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Do public research funds for universities hinder the acquisition of external funds, or do they induce it? —Department-level empirical analysis using system GMM

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Do public research funds for universities hinder the acquisition of external funds, or do they induce it?—Department-level empirical analysis using system GMM

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Abstract

In Japan's developed economy, there are high expectations for university research activities as bearers of innovation. With the tightening of national and local finances and the increasing pressure to reduce fundamental public funds allocated to universities, universities are expected to obtain external funding to strengthen their financial resource base and stimulate their research activities. However, in Japan, only a few studies have empirically analyzed how the enhancement of public funding affects the acquisition of external funds for university research. In this study, we examine the impact of the allocation of public research funds on the acquisition of external funds by national and local public universities by applying a system GMM method. We distinguish five academic fields (economics, science, engineering, agriculture, and medical) and develop a department-level panel data from 2004 to 2016. The results reveal that in Japan, public research funding has a crowding-in effect that induces rather than crowds out external funding. Specifically, we find that public funds induce the acceptance of external funds from firms in economics and engineering departments. In economics, science, and medical departments, public funds induce the acceptance of external funds from nonprofit organizations. In the medical departments, external funding acceptance from other universities is also induced. Moreover, the past performance of receiving external funds and the allocation of human resources in the department engaged in research activities also have an impact on the acquisition of external funds.

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1. Introduction

For Japan's developed economy to achieve long-term economic growth, it is essential to create innovations that raise the level of technology. In addition to playing a central role in promoting basic research, universities are expected to play an even greater role in making research results available to industrial society and producing added value.

Among the OECD countries, public spending on higher education institutions in Japan is at the lowest level, which was approximately 0.4% of GDP in 2018[1], and it is difficult to significantly increase public support under tight fiscal conditions. Regarding the financial situations of national and local public universities, which finance most of their operating expenses with public funds, national universities have continued to see a downward trend in subsidies for their fundamental operating expenses since their incorporation in 2004. The operating expenses of local public universities are funded by the local allocation tax, but it has become difficult to stabilize and expand operating financial resources because of the tightening of national and local finances.

Although the amount of funding for competitive funds is increasing, the pressure to reduce fundamental expenses for universities is also increasing. In Japan and other developed countries, performance-based funding is being expanded from input-oriented funding allocation to output-oriented funding measures. The shift from traditional public funding to encouraging market financing is in progress (Steil, et al., 2002). Universities are expected to secure limited funds in an increasingly competitive environment and strengthen their financial resource base by acquiring external research funds to stimulate their research activities.

There are few studies in Japan that empirically analyze how the allocation of public funds affects the acquisition of external funds for university research funding. This study discusses how the government can effectively finance university research activities in an era of tight financial constraint.

This paper focuses on national and local public universities, where the majority of operating expenses are publicly funded, and empirically analyzes the impact of the allocation of public research funds on the acquisition of external private funds by universities. Specifically, we examine whether the allocation of public research funds hinders (crowding out) or induces (crowding in) the acquisition of external funds.

2. Overview of external funding data

The data used for research funding at public universities are department level data from the

[1] OECD (2021) Education at a Glance, FigureC2.2 Total expenditure on educational institutions as a percentage of GDP, by source of funds (2018)

"Universities” questionnaire in the "Survey of Science and Technology Research” of the Statistics Bureau of the Ministry of Internal Affairs and Communications. The data period is from 2004 to 2016. In this survey, the expenses incurred by universities for research-related work are recorded as “research expenses used internally.” The sources of these funds are broadly classified into “funds received from outside sources” (hereinafter referred to as “external funds”) and “own funds.” External funds include commissioned funds, scientific research funds, subsidies, and grants; all other funds are treated as own funds. In addition to own income, such as tuition and other student fees collected by universities from students, subsidies for operation and facility development received from the government are also included in the category of own funds.

As subsidy for operating expenses, which is a fundamental expense granted by the government, is also a source of funds for university research activities, it is important to examine the impact it has on the acquisition of external private funds. However, because it is not possible to extract only the subsidies for operation expenses from own funds because of data limitation, this analysis focuses on examining the influence of the sources of external funds.

Table 1 presents the classification of sources of external funding. The sources of external funds can be broadly divided into (1) public institutions, (2) private sector, and (3) foreign sources. (1) The public institutions are subdivided into the national government, local governments, national and public universities, public research institutes, etc.; (2) private sectors are subdivided into firms, private universities, and nonprofit organizations, and (3) foreign countries are subdivided into foreign firms, universities, and others.

<Table1: The categories of the source of external research funding>

<table>
<tr><th colspan="4">MIC "Report on the survey of research and development"</th><th rowspan="2">this paper</th></tr>
<tr><th>funding source</th><th colspan="2">2004 - 2013</th><th>2014 - 2016</th></tr>
<tr><td rowspan="5">(1)from public sector</td><td colspan="3">central government</td><td rowspan="2">government</td></tr>
<tr><td colspan="3">local governemt</td></tr>
<tr><td colspan="3">national university/local public univeristy</td><td>university</td></tr>
<tr><td>public research institution</td><td>①national/local government institution,
②special public corporation, independent administrative agency
③public financial institution</td><td>①national/local government institution, independent administrative agency
②public enterprise, public financial institution</td><td rowspan="2">government</td></tr>
<tr><td colspan="3">others</td></tr>
<tr><td rowspan="3">(2)from private sector</td><td colspan="3">firm</td><td>firm</td></tr>
<tr><td colspan="3">private university</td><td>university</td></tr>
<tr><td colspan="3">nonprofit organization</td><td>nonprofit organization</td></tr>
<tr><td>(3)from abroad</td><td colspan="2">abroad</td><td>firm, university, others</td><td>—</td></tr>
</table>

Source: Author

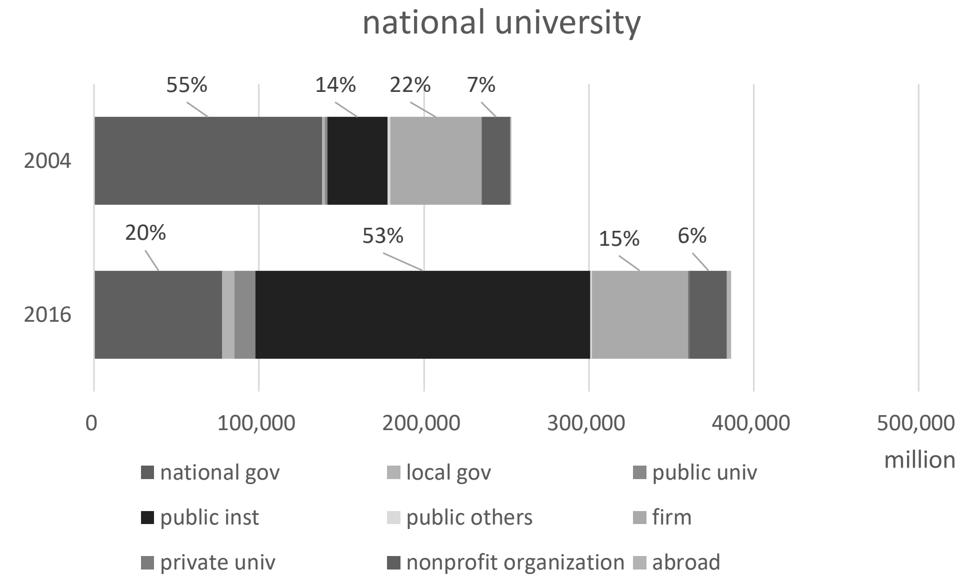
Graph 1 presents the total amount of external funding and the share of burden sources for public universities in 2004 and 2016. The departments analyzed in this study are university faculties, graduate schools, university-affiliated research institutes, and inter-university research institute corporations. The academic fields of the departments are classified as economics, science, engineering, agriculture, and medical (including dentistry and pharmacy). The amount in Graph 1 is the total of these departments.

