International Journal of Institutional Research and Management
International Institute of Applied Informatics
2023, Vol. 7, No. 1, IJIRM778

# Comparison of Research Performance by Institute based on Research Keywords

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## Abstract

To propose a new method of comparing performance between studies on the same subject at different institutions, this study obtained information on grant amounts, keywords related to the research, and the number of achievements for all projects from the Grants-in-Aid for Scientific Research (KAKENHI) Database. From this database, the information on research projects between FY 2012 and 2021 was obtained and classified into ten groups according to their budget amounts. Thereafter, 12 research institutes were focused and compared the number of research achievements in each group. Throughout all groups, the institute's performance differences were not apparent based on the comparison of research projects. However, the results revealed that the method of comparing by keywords better indicates the differences in the performance of each institute. To clarify the causes of the differences, the authors compared achievements in common and unique words separately. Consequently, there tended to be significant differences in performance for unique words than common words. More reliable results are expected to be obtained by improving the determination accuracy of the same keywords.

*Keywords:* KAKENHI, Research performance, University Research Administrator

## 1 Introduction

Most scientists affiliated with research institutions in Japan conduct their research activities by obtaining grants, known as Grants-in-Aid for Scientific Research (KAKENHI), and thereafter, publish the results to give back to society and build on their achievements. Nonetheless, the research institutes employing scientists also track their outcomes and consider the areas in which they can grow their research capabilities. This study aims to find research topics with high performance and differentiate them from others. Here, high performance means the ability to produce many research achievements or outcomes within a limited budget.

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In previous studies on grants, Nomura et al. attempted to classify institutions based on the number of projects selected for funding [1]. Nomura et al. and Nishizawa et al. obtained an index of research activity for each university based on the amount allocated to each research category [2][3][4]. Furthermore, Yabuki used data on the number of applications and grants received for KAKEN to compare research performance between similar research departments [5]. Recently, Hirai led the establishment of the Code for Research Administration (C4RA), a community of University Research Administrators (URAs), and others. This community aims to increase the efficiency and sophistication of research Institutional Research (IR) in Japan by sharing program codes and tools across institutions of affiliation. Community members develop and share programs and tools for analyzing papers and external funding [6]. With the support of the community, Kubo and Hirai developed an application that visualizes the number of adoptions and allocation amounts for each institution by research category or review section. Moreover, this application provides a network among researchers based on the information of collaborators [7].

Certain studies are government-sponsored. The Science for RE-designing Science, Technology, and Innovation Policy Center (SciREX) of the National Graduate Institute for Policy Studies (GRIPS) is developing the SciREX Policymaking Intelligent Assistance System (SPIAS). SPIAS searches the data of papers, patents, and press releases by the research subject, research institute, and researcher. The system can analyze the contribution of past allocations to the industry based on the number of papers published and patents obtained [8]. The Council for Science, Technology, and Innovation (CSTI) has collected and analyzed evidence on research, education, and fundraising status at research institutes. It has established the e-CSTI (Evidence Data Platform) to share this evidence with the government and research institution stakeholders. The e-CSTI provides an analysis of researcher attribution and output, allocation and output, and external fundraising productivity [9][10][11].

The previous studies analyzed research outputs focusing on research category, review section, research project, research institution, and researcher. However, these studies did not extend to detailed thematic analyses. Finding high-performing research topics will help in developing more detailed research strategies.

## 2 Data and Analysis Method

The information on grant amounts, keywords related to the research, and the number of achievements (including journal articles and presentations) for all projects was obtained from the database of KAKEN to support thematic studies. KAKEN is a public database that includes information on adopted projects, assessments, and research achievements from the KAKEN Program. The authors obtained data from this database on research projects conducted between FY 2015 and 2019 and analyzed the differences in performance between two universities in a previous study[12]. This study followed the analytical approach of the previous survey, obtained data from this database on research projects conducted between FY 2012 and FY 2021, and classified them into ten groups according to budget amounts. Table 1 presents the budget size of each group and examples of research categories. The range of amounts in each group is not equally spaced.

Table 1: Examples of research categories in each group

| Group | Range of Cost (Million yen) | Examples of Research Category |
|---|---|---|
| Ⅹ | 200 ~ 600 | Specially Promoted Research |
| Ⅸ | 100 ~ 200 | Scientific Research (S)<br>Transformative Research Areas (A) |
| Ⅷ | 60 ~ 100 | |
| Ⅶ | 40 ~ 60 | Scientific Research (A)<br>Transformative Research Areas (B)<br>Challenging Research (Pioneering) |
| Ⅵ | 20 ~ 40 | |
| Ⅴ | 10 ~ 20 | Scientific Research (B)<br>Challenging Research (Exploratory) |
| Ⅳ | 6 ~ 10 | |
| Ⅲ | 4 ~ 6 | Scientific Research (C)<br>Early-Career Scientists<br>Research Activity Start-up<br>JSPS Fellows |
| Ⅱ | 2 ~ 4 | |
| Ⅰ | 1 ~ 2 | |

To characterize the number of achievements according to the budget amount, the number of accomplishments per project and its conversion per million yen were obtained for each group (Figure 1, Figure 2). For each figure, the horizontal axis is the allocation amounts, and the vertical axis is the number of achievements. The research achievements here include international collaborative research, symposium sponsorships, journal articles, conference presentations, publications, and patents. The diamond marks indicate the median of the achievements. In addition, the vertical error bars indicate the first and third quartiles of the outcomes, and the horizontal error bars correspond to the range of the allocation amount for each group. The number of achievements per project increases with the allocation amount (Figure 1). This is because larger projects tend to have longer durations and include more researchers. Nonetheless, even if research costs doubled, the number of outcomes would not double immediately. The number of outcomes converted per million yen decreases as the budget increases (Figure 2).

