finance): From the perspective across all education stages", *RIETI Discussion Paper Series 14-J-009*, The Research Institute of Economy, Trade and Industry, Japan [published in Japanese].

Aoki, S. and M. Kimura (2016) "Analysis of Research Productivity at Japanese National Universities", *Financial Review - Policy Research Institute, Ministry of Finance Japan,* vol.128, pp. 55-66 [published in Japanese]

Fujimura, M. (2017) "Estimating Effects of the Basic Research Fund Reduction on the Competitive Fundraising Behavior and Continued Research : Negative Spiral", *International Joint Research Programs Discussion Paper Series,* No.6, Research Institute for Higher Education, Hiroshima University [published in Japanese].

Fukuzawa, N. (2015) "An Empirical Analysis of the Research Efficiency and its Factors in Life and Medical Sciences Fields: Gender and Research Funding", *NISTEP Discussion Paper*, No.124, National Institute of Science and Technology Policy, Japan [published in Japanese].

Fukuzawa, N. and T. Ida (2010) "Academic Innovation Management 2: 21-Seiki COE Puroguramu No Kenkyuu Sokushin Kouka No Jisshou Bunseki [Empirical Analyses of the Research Promoting Effect of the 21st Century Center of Excellence Program]", *Annual Conference of The Japan Society for Science Policy and Research Management 2010,* The Japan Society for Science Policy and Research Management, Japan, 25: 25-28 [published in Japanese].

Hayashi, T., M. Shirabe, Y. Yamashita, and H. Tomizawa (2008) "Effects of Institutional Research Management on Faculty Research Productivity", *Research on Academic Degrees and University Evaluation*, No. 8, pp. 23-41 [published in Japanese].

Hayashi, T. and H. Tomizawa (2007) "Transition of Research Performance and Research Structure in Japan", *Research on Academic Degrees and University Evaluation*, No. 5, pp.55-73 [published in Japanese].

Ida, T. and N. Fukuzawa (2011) "21-Seiki COE Puroguramu No Kenkyuu Sokushin Kouka No Jisshou Bunseki [Empirical Analyses of the Research Promoting Effect of the 21st Century Center of Excellence Program]", *Annual Conference of The Japan Society for Science Policy and Research Management 2011,* The Japan Society for Science Policy and Research Management, Japan, No. 26, pp. 590-593 [published in Japanese].

Ito, Y. (2011) "Research Activity of Faculties in Universities, etc. Characterized by Their Publication Productivity", *The Journal of Science Policy and Research Management*, vol. 26(1_2), pp. 73-84 [published in Japanese].

Kanda, Y. and M. Igami (2017) "Inputs Structure of the University System in Japan – In-depth Analyses of the Survey of Research and Development (2002～2015) –," *NISTEP Research Material,* No.257, National Institute of Science and Technology Policy, Japan [published in Japanese].

Ohtawa, Y. (1998) "A study on the number of Japanese Engineering research field papers through analyzing 'COMPENDEX PLUS'", *Journal of Information Processing and Management*, vol.41, No.7, pp. 509-516 [published in Japanese].

Saka, A. and T. Kuwahara (2013) "Benchmarking Scientific Research 2012 - Bibliometric Analysis on Dynamic Alteration of Research Activity in the world and Japan", *NISTEP Research Material*, No.218, National Institute of Science and Technology Policy, Japan [published in Japanese].

Yonetani, Y., K. Ikeuchi, and T. Kuwahara (2013) "An analysis on the relationship between input and output in the production of articles in universities - An approach using Web of Science and Survey of R&D", *NISTEP Discussion Paper*, No.89, National Institute of Science and Technology Policy, Japan [published in Japanese].