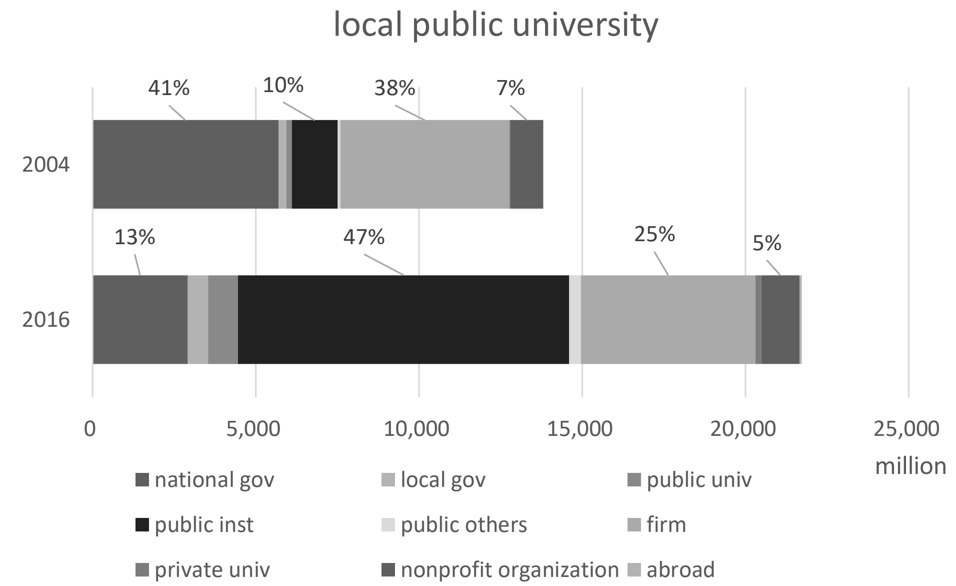
The total amount of external funds for national universities in 2004 was approximately 253 billion yen. In descending order, the sources of funding were the government (55%), firms (22%), public research institutions (14%), and nonprofit organizations (7%). In 2016, the total external funding increased about 1.5 times to approximately 386.4 billion yen, comprising public research institutions (55%), the national government (20%), firms (15%), and nonprofit organizations (6%). Acceptances from other national and local public universities and local governments also increased from 2004.

From 2004 to 2016, there has been a large decrease in acceptance from the national government and a large increase in acceptance from public research institutions, which can be attributed to changes in the entities that implement grant programs. For example, some of the Ministry of Medical, Labour and Welfare's Scientific Research Funds were transferred to the National Agency for Medical Research and Development. Similarly, some of the Ministry of Education, Culture, Sports, Science and Technology's Grants-in-Aid for Scientific Research were transferred to the Japan Society for the Promotion of Science. Thus, in some cases, grants that were previously allocated directly by the government are now allocated by public research institutions.

The total amount of external funding for local public universities in 2004 was approximately 13.8 billion yen, with the largest shares going to the government (41%), firms (38%), public research institutions (10%), and nonprofit organizations (7%). In 2016, the total amount increased by approximately 1.6 times to about 21.7 billion yen, with the total amount increasing significantly over the past 12 years. In order of share, public research institutions received 47%, firms 25%, the national government 13%, and nonprofit organizations 5%. The reasons mentioned above also account for the reversal in the order of the share of the national government and public research institutions. The acceptance of external funds from firms is relatively larger in local public universities than in national universities.

<Graph 1: The amount of external research funding and the share of its sources in national and local public universities>





Source: Author

As presented in Table 1, the Survey of Science and Technology Research reveals the changes in the survey items during the 2004–2013 and 2014–2016 survey periods. To unify the data of these survey items, this paper re-categorizes the sources of external funding into four—government, firms, universities, and nonprofit organizations—and then compiles the data. By putting government and public organizations into one category (government), we take into account the impact of changes in the entities that implement grant programs. As depicted in Graph 1, the share of external funding by foreign countries is limited to 1% or less; thus, it is not included in this analysis.