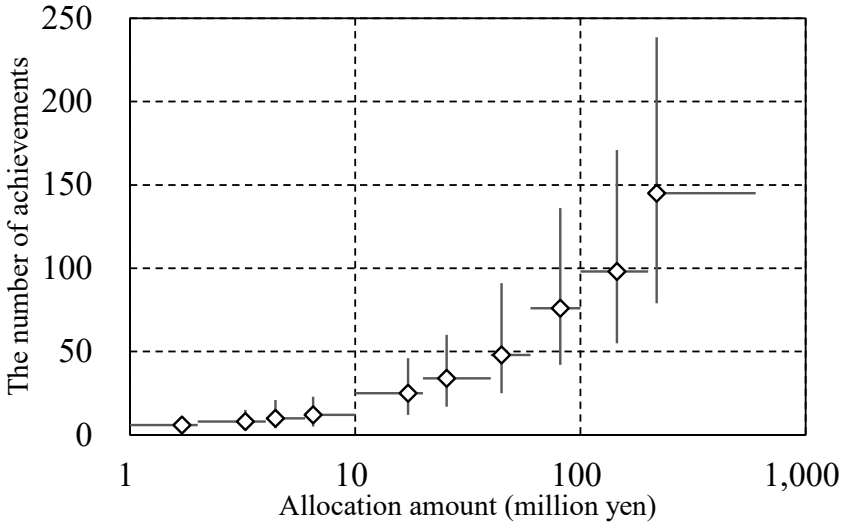


Figure 1: The number of achievements for each group

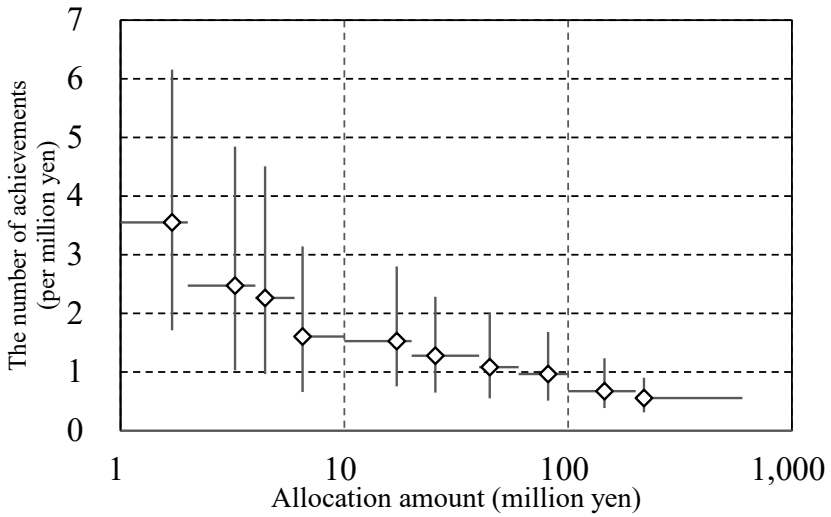


Figure 2: The number of achievements per million yen for each group

As Figures 1 and 2 illustrate, comparing projects of different sizes is not appropriate because the scale of the number of achievements varies with the project size. Therefore, 12 research institutes were focused on, and compared the number of research achievements in each group. As these institutions receive a large allocation amount and their research fields are diverse, they have many areas in common. Therefore, it will be easy to compare their research performance. Their achievements will serve as benchmarks for each other. Table 2 summarizes the number of projects, the number of keywords, the allocation amount, and the achievements of each institute from FY 2012 to 2021 for Group I to X. The meaning of the keywords will be explained later. The abbreviations were provided for each institute. For example, Ti stands for Tokyo Institute of Technology, and Os for Osaka University.

Table 2: A summary of the number of projects, keywords, achievements, and allocation amount of 12 institutes in each group