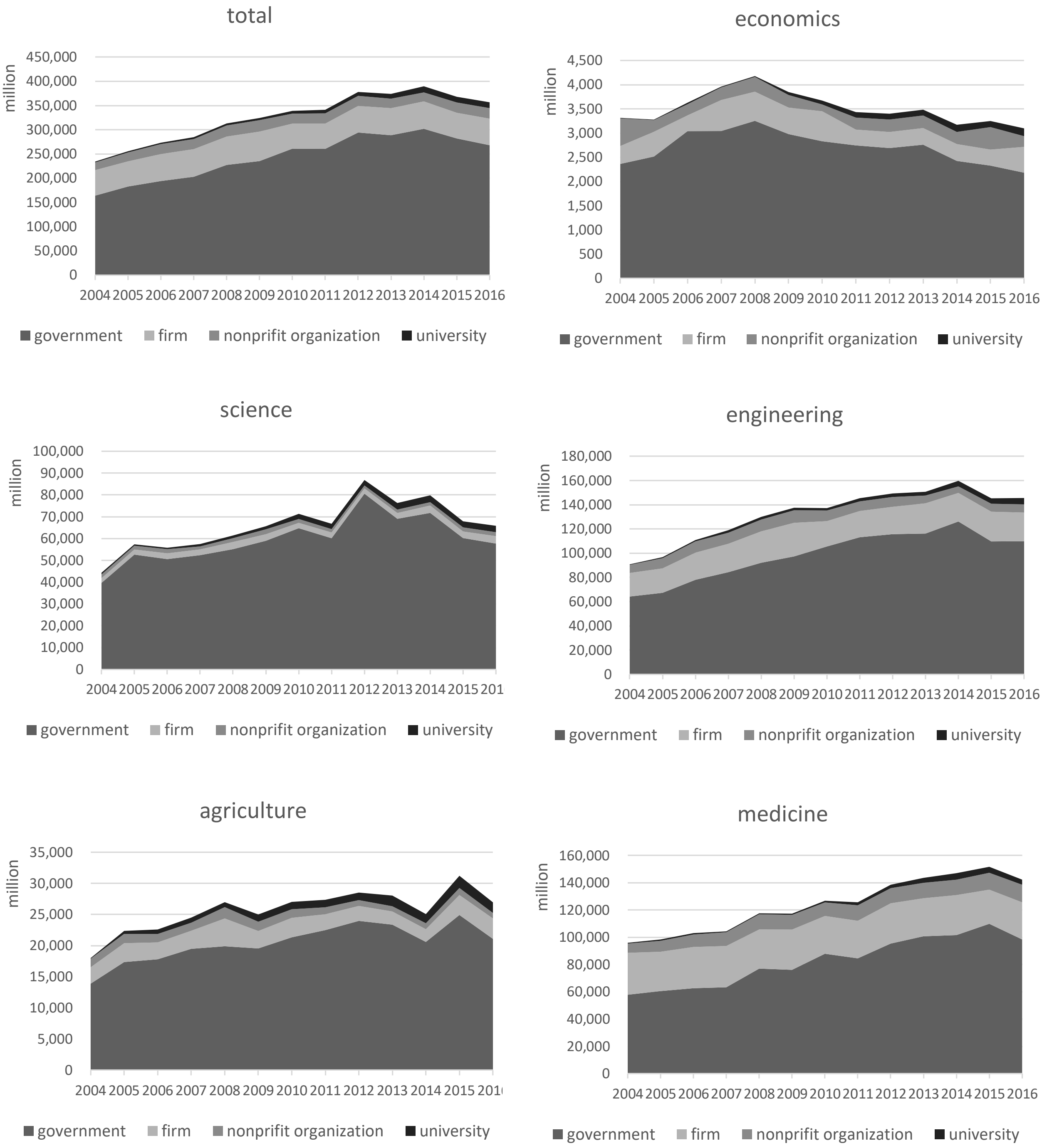
Graph 2 depicts the total amount of external funds received by national universities in five academic fields—economics, science, engineering, agriculture, and medical—as well as the share of funding sources. The funding scale in the engineering and medical fields, which are the largest, experienced a decreasing trend after peaking at around 160 billion yen for engineering and 150 billion yen for medical, although they had been on an increasing trend until around 2014. The funding scale in the field of science continues to be large, but the total amount of funds has been increasing and decreasing repeatedly, peaking at about 73 billion yen in 2012, and is on a downward trend. Compared with other fields, the agriculture field has been relatively flat, peaking at over 30 billion yen in 2015, and has been on a downward trend since then. In the field of economics, where the size of funds is the smallest, the peak was 4 billion yen in 2008 and has continued to decline until recently.

Regarding the share of funding sources, the share of government has remained significant in all fields. In particular, in the field of science, nearly 90% of external funding is received from the government. The next largest source is from firms, with a share of nearly 20% in the medical field and more than 15% in the economics and engineering fields. The acceptance from nonprofit organizations is also more prominent in the medical and economics fields than in other fields. In all fields, the share of funds received from other universities has been increasing in recent years.

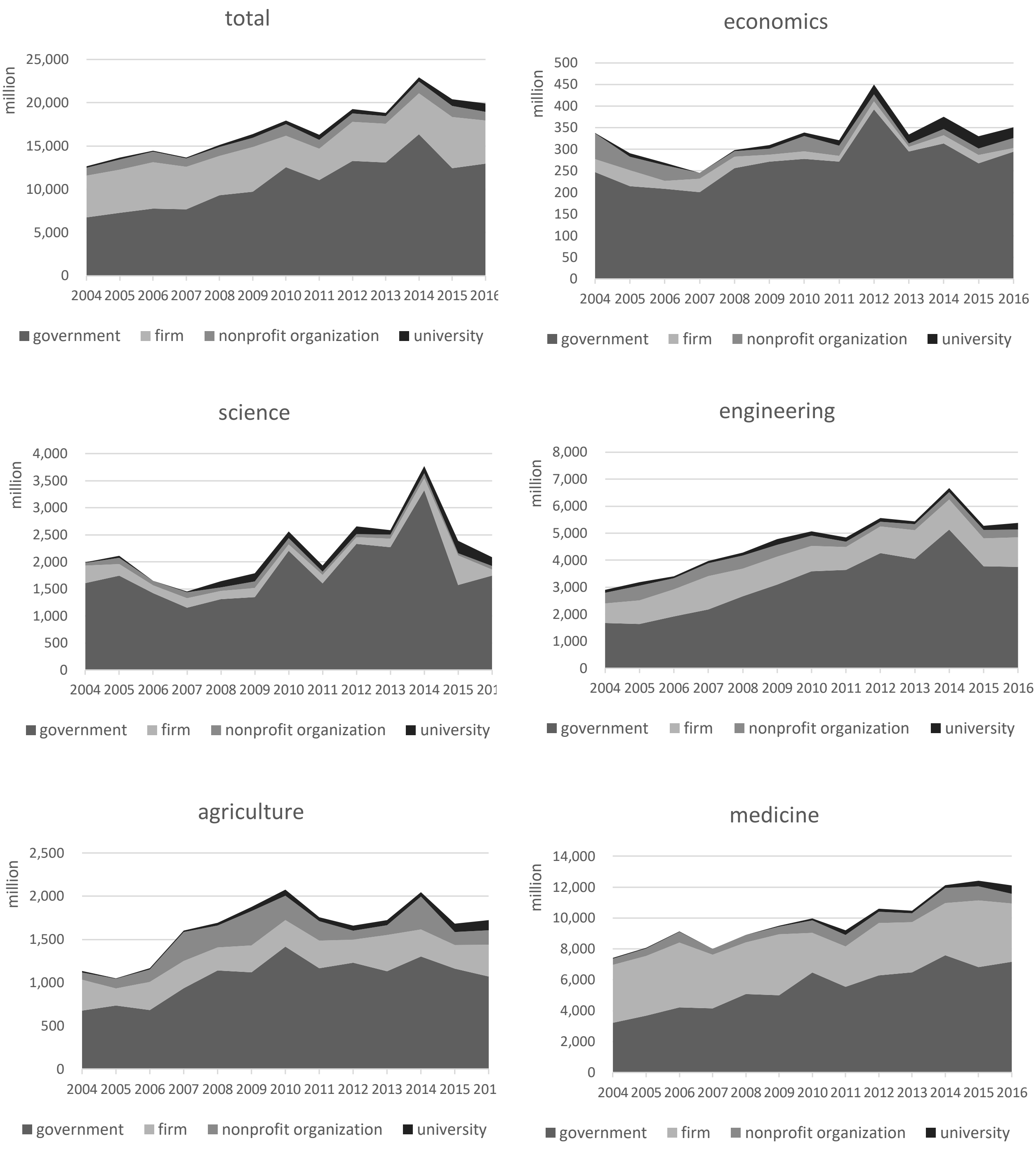
Local public universities have experienced more rapid increases and decreases in external funding than national universities. In national universities, there has been a declining trend in recent years after peaking around 2014. The scale of funding is the largest in the medical fields and has been increasing and remained flat among local public universities until recently.

As with national universities, the share of funding from the government is much larger, exceeding 80% in the fields of science and economics, whereas it is approximately 70% in engineering and approximately 60% in the medical and agriculture fields. The share of acceptance from firms also differs remarkably by field. In the medical field, it exceeds 30%, and in the engineering and agriculture fields, the share remains above 20%, which is larger than that of national universities. However, in the economics and science fields, the share is only 2%–5%. In the agriculture field, compared with national universities, local public universities accept more funds from nonprofit organizations.

<Graph 2-1: The transition of the share of external research funding sources by academic fields (National universities)>



<Graph 2-2: The transition of the share of external research funding sources by academic fields (Local public universities)>



Source: Author

3. Previous Studies

Traditional theory points to an alternative relationship in which public funding crowds out private funding. It has been pointed out that universities may stop looking for funds once they obtain government grants (Blume-Kohout, 2009). However, public funding performance can signal research quality and academic reputation to attract private funding (Muscio et al,2013; Jensen et al.,2010; Murray, 2004), or companies can free ride on publicly funded university capital investment and human resources (Muscio et al,2013); the two may be complementary. Whereas Sav (2012) suggested an alternative relationship between public and private funding, complementary relationships have been suggested by Connolly (1997), Muscio et al. (2013), and Lanahan et al. (2016), but Payne (2001) and Blume-Kohout et al. (2015), and others suggested both relationships, revealing mixed results in empirical research.

Empirical studies about the influence of public and private funding on university research funding have been accumulating, especially in the United States (U.S.). Connolly (1997) applied a panel vector autoregressive model to university level data from 1979 to 1990 to analyze the interdependence in the acquisition of internal and external funding. He found that there is no crowding out of both sources of funds, but they induce each other's acquisitions. It was also pointed out that causality can be confirmed in both directions for both financial sources, and past acquisitions have an impact on future performance.

Diamond (1999) examined the impact of federal research funding on the acquisition of private basic research funding by applying Granger causality tests using time series data from 1953 to 1995. Here, the private sector refers to academia, nonprofit organizations, and industry, and the result revealed that federal research funding crowds in basic research funding from these sectors.

Payne (2011) applied the fixed effects model and instrumental variable (IV) methods to examine the impact of federal research spending on private endowment acquisition using panel data of 10,795 universities from 1972 to 1997. The results revealed that crowding in is observed among research universities, whereas crowding out is observed among nonresearch universities. Sav (2012) also applied the two-stage least squares method to university panel data to examine the impact of private funding on government funding. He revealed that private funding crowds out government funding and pointed to a free ride in the allocation of university research funds by the government.

Using generalized momentum method-IV (GMM-IV) models, Blume–Kohout et al. (2015) examined the impact of the U.S. National Institutes of Medical grants on the acquisition of biomedical-related nongovernmental funding by universities. They pointed out that during periods of substantial grant increases, grants crowd in nongovernmental funding, especially in less research-oriented universities. However, they revealed that since the end of the increase in grants, grants have been crowding out nongovernmental funds, especially in universities with high research orientation.

A recent research trend has been the application of dynamic models that capture the effects of dynamism in acquiring research funds. Using panel data on a 13,840 sample of science departments from 2010 to 2014, Lanhan et al. (2016) analyzed the impact of the U.S. federal government's allocation of research funding on the acquisition of research funding from state governments, nonprofit organizations, and industry by applying a dynamic IV model. They concluded that the federal government’s allocation crowds in research funding from other sources in the fields of engineering, environmental science, life science, mathematics and computer science, physical chemistry, as well as social science and psychology.

Muscio et al. (2013) used the dynamic Tobit and dynamic probit models to examine the impact of public research funds on private research funds in 228 Italian university departments from 2005 to 2009. The results revealed that research funds allocated by various public institutions, including the EU and Italian central and local governments, crowd in private research funds. Wang et al. (2020) pointed out that there is limited research that examines the interrelationship between public and private university research funding in developing countries and analyzed the factors that encourage university–industry linkages in China. By applying the GMM method to university panel data from 2009 to 2018, they analyzed the impact of total research funding on private research funding. The results revealed an alternative relationship between the two, although the trends vary by type of university. They proposed that the results might be due to the following reasons: high dependence of universities in China on government funding, relatively low-tech companies and low demand for the intellectual property of domestic universities, faculty members' reluctance to collaborate with the private sector due to an evaluation system that emphasizes academic performance, and the signaling effect of public funding on private funding. They pointed out that the phenomenon of crowd in is a characteristic of developed countries, such as Europe and the U.S.

Recent studies that used dynamic models have found that public funding relatively crowds in private funding in university research funding, but the results vary by country and type of university. In addition, recent studies have increasingly conducted empirical analyses at the department level to control differences in the trends of the academic fields.

Based on the above review of previous studies, this paper applies a dynamic model to analyze the impact of public research funds on private research funds for departments of Japanese public universities (national and local public universities). As the actual situations of obtaining research funds and the cost structure of research activities differ greatly depending on the academic discipline, a database that is based on academic fields is constructed. Using this database, we analyze where various faculties and graduate schools are concentrated at the department level rather than at the university level. In constructing the model, we also consider the impact of the human resource allocation in the department, such as the number of faculty members, the working style of researchers, the number of doctoral course enrollments, and the number of research support staff, on the private sector research funding.

4. Empirical Analysis

4.1 The model

The models used in the analysis are as follows

$$PRIV_{i,t} = \rho PRIV_{i,t-1} + \beta GOV_{i,t-1} + \gamma YEAR_t + \alpha_i + u_{i,t} \tag{1}$$

$$PRIV_{i,t} = \rho PRIV_{i,t-1} + \beta GOV_{i,t-1} + X_{i,t}\boldsymbol{\delta} + \gamma YEAR_t + \alpha_i + u_{i,t} \tag{2}$$

$$PRIV_{i,t} = \rho PRIV_{i,t-1} + \beta GOV_{i,t-1} + X_{i,t}\boldsymbol{\delta} + Z_{i,t-1}\boldsymbol{\theta} + \gamma YEAR_t + \alpha_i + u_{i,t} \tag{3}$$

Equation (1) is the base model, where $PRIV_{i,t}$ is the external research funds from private institutions and other sources in department i in year t. In the analysis, we estimate three different sources of external research funds ($PRIV_{i,t}$)—firms ($firm$), nonprofit organizations (npo), and other universities ($univ$). $PRIV_{i,t-1}$ is a one-lagged explained variable. It is more likely for external research funds to be accepted continuously over several years than in a single year only, and the dynamic behavior of the department in obtaining funds should also be considered. $GOV_{i,t-1}$ denotes the research funds received from public institutions in the previous year, and β is the estimated coefficient that we focus on most in this paper. $YEAR_t$ is a dummy variable controlling the time series impact of macro-economic shocks; α_i is an unobservable departmental characteristic that does not change through time, and $u_{i,t}$ is a stochastic error term. All series are log-transformed, and funding data are standardized by dividing them by the number of full-time faculty members in the department.