| Group | | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | Projects | 514 | 804 | 2,338 | 531 | 1,403 | 824 | 531 | 403 | 457 | 254 | 291 | 460 |
| | Keywords | 3,068 | 4,565 | 11,873 | 3,025 | 7,671 | 4,544 | 2,988 | 2,305 | 2,923 | 1,567 | 1,838 | 3,005 |
| | Allocation amount*1 | 853 | 1,356 | 3,899 | 873 | 2,343 | 1,389 | 892 | 687 | 763 | 425 | 482 | 750 |
| | Achievements | 4,087 | 7,089 | 17,332 | 4,701 | 11,011 | 6,404 | 4,311 | 3,478 | 3,548 | 1,947 | 2,323 | 3,617 |
| II | Projects | 1,861 | 2,784 | 5,738 | 1,847 | 3,810 | 2,908 | 2,076 | 1,018 | 1,423 | 1,063 | 1,035 | 1,188 |
| | Keywords | 9,890 | 13,717 | 25,844 | 9,870 | 18,713 | 13,861 | 11,138 | 5,752 | 8,071 | 6,309 | 5,451 | 7,595 |
| | Allocation amount*1 | 5,923 | 8,957 | 17,197 | 5,901 | 11,724 | 9,385 | 6,606 | 3,150 | 4,492 | 3,417 | 3,341 | 3,600 |
| | Achievements | 24,793 | 36,245 | 67,163 | 24,566 | 47,536 | 37,645 | 24,969 | 14,693 | 17,070 | 13,247 | 11,515 | 14,008 |
| III | Projects | 2,376 | 3,360 | 4,369 | 2,299 | 3,603 | 3,574 | 2,730 | 1,025 | 1,666 | 1,597 | 1,759 | 971 |
| | Keywords | 12,080 | 15,854 | 19,527 | 11,471 | 17,385 | 16,197 | 13,972 | 5,819 | 9,486 | 8,651 | 8,210 | 6,626 |
| | Allocation amount*1 | 10,876 | 15,248 | 19,644 | 10,446 | 16,398 | 16,191 | 12,467 | 4,710 | 7,603 | 7,321 | 7,976 | 4,406 |
| | Achievements | 39,738 | 52,183 | 66,877 | 38,354 | 58,840 | 56,421 | 41,335 | 19,075 | 26,535 | 26,989 | 24,181 | 17,114 |
| IV | Projects | 333 | 513 | 833 | 394 | 694 | 562 | 376 | 231 | 249 | 166 | 183 | 124 |
| | Keywords | 1,851 | 2,873 | 4,231 | 2,144 | 3,614 | 2,946 | 2,252 | 1,321 | 1,596 | 1,045 | 1,071 | 882 |
| | Allocation amount*1 | 2,387 | 3,590 | 6,021 | 2,821 | 4,939 | 4,041 | 2,665 | 1,622 | 1,771 | 1,196 | 1,342 | 868 |
| | Achievements | 5,390 | 8,326 | 13,447 | 6,289 | 11,533 | 9,907 | 6,646 | 4,158 | 4,520 | 3,370 | 2,829 | 2,226 |
| V | Projects | 961 | 1,335 | 2,033 | 934 | 1,670 | 1,257 | 912 | 533 | 607 | 519 | 412 | 383 |
| | Keywords | 5,592 | 7,365 | 10,714 | 5,410 | 9,172 | 6,983 | 5,618 | 3,257 | 3,793 | 3,205 | 2,507 | 2,840 |
| | Allocation amount*1 | 15,960 | 21,985 | 32,940 | 15,377 | 27,349 | 20,566 | 15,012 | 8,812 | 9,844 | 8,466 | 6,709 | 6,160 |
| | Achievements | 33,160 | 43,651 | 65,416 | 32,717 | 57,883 | 46,010 | 31,363 | 17,393 | 20,921 | 19,403 | 13,978 | 15,879 |
| VI | Projects | 150 | 237 | 530 | 168 | 333 | 243 | 173 | 107 | 103 | 54 | 89 | 65 |
| | Keywords | 1,098 | 1,642 | 3,293 | 1,237 | 2,360 | 1,635 | 1,275 | 754 | 791 | 405 | 631 | 462 |
| | Allocation amount*1 | 4,039 | 6,407 | 14,640 | 4,715 | 9,285 | 6,706 | 4,833 | 2,948 | 2,819 | 1,438 | 2,302 | 1,912 |
| | Achievements | 8,086 | 12,078 | 23,186 | 7,449 | 16,239 | 12,497 | 7,970 | 6,205 | 4,881 | 3,152 | 3,569 | 4,827 |
| VII | Projects | 171 | 311 | 687 | 215 | 430 | 296 | 218 | 153 | 113 | 57 | 86 | 79 |
| | Keywords | 1,246 | 2,096 | 4,092 | 1,529 | 2,906 | 1,930 | 1,559 | 1,097 | 843 | 429 | 571 | 602 |
| | Allocation amount*1 | 7,648 | 14,065 | 31,032 | 9,741 | 19,411 | 13,318 | 9,764 | 6,917 | 5,023 | 2,531 | 3,896 | 3,513 |
| | Achievements | 12,167 | 19,635 | 43,282 | 13,978 | 28,337 | 19,995 | 13,802 | 10,460 | 8,245 | 5,250 | 5,466 | 5,412 |
| VIII | Projects | 31 | 34 | 88 | 26 | 50 | 64 | 26 | 15 | 16 | 5 | 12 | 5 |
| | Keywords | 240 | 272 | 657 | 199 | 392 | 502 | 208 | 113 | 129 | 41 | 99 | 31 |
| | Allocation amount*1 | 2,447 | 2,732 | 7,111 | 2,199 | 4,091 | 5,252 | 2,044 | 1,252 | 1,224 | 408 | 1,035 | 403 |
| | Achievements | 3,419 | 4,994 | 9,089 | 3,099 | 6,128 | 6,937 | 4,078 | 1,057 | 1,863 | 630 | 849 | 710 |
| IX | Projects | 38 | 73 | 190 | 61 | 134 | 100 | 50 | 36 | 24 | 18 | 18 | 14 |
| | Keywords | 293 | 565 | 1,356 | 468 | 964 | 794 | 367 | 290 | 205 | 128 | 126 | 117 |
| | Allocation amount*1 | 5,604 | 10,632 | 28,573 | 9,003 | 20,574 | 14,523 | 7,403 | 5,264 | 3,541 | 2,405 | 2,808 | 2,074 |
| | Achievements | 5,952 | 8,391 | 27,340 | 7,875 | 21,753 | 12,026 | 7,231 | 6,564 | 3,204 | 3,810 | 2,287 | 1,898 |
| X | Projects | 13 | 47 | 178 | 31 | 68 | 55 | 27 | 30 | 7 | 7 | 14 | 10 |
| | Keywords | 96 | 363 | 1,174 | 261 | 530 | 427 | 222 | 229 | 57 | 55 | 108 | 94 |
| | Allocation amount*1 | 3,319 | 14,903 | 53,607 | 8,625 | 18,368 | 16,802 | 7,283 | 8,621 | 2,334 | 1,535 | 3,399 | 2,799 |
| | Achievements | 3,141 | 10,014 | 31,244 | 6,630 | 12,239 | 11,043 | 4,780 | 7,191 | 1,864 | 947 | 2,400 | 2,682 |
| Total | Projects | 6,448 | 9,498 | 16,984 | 6,506 | 12,195 | 9,883 | 7,119 | 3,551 | 4,665 | 3,740 | 3,899 | 3,299 |
| | Keywords | 35,454 | 49,312 | 82,761 | 35,614 | 63,707 | 49,819 | 39,599 | 20,937 | 27,894 | 21,835 | 20,612 | 22,254 |
| | Allocation amount*1 | 59,056 | 99,875 | 214,664 | 69,701 | 134,482 | 108,173 | 68,969 | 43,983 | 39,414 | 29,142 | 33,290 | 26,485 |
| | Achievements | 139,933 | 202,606 | 364,376 | 145,658 | 271,499 | 218,885 | 146,485 | 90,274 | 92,651 | 78,745 | 69,397 | 68,373 |