In Equation (2), the number of doctoral students enrolled per full-time faculty member ($phdst\_fac$), the number of part-time researchers per full-time faculty member ($part\_fac$), and the number of research assistants per full-time faculty member (sup_fac) are used as the control variables ($X_{i,t}$). These variables indicate the allocation of personnel to research activities in a department, and all of them are ratios to full-time faculty members who are the focus of research activities.

Regarding $phdst\_fac$, it is not uncommon for faculty members, especially those in natural science departments, to conduct research activities with doctoral students at the laboratory, and joint research with graduate students may contribute to obtaining external funding. However, when faculty members' research time is reduced due to the need to devote time to the education of doctoral students, the opportunity to obtain external funding may be limited as the number of doctoral students increases. Therefore, the estimated coefficient of $phdst\_fac$ is assumed to be both positive and negative. Regarding both $part\_fac$ and sup_fac, it is assumed to have a positive impact on the acquisition of external research funds. Part-time researchers who have their proper status at other academic institutions and engage in joint research and research assistants who follow the instructions of the departments to assist research activities are expected to play a complementary role in the research activities of their full-time faculty members.

In Equation (3), following Lanahan et al. (2016), in addition to the explained variable, we add external research funding from private institutions and other sources in the previous year as an explanatory variable ($Z_{i,t-1}$). This allows us to examine the impact of obtaining research funds from other sources other than public institutions on each explained variable. Other financial sources other than public institutions are as follows: when $firm_{it-1}$is the explained variable, $Z_{i,t-1}$ includes npo_{it-1} and $univ_{it-1}$; when npo_{it-1} is the explained variable, $Z_{i,t-1}$ includes $firm_{it-1}$ and $univ_{it-1}$, and when $univ_{it-1}$ is the explained variable, $Z_{i,t-1}$ includes $firm_{it-1}$ and npo_{it-1}.

In the analysis, the following first difference model is estimated. The individual effect α_i is eliminated in the model. Using Equation (1) as an example, the first difference model is as follows:

$$\Delta PRIV_{i,t} = \rho \Delta PRIV_{i,t-1} + \beta \Delta GOV_{i,t-1} + \Delta X_{i,t}\boldsymbol{\delta} + \gamma YEAR_t + \Delta u_{i,t}. \qquad (4)$$

As we take the log differences, the above equation captures the movement in the rate of change. In Equation (4), $\Delta PRIV_{i,t-1}$ and $\Delta u_{i,t}$ are correlated, so the usual fixed effects model or generalized least squares model cannot satisfy the consistency of the estimators. To deal with this problem, this paper uses a dynamic panel analysis with the Blundell-Bond (1998) system GMM (hereafter B-B model).

The IVs to deal with the endogeneity of $\Delta PRIV_{i,t-1}$ at time t should be uncorrelated with $\Delta u_{i,t}$ but correlated with $\Delta PRIV_{i,t}$. As variables for satisfying these conditions,$y_{i,t-2}$ and $\Delta y_{i,t-2}$ are used as IVs, and the time series is considered by the trend term. The B-B model is a method that uses the GMM to obtain matching estimators. Employing the following moment conditions to define the GMM objective function, the B-B model combines the first-order difference regression equation with the level regression equation to estimate the unknown parameters using an IV that satisfies $y_{is}, s \leq t-2$.

$$E[y_{i,s}\Delta u_{i,t}] = 0, t = 2, \dots, T, \qquad s = 0, \dots, t-2 \qquad (5)$$

$$E[\Delta x_{i,s}\Delta u_{i,t}] = 0, t = 2, \dots, T, \qquad s = 1, \dots, T \qquad (6)$$

In addition to the B-B model, the two-stage least squares method of Anderson and Hisao (1982) (hereafter A-H model) and the first-order difference GMM of Arellano–Bond (1991) (hereafter A-B model) are well known. According to Takahashi (2013), GMM estimation with the A-B and B-B models is a more valid estimator than the two-stage least squares method of the A-H model for data with a small number of time series than a sufficiently large number of cross-sections. Moreover, unlike the A-B model, the B-B model does not suffer from the weak operating variable problem even when

$\rho \rightarrow 1$. Therefore, the B-B model is employed in this paper.

For the lags of the IVs used in GMM estimation, increasing the number of lag periods may increase the effectiveness, but as Hisao et al. (2002) and others have demonstrated, imposing excessive orthogonality conditions may increase downward bias. Therefore, in this paper, we use the two-period lag of the endogenous variable as the IV ($s = 2$) and consider higher lag period numbers if the orthogonality condition of the IV is not satisfied. In both models, the absence of serial correlation in the error terms is an important assumption for obtaining a consistent estimator in GMM estimation. In this paper, we also test for serial correlation for the first-order difference error term, and if the first-order autocorrelation is significant and the second-order autocorrelation is not significant, we conclude that the original error term is uncorrelated.

The descriptive statistics of the data are presented in Table 2, which totals 5,503 samples for all five academic fields of study, of which engineering and agricultural departments have the largest (1,767) and smallest (777) number of samples, respectively. Table 2 presents the average amount of external research funds obtained in each academic field. Regarding research funds from public organizations (*gov*), science departments received the largest amount of 6.61 million yen per full-time faculty member, followed by medicine (6.08 million yen) and engineering (6.05 million yen). The lowest is 1.15 million yen for economics departments. Research funds from firms (*firm*) amounted to 1.2–1.3 million yen in the medical and engineering fields, whereas those from the economics and science fields were in the range of 180,000–350,000 yen. Research funds from nonprofit organizations (*npo*) are also relatively more common in the medical and engineering fields, whereas those from other universities (*univ*) are more common in the science and agriculture fields.

<Table2: Descriptive statistics>

TOTAL (unit:10K)

Variable	Obs.	Mean	S.D.	Min	Max
gov	5,503	528	1,492	0	77,639
firm	5,503	89	133	0	3,992
npo	5,503	36	63	0	897
univ	5,503	18	60	0	1,556
phdst_fac	5,503	3	20	0	357
pres_fac	5,503	2	16	0	533
supres_fac	5,503	0	0	0	7

ECON

Variable	Obs.	Mean	S.D.	Min	Max
gov	785	115	188	0	1,402
firm	785	18	55	0	659
npo	785	12	47	0	872
univ	785	3	7	0	69
phdst_fac	785	1	1	0	5
pres_fac	785	0	0	0	2
supres_fac	785	0	0	0	1

SCI

Variable	Obs.	Mean	S.D.	Min	Max
gov	927	661	780	0	9,535
firm	927	35	55	0	579
npo	927	22	37	0	379
univ	927	24	64	0	973
phdst_fac	927	1	9	0	211
pres_fac	927	2	24	0	533
supres_fac	927	0	0	0	7

ENG

Variable	Obs.	Mean	S.D.	Min	Max
gov	1,767	605	2,047	0	77,639
firm	1,767	125	119	0	1,125
npo	1,767	45	74	0	897
univ	1,767	20	77	0	1,556
phdst_fac	1,767	1	9	0	357
pres_fac	1,767	0	0	0	6
supres_fac	1,767	0	0	0	5