Hk: Hokkaido Univ. / Th: Tohoku Univ. / Tk: Tokyo Univ. / Ng: Nagoya Univ. / Kt: Kyoto Univ. / Os: Osaka Univ. / Ks: Kyushu Univ. / Ti: Tokyo Institute of Technology / Tb: Tsukuba Univ. / Kb: Kobe Univ. / Ko: Keio Univ. / Ws: Waseda Univ.

*1 Million yen

# 3 Result of Analysis and Discussion

Using Wilcoxon's rank-sum test (one-tailed, significance level of 5%), the achievements (per million yen) of the 12 institutions were compared for each group. Institutions with fewer than 20 research themes in a group were excluded from the comparison. Table 3 presents the results of comparing each institute's performance by the group. "○(×)" indicates that the institute's achievements displayed in the row are more(less) than those shown in the column, "△" is that there is no significant difference, and "—" means that there is no comparison. For Group VIII or over, it wasn't easy to obtain enough results because there were not many institutes receiving such a huge budget. Although these results are not simply comparable with previous studies that covered different periods, there was no significant discrepancy between their results [12]. However, the institute's performance differences are not apparent, as there are many tie-breaking results throughout all the tables.

Table 3: Comparison of each institute's achievements (by research projects)

| I | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | ＼ | × | △ | × | △ | △ | △ | △ | △ | △ | △ | △ | 0 | 9 | 2 |
| Th | ○ | ＼ | ○ | △ | ○ | ○ | ○ | △ | ○ | ○ | △ | △ | 7 | 4 | 0 |
| Tk | △ | × | ＼ | × | × | △ | △ | × | △ | △ | △ | △ | 0 | 7 | 4 |
| Ng | ○ | △ | ○ | ＼ | ○ | ○ | ○ | △ | ○ | ○ | △ | △ | 7 | 4 | 0 |
| Kt | △ | × | ○ | × | ＼ | △ | △ | △ | △ | △ | △ | △ | 1 | 8 | 2 |
| Os | △ | × | △ | × | △ | ＼ | △ | × | △ | △ | △ | △ | 0 | 8 | 3 |
| Ks | △ | × | △ | × | △ | △ | ＼ | △ | △ | △ | △ | △ | 0 | 9 | 2 |
| Ti | △ | △ | ○ | △ | △ | ○ | △ | ＼ | ○ | ○ | △ | △ | 4 | 7 | 0 |
| Tb | △ | × | △ | × | △ | △ | △ | × | ＼ | △ | △ | △ | 0 | 8 | 3 |
| Kb | △ | × | △ | × | △ | △ | △ | × | △ | ＼ | △ | △ | 0 | 8 | 3 |
| Ko | △ | △ | △ | △ | △ | △ | △ | △ | △ | △ | ＼ | △ | 0 | 11 | 0 |
| Ws | △ | △ | △ | △ | △ | △ | △ | △ | △ | △ | △ | ＼ | 0 | 11 | 0 |

| II | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | ＼ | ○ | ○ | △ | △ | ○ | ○ | × | ○ | △ | ○ | △ | 6 | 4 | 1 |
| Th | × | ＼ | △ | × | × | △ | ○ | × | △ | △ | ○ | △ | 2 | 5 | 4 |
| Tk | × | △ | ＼ | △ | × | ○ | ○ | × | ○ | △ | ○ | △ | 4 | 4 | 3 |
| Ng | △ | ○ | △ | ＼ | △ | ○ | ○ | × | ○ | △ | ○ | △ | 5 | 5 | 1 |
| Kt | △ | ○ | ○ | △ | ＼ | ○ | ○ | × | ○ | ○ | ○ | ○ | 8 | 2 | 1 |
| Os | × | △ | × | × | × | ＼ | △ | × | △ | △ | ○ | △ | 1 | 5 | 5 |
| Ks | × | × | × | × | × | △ | ＼ | × | △ | × | ○ | × | 1 | 2 | 8 |
| Ti | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ＼ | ○ | ○ | ○ | ○ | 11 | 0 | 0 |
| Tb | × | △ | × | × | × | △ | △ | × | ＼ | △ | ○ | × | 1 | 4 | 6 |
| Kb | △ | △ | △ | △ | × | △ | ○ | × | △ | ＼ | ○ | △ | 2 | 7 | 2 |
| Ko | × | × | × | × | × | × | × | × | × | × | ＼ | × | 0 | 0 | 11 |
| Ws | △ | △ | △ | △ | × | △ | ○ | × | ○ | △ | ○ | ＼ | 3 | 6 | 2 |