AGR

Variable	Obs.	Mean	S.D.	Min	Max
gov	777	488	1,255	0	20,280
firm	777	70	217	0	3,992
npo	777	30	51	0	583
univ	777	23	42	0	379
phdst_fac	777	18	49	0	297
pres_fac	777	8	31	0	207
supres_fac	777	0	0	0	2

MED

Variable	Obs.	Mean	S.D.	Min	Max
gov	1,247	608	1,518	0	33,328
firm	1,247	133	123	0	1,146
npo	1,247	53	70	0	897
univ	1,247	17	56	0	869
phdst_fac	1,247	1	1	0	27
pres_fac	1,247	0	1	0	5
supres_fac	1,247	0	0	0	5

Source: Author

4.1 The estimation results

The estimation results for Equations (1) through (3) are presented in Table 3. First, let us examine the results for the economics departments. For Models 1–3, the exogeneity of the IVs satisfies the Hansen J statistic (values in the table are p-values), and there is no serial correlation in the error terms. In every model, the impact of one-lagged public research funding on external funding from firms and nonprofit organizations is positively significant at the 5% significance level, whereas the impact on external funding from other universities is not significant. This result demonstrates that public research funding, which induces external funding from firms and nonprofit organizations, has a crowding in effect on research funding in economics departments.

The results of the estimated coefficients of the other explanatory variables reveal that the one-lagged variable for each of the explained variables is significant at the 1% level, indicating that past funding performance has a positive impact on the current scale of external funding. The estimation results in Model 3 also reveal that receiving external funding from firms is affected not only by the past performance of firms but also by funding from nonprofit organizations. The same can be said about receiving external funding from nonprofit organizations, suggesting that the past receipt of external funding from firms and nonprofit organizations is closely related to the external funding scheme in economics departments. Other estimates from Models 2 and 3 indicate that the number of doctoral students per full-time faculty member has a significantly positive impact on external funding from firms. In economics departments, collaborative research with graduate students may also contribute to obtaining external funds. The number of research assistants per full-time faculty member has also a significantly positive impact on external funding from nonprofit organizations.

Next, we look at the estimation results for the science departments. In all models, the exogeneity of the IV is satisfied. However, when external funds from firms are used as the explained variable, the possibility of serial correlation in the error term cannot be denied. The effect of the public research funds that we focus on is not significant in this case. Focusing on the estimation results for when other external funds are the explained variable, the impact of public research funds on external funds from nonprofit organizations is positively significant at the 10% level. This suggests that public research funds have a crowding in effect on research funding in science departments, which induces external funding from nonprofit organizations.

In all models, the past performance of receiving external funds also affects the current scale of the relevant funds, but unlike the economics departments, there is no cross-over effect when the acceptance performance of different sources also affects the acceptance of the relevant funds. Regarding the effects of other variables related to human resources, it appears that a higher number of research assistants per full-time faculty member increases the acceptance of funds from other universities.

The estimation results for the engineering departments indicate that the exogeneity of the operating variable is satisfied in all models, but the serial correlation of the error term is suspect when external funding from other universities is used as the explained variable. The effect of public research funding on external funding from other universities is not significant. Regarding the other explained variable, in both models, public research funds have a significantly positive effect on the acceptance of external funding from firms at the 1% level. In Model 1, there is also a positive effect on external funding from nonprofit organizations at the 10% significance level. This suggests that public research funds have a crowding in effect on research funding in engineering departments, which induces external funding from firms and may also induce external funding from nonprofit organizations.

Similar to previous departments, past external funding performance has a positive impact on the current funding status of relevant funds, and the status of acceptance from firms is also influenced by past acceptance from nonprofit organizations. Other findings suggest that the acceptance of external funding from firms and nonprofit organizations increases with the number of part-time researchers and research assistants who are expected to play a complementary role in the research activities of the full-time faculty member.

Next, we examine the estimation results for agricultural departments. Although the exogenous nature of the IV is satisfied in all models, the serial correlation of the error term for agricultural departments is questionable, except for when the external funds from firms are used as the explained variable. When external funds from firms are used as the explained variable, the estimated coefficient of public research funds, which has been the focus of attention, is not significant. This result reveals that the level of public research funds does not have a statistically significant effect on any of the external funding of research in agricultural departments. However, as in the case of other academic fields, past receipt of external funding is associated with the current funding status.

Due to the characteristic of agricultural departments, the number of doctoral students per full-time faculty member has a negative and significant impact on external funding from firms (and external funding from other universities, although the robustness of the estimation results is questionable due to the existence of serial correlation).

Finally, we look at the estimation results for the medical departments. In all models, the exogeneity of the IVs is satisfied, and there is no serial correlation in the error terms. First, in all models, the estimated coefficients of public research funds, which are the focus of interest, are positive and significant at the 1% and 5% levels for the receipt of external funds from nonprofit organizations and other universities, respectively. In addition, Model 1 is statistically significant at the 10% level for receipt of funds from firms. This indicates that public research funds induce crowding in of external funds from nonprofit organizations and other universities and may also induce external funds from firms for research funding in medical departments.

In all models, the past external funding performance has a positive impact on the current funding status of the relevant funds. However, like most other natural science departments, there is no cross effect, where the acceptance performance of different sources also affects the acceptance status of the relevant funds. Regarding the variables related to human resources, both positive and negative effects of the number of doctoral students per full-time faculty member are confirmed for medical departments, which contributes to obtaining external funds from companies, but limits obtaining funds from nonprofit organizations and other universities. The relationship with graduate students is diverse, as faculty members engage in education and research activities within their limited time, and the direction of the impact on the results of external funding acquisition is complex.

The number of adjunct faculty members who are expected to play a complementary role in the research activities of regular faculty members has a positive impact on the receipt of external funds from companies. However, it has a negative impact on the receipt of funds from other universities, suggesting that for medical departments, other than regular faculty members, having many staff members who are engaged in research activities does not necessarily lead to the acquisition of external funds. This suggests that for medical departments, having a large number of staff engaged in research other than the core faculty members does not necessarily lead to the acquisition of external funds. The number of part-time faculty members who are expected to play a complementary role in the research activities of full-time faculty members has a positive impact on external funds from firms. However, it has a negative impact on funds from other universities, suggesting that for medical departments, a large number of staff engaged in research other than the main faculty members does not necessarily lead to the acquisition of external funds.

<Table3: Estimation results>

(ECN)

	Model1: eq.(1)			Model2: eq.(2)			Model3: eq.(3)		
VARIABLES	firm	npo	univ	firm	npo	univ	firm	npo	univ
L.lngov_int_fac	0.181**	0.142**	0.0174	0.148**	0.0875**	0.0121	0.130**	0.0799**	0.00655
	(0.0904)	(0.0566)	(0.0236)	(0.0674)	(0.0403)	(0.0310)	(0.0603)	(0.0405)	(0.0334)
L.lnfirm_int_fac	0.680***			0.605***			0.601***	0.144***	0.0476
	(0.198)			(0.171)			(0.182)	(0.0364)	(0.0348)
L.lnnpo_int_fac		0.477***			0.594***		0.0944**	0.482***	-0.0317
		(0.137)			(0.0723)		(0.0431)	(0.0946)	(0.0334)
L.lnuniv_int_fac			0.918***			0.915***	-0.000113	0.0442	0.918***
			(0.0365)			(0.0365)	(0.0610)	(0.0486)	(0.0379)
phdst_fac				0.236**	0.101	-0.00740	0.208*	0.0374	-0.0263
				(0.115)	(0.0658)	(0.0349)	(0.113)	(0.0724)	(0.0369)
pres_fac				0.236	0.152	-0.0409	0.0871	0.00519	-0.0300
				(0.575)	(0.263)	(0.131)	(0.521)	(0.229)	(0.127)
supres_fac				0.111	0.609**	0.252	0.0590	0.583*	0.240
				(0.297)	(0.290)	(0.400)	(0.286)	(0.315)	(0.423)
Constant	-0.477***	0.0945	-0.0167	-0.385**	0.00524	-0.0121	-0.404***	0.0509	-0.000745
	(0.173)	(0.132)	(0.145)	(0.170)	(0.140)	(0.148)	(0.156)	(0.133)	(0.137)
Observations	714	714	714	714	714	714	714	714	714
Number of scicode	70	70	70	70	70	70	70	70	70
Hansen J	[0.450]	[0.842]	[0.408]	[0.542]	[0.676]	[0.388]	[0.491]	[0.603]	[0.422]
AR(1)	[0.004]	[0.000]	[0.000]	[0.003]	[0.000]	[0.000]	[0.005]	[0.000]	[0.000]
AR(2)	[0.887]	[0.536]	[0.163]	[0.805]	[0.617]	[0.160]	[0.792]	[0.635]	[0.136]

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

(SCI)

	Model1: eq.(1)			Model2: eq.(2)			Model3: eq.(3)		
VARIABLES	firm	npo	univ	firm	npo	univ	firm	npo	univ
L.lngov_int_fac	0.0579	0.126*	0.0252	0.0597	0.115*	0.0170	0.0511	0.0903*	-0.00176
	(0.0477)	(0.0681)	(0.0830)	(0.0492)	(0.0602)	(0.0712)	(0.0852)	(0.0541)	(0.0680)
L.lnfirm_int_fac	0.728***			0.720***			0.699***	0.0702	0.0581
	(0.134)			(0.145)			(0.129)	(0.0430)	(0.0477)
L.lnnpo_int_fac		0.525***			0.524***		0.149	0.590***	-0.0579
		(0.171)			(0.175)		(0.124)	(0.151)	(0.0514)
L.lnuniv_int_fac			0.867***			0.852***	-0.0733	0.00534	0.885***
			(0.116)			(0.106)	(0.121)	(0.0386)	(0.101)
phdst_fac				0.0118	0.0798	0.00173	-0.0126	0.0469	0.00487
				(0.0339)	(0.0625)	(0.0354)	(0.0437)	(0.0538)	(0.0351)
pres_fac				-0.00722	-0.0330	-0.00175	0.00251	-0.0199	-0.00273
				(0.0128)	(0.0232)	(0.0129)	(0.0166)	(0.0200)	(0.0128)
supres_fac				-0.0361	-0.0987	0.338***	-0.0337	-0.105	0.332***
				(0.0612)	(0.0861)	(0.128)	(0.0655)	(0.0740)	(0.120)
Constant	0.486*	0.519*	0.335	0.390	0.453	0.316	0.381	0.314	0.291
	(0.250)	(0.302)	(0.402)	(0.282)	(0.324)	(0.310)	(0.284)	(0.278)	(0.298)
Observations	834	834	834	834	834	834	834	834	834
Number of scicode	85	85	85	85	85	85	85	85	85
Hansen J	[0.200]	[0.179]	[0.350]	[0.184]	[0.190]	[0.394]	[0.281]	[0.450]	[0.460]
AR(1)	[0.001]	[0.000]	[0.000]	[0.001]	[0.001]	[0.000]	[0.001]	[0.000]	[0.000]
AR(2)	[0.018]	[0.300]	[0.348]	[0.020]	[0.307]	[0.332]	[0.024]	[0.226]	[0.305]

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

(ENG)

VARIABLES	Model1: eq.(1) firm	Model1: eq.(1) npo	Model1: eq.(1) univ	Model2: eq.(2) firm	Model2: eq.(2) npo	Model2: eq.(2) univ	Model3: eq.(3) firm	Model3: eq.(3) npo	Model3: eq.(3) univ
L.lngov_int_fac	0.231***	0.114**	0.0365	0.188***	0.0840	0.0347	0.178***	0.0548	0.0520
	(0.0746)	(0.0573)	(0.0421)	(0.0679)	(0.0675)	(0.0434)	(0.0571)	(0.0564)	(0.0517)
L.lnfirm_int_fac	0.430***			0.459***			0.444***	0.0692	-0.0513
	(0.134)			(0.125)			(0.120)	(0.0759)	(0.0517)
L.lnnpo_int_fac		0.601***			0.601***		0.0535**	0.596***	0.0183
		(0.0804)			(0.0820)		(0.0267)	(0.0810)	(0.0321)
L.lnuniv_int_fac			0.901***			0.907***	-0.00372	0.0115	0.913***
			(0.0925)			(0.0930)	(0.0130)	(0.0281)	(0.0915)
phdst_fac				0.000695	-0.00255	-0.00447	0.00286	-0.00647	-0.00319
				(0.00444)	(0.0350)	(0.00364)	(0.00453)	(0.0348)	(0.00381)
pres_fac				0.124**	0.0684	-0.0349	0.130**	0.0575	-0.0367
				(0.0620)	(0.0868)	(0.0739)	(0.0628)	(0.0846)	(0.0695)
supres_fac				0.295**	0.423*	0.0747	0.309**	0.440*	0.0844
				(0.140)	(0.256)	(0.137)	(0.141)	(0.263)	(0.147)
Constant	1.146***	0.593*	0.165	1.209***	0.708**	0.164	1.184***	0.579	0.214
	(0.321)	(0.308)	(0.203)	(0.329)	(0.338)	(0.204)	(0.310)	(0.390)	(0.200)
Observations	1,608	1,608	1,608	1,608	1,608	1,608	1,608	1,608	1,608
Number of scicode	154	154	154	154	154	154	154	154	154
Hansen J	[0.401]	[0.113]	[0.480]	[0.423]	[0.119]	[0.490]	[0.464]	[0.122]	[0.485]
AR(1)	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
AR(2)	[0.861]	[0.850]	[0.007]	[0.807]	[0.868]	[0.007]	[0.837]	[0.863]	[0.007]

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

(AGR)