| III | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | ＼ | ○ | ○ | △ | △ | ○ | ○ | × | ○ | △ | ○ | × | 6 | 3 | 2 |
| Th | × | ＼ | △ | × | × | △ | △ | × | △ | × | ○ | × | 1 | 4 | 6 |
| Tk | × | △ | ＼ | × | × | △ | △ | × | △ | × | ○ | × | 1 | 4 | 6 |
| Ng | △ | ○ | ○ | ＼ | △ | ○ | ○ | × | ○ | △ | ○ | × | 6 | 3 | 2 |
| Kt | △ | ○ | ○ | △ | ＼ | ○ | ○ | × | ○ | △ | ○ | × | 6 | 3 | 2 |
| Os | × | △ | △ | × | × | ＼ | △ | × | △ | × | ○ | × | 1 | 4 | 6 |
| Ks | × | △ | △ | × | × | △ | ＼ | × | △ | × | ○ | × | 1 | 4 | 6 |
| Ti | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ＼ | ○ | ○ | ○ | △ | 10 | 1 | 0 |
| Tb | × | △ | △ | × | × | △ | △ | × | ＼ | × | ○ | × | 1 | 4 | 6 |
| Kb | △ | ○ | ○ | △ | △ | ○ | ○ | × | ○ | ＼ | ○ | × | 6 | 3 | 2 |
| Ko | × | × | × | × | × | × | × | × | × | × | ＼ | × | 0 | 0 | 11 |
| Ws | ○ | ○ | ○ | ○ | ○ | ○ | ○ | △ | ○ | ○ | ○ | ＼ | 10 | 1 | 0 |

| IV | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | ＼ | △ | △ | △ | △ | △ | △ | △ | △ | △ | △ | △ | 0 | 11 | 0 |
| Th | △ | ＼ | △ | △ | △ | △ | △ | △ | △ | △ | △ | △ | 0 | 11 | 0 |
| Tk | △ | △ | ＼ | △ | × | × | × | × | △ | × | △ | △ | 0 | 6 | 5 |
| Ng | △ | △ | △ | ＼ | × | × | × | × | △ | × | △ | △ | 0 | 6 | 5 |
| Kt | △ | △ | ○ | ○ | ＼ | △ | △ | △ | △ | △ | △ | △ | 2 | 9 | 0 |
| Os | △ | △ | ○ | ○ | △ | ＼ | △ | △ | ○ | △ | ○ | △ | 4 | 7 | 0 |
| Ks | △ | △ | ○ | ○ | △ | △ | ＼ | △ | △ | △ | △ | △ | 2 | 9 | 0 |
| Ti | △ | △ | ○ | ○ | △ | △ | △ | ＼ | △ | △ | △ | △ | 2 | 9 | 0 |
| Tb | △ | △ | △ | △ | △ | × | △ | △ | ＼ | × | △ | △ | 0 | 9 | 2 |
| Kb | △ | △ | ○ | ○ | △ | △ | △ | △ | ○ | ＼ | △ | △ | 3 | 8 | 0 |
| Ko | △ | △ | △ | △ | △ | × | △ | △ | △ | △ | ＼ | △ | 0 | 10 | 1 |
| Ws | △ | △ | △ | △ | △ | △ | △ | △ | △ | △ | △ | ＼ | 0 | 11 | 0 |

| V | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | ＼ | ○ | ○ | △ | △ | △ | △ | △ | △ | × | △ | × | 2 | 7 | 2 |
| Th | × | ＼ | △ | △ | △ | × | △ | △ | △ | × | △ | × | 0 | 7 | 4 |
| Tk | × | △ | ＼ | △ | △ | × | △ | △ | △ | × | △ | × | 0 | 7 | 4 |
| Ng | △ | △ | △ | ＼ | △ | × | △ | △ | △ | × | △ | × | 0 | 8 | 3 |
| Kt | △ | △ | △ | △ | ＼ | × | △ | △ | △ | × | △ | × | 0 | 8 | 3 |
| Os | △ | ○ | ○ | ○ | ○ | ＼ | ○ | ○ | △ | △ | △ | × | 6 | 4 | 1 |
| Ks | △ | △ | △ | △ | △ | × | ＼ | △ | △ | × | △ | × | 0 | 8 | 3 |
| Ti | △ | △ | △ | △ | △ | × | △ | ＼ | △ | × | △ | × | 0 | 8 | 3 |
| Tb | △ | △ | △ | △ | △ | △ | △ | △ | ＼ | × | △ | × | 0 | 9 | 2 |
| Kb | ○ | ○ | ○ | ○ | ○ | △ | ○ | ○ | ○ | ＼ | ○ | △ | 9 | 2 | 0 |
| Ko | △ | △ | △ | △ | △ | △ | △ | △ | △ | × | ＼ | × | 0 | 9 | 2 |
| Ws | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | △ | ○ | ＼ | 10 | 1 | 0 |

| VI | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | ＼ | △ | ○ | △ | △ | △ | △ | △ | △ | △ | △ | △ | 1 | 10 | 0 |
| Th | △ | ＼ | ○ | △ | △ | △ | △ | △ | △ | △ | △ | × | 1 | 9 | 1 |
| Tk | × | × | ＼ | △ | × | × | △ | × | × | × | △ | × | 0 | 3 | 8 |
| Ng | △ | △ | △ | ＼ | △ | △ | △ | △ | △ | × | △ | × | 0 | 9 | 2 |
| Kt | △ | △ | ○ | △ | ＼ | △ | △ | △ | △ | △ | △ | × | 1 | 9 | 1 |
| Os | △ | △ | ○ | △ | △ | ＼ | △ | △ | △ | △ | △ | △ | 1 | 10 | 0 |
| Ks | △ | △ | △ | △ | △ | △ | ＼ | △ | △ | × | △ | × | 0 | 9 | 2 |
| Ti | △ | △ | ○ | △ | △ | △ | △ | ＼ | △ | △ | △ | △ | 1 | 10 | 0 |
| Tb | △ | △ | ○ | △ | △ | △ | △ | △ | ＼ | △ | △ | △ | 1 | 10 | 0 |
| Kb | △ | △ | ○ | ○ | △ | ○ | △ | △ | △ | ＼ | ○ | △ | 4 | 7 | 0 |
| Ko | △ | △ | △ | △ | △ | △ | △ | △ | △ | × | ＼ | × | 0 | 9 | 2 |
| Ws | △ | ○ | ○ | ○ | ○ | △ | ○ | △ | △ | △ | ○ | ＼ | 6 | 5 | 0 |

| VII | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | ＼ | ○ | ○ | △ | ○ | △ | ○ | △ | △ | △ | △ | △ | 4 | 7 | 0 |
| Th | × | ＼ | △ | △ | △ | △ | △ | × | △ | × | △ | △ | 0 | 8 | 3 |
| Tk | × | △ | ＼ | △ | △ | × | △ | × | × | × | △ | × | 0 | 5 | 6 |
| Ng | △ | △ | △ | ＼ | △ | △ | △ | △ | △ | × | △ | △ | 0 | 10 | 1 |
| Kt | × | △ | △ | △ | ＼ | △ | △ | × | × | × | △ | △ | 0 | 7 | 4 |
| Os | △ | △ | ○ | △ | △ | ＼ | △ | △ | △ | × | △ | △ | 1 | 9 | 1 |
| Ks | × | △ | △ | △ | △ | △ | ＼ | × | △ | × | △ | △ | 0 | 8 | 3 |
| Ti | △ | ○ | ○ | △ | ○ | △ | ○ | ＼ | △ | △ | △ | △ | 4 | 7 | 0 |
| Tb | △ | △ | ○ | △ | ○ | △ | △ | △ | ＼ | △ | △ | △ | 2 | 9 | 0 |
| Kb | △ | ○ | ○ | ○ | ○ | ○ | ○ | △ | △ | ＼ | ○ | △ | 7 | 4 | 0 |
| Ko | △ | △ | △ | △ | △ | △ | △ | △ | △ | × | ＼ | △ | 0 | 10 | 1 |
| Ws | △ | △ | ○ | △ | △ | △ | △ | △ | △ | △ | △ | ＼ | 1 | 10 | 0 |

| VIII | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | ＼ | △ | △ | △ | △ | △ | △ | − | − | − | − | − | 0 | 6 | 0 |
| Th | △ | ＼ | △ | △ | △ | △ | △ | − | − | − | − | − | 0 | 6 | 0 |
| Tk | △ | △ | ＼ | △ | △ | △ | △ | − | − | − | − | − | 0 | 6 | 0 |
| Ng | △ | △ | △ | ＼ | △ | △ | △ | − | − | − | − | − | 0 | 6 | 0 |
| Kt | △ | △ | △ | △ | ＼ | △ | △ | − | − | − | − | − | 0 | 6 | 0 |
| Os | △ | △ | △ | △ | △ | ＼ | △ | − | − | − | − | − | 0 | 6 | 0 |
| Ks | △ | △ | △ | △ | △ | △ | ＼ | − | − | − | − | − | 0 | 6 | 0 |
| Ti | − | − | − | − | − | − | − | ＼ | − | − | − | − | 0 | 0 | 0 |
| Tb | − | − | − | − | − | − | − | − | ＼ | − | − | − | 0 | 0 | 0 |
| Kb | − | − | − | − | − | − | − | − | − | ＼ | − | − | 0 | 0 | 0 |
| Ko | − | − | − | − | − | − | − | − | − | − | ＼ | − | 0 | 0 | 0 |
| Ws | − | − | − | − | − | − | − | − | − | − | − | ＼ | 0 | 0 | 0 |

| IX | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | ＼ | ○ | ○ | ○ | △ | ○ | △ | △ | △ | − | − | − | 4 | 4 | 0 |
| Th | × | ＼ | △ | △ | △ | △ | × | × | △ | − | − | − | 0 | 5 | 3 |
| Tk | × | △ | ＼ | △ | △ | △ | △ | △ | △ | − | − | − | 0 | 7 | 1 |
| Ng | × | △ | △ | ＼ | △ | △ | △ | △ | △ | − | − | − | 0 | 7 | 1 |
| Kt | △ | △ | △ | △ | ＼ | △ | △ | △ | △ | − | − | − | 0 | 8 | 0 |
| Os | × | △ | △ | △ | △ | ＼ | △ | × | △ | − | − | − | 0 | 6 | 2 |
| Ks | △ | ○ | △ | △ | △ | △ | ＼ | △ | △ | − | − | − | 1 | 7 | 0 |
| Ti | △ | ○ | △ | △ | △ | ○ | △ | ＼ | △ | − | − | − | 2 | 6 | 0 |
| Tb | △ | △ | △ | △ | △ | △ | △ | △ | ＼ | − | − | − | 0 | 8 | 0 |
| Kb | − | − | − | − | − | − | − | − | − | ＼ | − | − | 0 | 0 | 0 |
| Ko | − | − | − | − | − | − | − | − | − | − | ＼ | − | 0 | 0 | 0 |
| Ws | − | − | − | − | − | − | − | − | − | − | − | ＼ | 0 | 0 | 0 |