VARIABLES	Model1: eq.(1) firm	Model1: eq.(1) npo	Model1: eq.(1) univ	Model2: eq.(2) firm	Model2: eq.(2) npo	Model2: eq.(2) univ	Model3: eq.(3) firm	Model3: eq.(3) npo	Model3: eq.(3) univ
L.lngov_int_fac	0.124	-0.000143	0.00258	0.0963	0.00321	0.00918	0.0891	0.000937	-0.00643
	(0.0826)	(0.0311)	(0.0428)	(0.0874)	(0.0289)	(0.0427)	(0.0799)	(0.0326)	(0.0413)
L.lnfirm_int_fac	0.464**			0.457**			0.457**	0.00811	0.0734*
	(0.232)			(0.225)			(0.218)	(0.0588)	(0.0399)
L.lnnpo_int_fac		0.903***			0.864***		0.0165	0.861***	-0.0199
		(0.0995)			(0.142)		(0.0454)	(0.116)	(0.0524)
L.lnuniv_int_fac			0.902***			0.876***	0.0654***	0.0213	0.867***
			(0.0577)			(0.0661)	(0.0237)	(0.0325)	(0.0647)
phdst_fac				-0.00663**	-0.00292	-0.00260**	-0.00551**	-0.00262	-0.00260***
				(0.00269)	(0.00440)	(0.00112)	(0.00256)	(0.00326)	(0.000967)
pres_fac				-0.00573	0.000931	-0.000504	-0.00599	0.00105	0.000268
				(0.00553)	(0.00320)	(0.000926)	(0.00526)	(0.00318)	(0.00109)
supres_fac				-0.0843	-0.221	-0.0576	-0.0565	-0.252	-0.0811
				(0.367)	(0.665)	(0.138)	(0.354)	(0.576)	(0.144)
Constant	1.234**	0.159	0.544**	1.273***	0.307	0.606**	1.104**	0.254	0.516**
	(0.480)	(0.305)	(0.259)	(0.476)	(0.427)	(0.264)	(0.475)	(0.283)	(0.259)
Observations	709	709	709	709	709	709	709	709	709
Number of scicode	67	67	67	67	67	67	67	67	67
Hansen J	[0.510]	[0.241]	[0.483]	[0.481]	[0.256]	[0.464]	[0.486]	[0.239]	[0.459]
AR(1)	[0.044]	[0.000]	[0.000]	[0.039]	[0.000]	[0.000]	[0.039]	[0.000]	[0.000]
AR(2)	[0.147]	[0.028]	[0.044]	[0.121]	[0.036]	[0.043]	[0.144]	[0.035]	[0.047]

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

(MED)

VARIABLES	Model1: eq.(1) firm	npo	univ	Model2: eq.(2) firm	npo	univ	Model3: eq.(3) firm	npo	univ
L.lngov_int_fac	0.102*	0.175**	0.109**	0.0723	0.192**	0.122**	0.0798	0.181***	0.125**
	(0.0574)	(0.0730)	(0.0451)	(0.0754)	(0.0782)	(0.0491)	(0.0627)	(0.0647)	(0.0502)
L.lnfirm_int_fac	0.613***			0.614***			0.577***	0.132	-0.0206
	(0.112)			(0.156)			(0.151)	(0.0899)	(0.0309)
L.lnnpo_int_fac		0.645***			0.630***		0.0393	0.488**	0.0251
		(0.197)			(0.189)		(0.0364)	(0.213)	(0.0287)
L.lnuniv_int_fac			0.800***			0.782***	-0.0251	0.0190	0.775***
			(0.0538)			(0.0571)	(0.0260)	(0.0547)	(0.0580)
phdst_fac				0.125***	-0.0965***	-0.0504***	0.124***	-0.0944***	-0.0510***
				(0.0286)	(0.0332)	(0.0187)	(0.0279)	(0.0299)	(0.0181)
pres_fac				0.0767***	-0.0584	-0.0545*	0.0783**	-0.0886	-0.0527*
				(0.0285)	(0.0563)	(0.0304)	(0.0323)	(0.0706)	(0.0310)
supres_fac				0.0420	0.0292	-0.0172	0.0329	-0.0852	-0.00183
				(0.254)	(0.187)	(0.0809)	(0.221)	(0.213)	(0.0796)
Constant	1.142***	0.261	-0.576**	1.227***	0.310	-0.584**	1.269***	0.203	-0.570**
	(0.356)	(0.394)	(0.239)	(0.464)	(0.370)	(0.255)	(0.424)	(0.261)	(0.254)
Observations	1,140	1,140	1,140	1,140	1,140	1,140	1,140	1,140	1,140
Number of scicode	101	101	101	101	101	101	101	101	101
Hansen J	[0.335]	[0.425]	[0.131]	[0.180]	[0.531]	[0.199]	[0.220]	[0.609]	[0.200]
AR(1)	[0.002]	[0.000]	[0.000]	[0.004]	[0.000]	[0.000]	[0.004]	[0.001]	[0.000]
AR(2)	[0.298]	[0.395]	[0.150]	[0.322]	[0.433]	[0.155]	[0.375]	[0.666]	[0.150]

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Author

5. Concluding remarks

In this paper, using external funding data for Japanese public universities from 2004 to 2016, we conduct an empirical analysis at the department level on the impact of the allocation of public research funds on external funds in five academic fields (economics, science, engineering, agriculture, and medicine). A dynamic panel analysis of B-B's system GMM is used to account for the impact of past external funding receipt performance in the model. The main conclusions are as follows.

First, regardless of the academic field, we could not identify any crowding out effect of public research funding allocations that prevent a department from acquiring external funding. This suggests that even if the government implements additional public research funding measures in the future, it is unlikely that they will reduce the acquisition of research funds from the private sector. Conversely, this result also reveals that if the allocation of public research funds by the government decreases, the lack of crowding out effect suggests that the university could not expect to obtain enough external funding from the private sector to compensate for the decrease, and the university might find it more difficult to raise funds for research.

Second, we find that public research funding does not crowd out external funding but rather leads to a crowding in effect, which further induces it. Specifically, the fact that public research funds induce external funds from firms is confirmed in the economics and engineering departments, and their ability to induce external funds from nonprofit organizations is confirmed in the economics, science, and medical departments. In the medical department, public research funds also induce external funds from other universities, which suggests that public funding may promote research collaboration among universities. Regarding agriculture departments, the impact of public research funds on the acquisition of external funds is not confirmed. The crowding in effects suggest that in many cases, increasing public research funding may strengthen the research funding base of universities.

Third, it is demonstrated that past external funding performance has a positive impact on the current funding status of the relevant funds. It can be suggested that it is important to build long-term relationships with external funding sources. In particular, in the economics and engineering departments, the performance of receiving funds from different sources also affects the status of receiving funds from relevant sources. This suggests that establishing comprehensive relationships with counterparts and forming individual relationships with the sources of external funds may lead to the acquisition of funds in the future.

The remaining issue is to conduct an analysis that considers the qualitative aspects of research activities in university departments. For instance, future research can examine whether the enhancement of public or private research funding leads to desirable research outcomes. Although it is difficult to quantify research outcomes, it is necessary to develop evaluable indicators of research outcomes from a longer-term perspective.

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