| X | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | ＼ | − | − | − | − | − | − | − | − | − | − | − | 0 | 0 | 0 |
| Th | − | ＼ | △ | △ | △ | △ | △ | △ | − | − | − | − | 0 | 6 | 0 |
| Tk | − | △ | ＼ | △ | △ | △ | △ | × | − | − | − | − | 0 | 5 | 1 |
| Ng | − | △ | △ | ＼ | △ | △ | △ | △ | − | − | − | − | 0 | 6 | 0 |
| Kt | − | △ | △ | △ | ＼ | △ | △ | × | − | − | − | − | 0 | 5 | 1 |
| Os | − | △ | △ | △ | △ | ＼ | △ | × | − | − | − | − | 0 | 5 | 1 |
| Ks | − | △ | △ | △ | △ | △ | ＼ | △ | − | − | − | − | 0 | 6 | 0 |
| Ti | − | △ | ○ | △ | ○ | ○ | △ | ＼ | − | − | − | − | 3 | 3 | 0 |
| Tb | − | − | − | − | − | − | − | − | ＼ | − | − | − | 0 | 0 | 0 |
| Kb | − | − | − | − | − | − | − | − | − | ＼ | − | − | 0 | 0 | 0 |
| Ko | − | − | − | − | − | − | − | − | − | − | ＼ | − | 0 | 0 | 0 |
| Ws | − | − | − | − | − | − | − | − | − | − | − | ＼ | 0 | 0 | 0 |

To clarify the differences in performance, the authors decided to recount the results by keywords included in each project. Typically, a single project comprises several keywords related to its content. The principal investigator of each project devises and assigns these keywords. Since a list of candidate keywords is not prepared, there is a problem with orthographical variants. This problem needs to be resolved in the future. In this study, the allocation amount was prorated according to the number of keywords and their order of appearance. The number of keywords varies with each project. If many words are attached to a project, the allocation per word will be smaller. In addition, the importance of the first word will differ from the last. Figure 3 illustrates the percentage of total projects that comprise a particular ranked keyword. This figure includes all projects funded from FY 2012 to 2021. This graph provides the importance of the keywords in each rank. Naturally, all projects included the first keyword. For example, approximately 30% of the projects had the 11th keyword. However, the other 70% of the projects did not need the 11th keyword. Therefore, for a maximum of 10 keywords per project, the budget amount and number of results were allocated according to the relative frequencies, as illustrated in Figure 3.

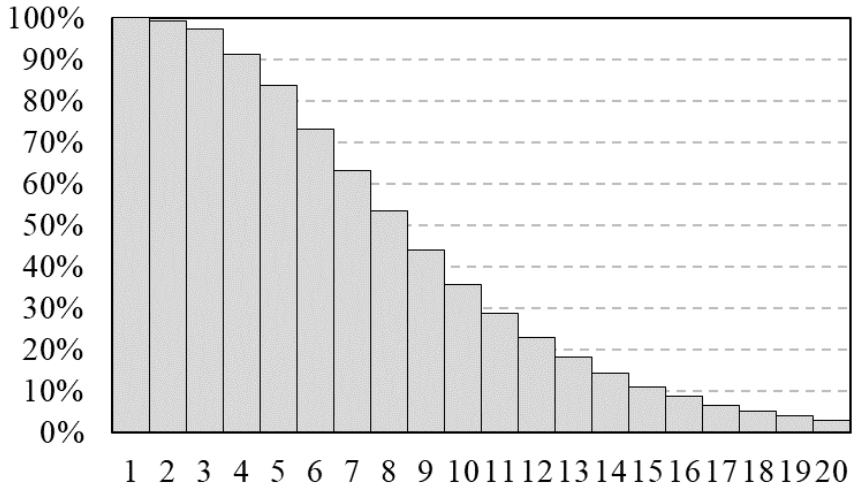


Figure 3: The percentage of total projects comprising a particular ranked keyword

Table 4 presents an example. Since the project listed in Table 4 includes five keywords, the amounts for each year and the number of achievements are respectively allocated to each keyword proportionally by the ratio calculated from the relative frequencies in Figure 3. This study calculated this for all the projects and thereafter summed them up to obtain the performance for each keyword.

Table 4: How to distribute the amount for each keyword

| Project | Budget Amount | | Achievments |
|---|---|---|---|
| | FY2018 | FY2019 | |
| Novel spin filter function using graphene nanoribbon | 5,200,000 | 1,300,000 | 25 |

| Keywords | Allocation Ratio | Budget Amount | | Achievments |
|---|---|---|---|---|
| | | FY2018 | FY2019 | |
| Graphene | 21% | 1,092,000 | 273,000 | 5.25 |
| Nanoribbon | 21% | 1,092,000 | 273,000 | 5.25 |
| Topology | 21% | 1,092,000 | 273,000 | 5.25 |
| Spin filter | 19% | 988,000 | 247,000 | 4.75 |
| Spintronics | 18% | 936,000 | 234,000 | 4.50 |
| Total | 100% | 5,200,000 | 1,300,000 | 25 |

When recounting the results by keyword, this study corrected differences in wording and attempted to unify keywords with different terminology that had the same meaning. Specifically, the authors modified the words according to the following criteria:
(1) Convert full-width characters to half-width characters
(2) Delete hyphens
(3) Convert plural words to singular
(4) Remove redundant words
However, the above modifications are insufficient to unify all keywords with the same meaning. This problem will be discussed later.

The top ten most frequent keywords in Groups III, V, and VII, which have many projects, are shown for each institute (Table 5). While some keywords, such as “Machine learning,” are found in all institutes, others, such as “Primates” (Kt) and “Pancreatic cancer” (Ks), are found in areas where certain institutes have strengths.

Table 6 compares keyword-based results (per million yen) for each institution. All groups had more significantly different combinations than in Table 3. Furthermore, compared with Table 3, there was no reversal of large and small results. The method of comparison by keyword can better indicate each institute’s performance differences.

To clarify the cause of this difference, the two institutes’ achievements were compared for common and unique keywords separately. Table 7 presents the number of keywords obtained from Th and Kt projects in Group II. Kt has more projects and, therefore, more keywords. There are 2,787 words common to both, accounting for about 20% of the total number of keywords in Th. Figures 4 and 5 illustrate the histograms for common and unique keywords, classified by the number of results per million yen. Each figure’s diamond marks indicate the achievements’ median, and the horizontal error bar indicates the first and third quartiles. The vertical axis presents a percentage of the total number. The black bins indicate Th, and the gray is Kt. As illustrated in Figure 4, both are similar. Statistically, there were no significant differences between the two institutes for common keywords. However, comparing the number of achievements obtained from studies on unique keywords reveals that Kt results exceeded those of Th (Figure 5).

Table 5: The top ten most frequent keywords in Groups III, V, and VII

| Hk | GroupIII | | GroupV | | GroupVII | |
|---|---|---|---|---|---|---|
| 1 | Cancer | 35 | Genome | 16 | Nanomaterial | 4 |
| 2 | Cytokine | 22 | Climate change | 14 | Birth cohort | 4 |
| 3 | Innate immunity | 22 | Signal transduction | 13 | Environmental chemicals | 4 |
| 4 | Virus | 21 | Virus | 12 | Maternal and child health | 3 |
| 5 | Macrophage | 20 | Nanomaterial | 11 | Defatigation | 3 |
| 6 | NMR | 20 | Imaging | 11 | Virus | 3 |
| 7 | Biomarker | 19 | Fuel cell | 10 | Nanoparticle | 3 |
| 8 | Climate change | 18 | Plant | 10 | Reaction mechanism | 3 |
| 9 | Neuroscience | 17 | Infection | 10 | Plasmon | 3 |
| 10 | Insect | 17 | Nanoparticle | 9 | Imaging | 3 |

| Ks | GroupIII | | GroupV | | GroupVII | |
|---|---|---|---|---|---|---|
| 1 | Pancreatic cancer | 56 | Mitochondria | 15 | Regenerative medicine | 6 |
| 2 | Mitochondria | 41 | Pancreatic cancer | 15 | Cell tissue | 5 |
| 3 | MRI | 37 | Signal transduction | 13 | Plasma | 5 |
| 4 | Macrophage | 33 | Biomarker | 11 | CRISPR | 5 |
| 5 | Oxidative stress | 28 | Nanomaterial | 11 | Gene | 5 |
| 6 | Microglia | 25 | Biotechnology | 11 | Cancer | 4 |
| 7 | Autophagy | 25 | Cell tissue | 11 | Inflammation | 4 |
| 8 | Signal transduction | 24 | Crystal growth | 11 | Machine learning | 4 |
| 9 | Pancreatic stellate cells | 23 | Nanoparticle | 10 | Climate change | 4 |
| 10 | Inflammation | 23 | Electronic microscope | 10 | Deoxyribonucleic acid methylation | 4 |

| Th | GroupIII | | GroupV | | GroupVII | |
|---|---|---|---|---|---|---|
| 1 | Oxidative stress | 45 | Inflammation | 18 | Crystal growth | 7 |
| 2 | MRI | 43 | Nanoparticle | 18 | Nanomaterial | 7 |
| 3 | Diabetes | 35 | Cell tissue | 17 | Graphene | 6 |
| 4 | Mitochondria | 34 | Genome | 17 | Recycling | 6 |
| 5 | Inflammation | 34 | Spintronics | 16 | Asymmetric synthesis | 6 |
| 6 | Cancer | 30 | Great East Japan Earthquake | 14 | Norovirus | 5 |
| 7 | Great East Japan Earthquake | 29 | Oxidative stress | 14 | Biomolecules | 5 |
| 8 | Gene | 28 | Transcription factor | 14 | Semiconductor properties | 5 |
| 9 | nrf2 | 27 | Cancer | 14 | Spintronics | 5 |
| 10 | Implant | 25 | PET | 14 | Semiconductor | 5 |

| Ti | GroupIII | | GroupV | | GroupVII | |
|---|---|---|---|---|---|---|
| 1 | Machine learning | 16 | Catalyst | 11 | Thin-film | 5 |
| 2 | Autophagy | 13 | Machine learning | 10 | Magnetism | 4 |
| 3 | Crystal structure analysis | 12 | Evolution | 10 | Organic chemistry | 4 |
| 4 | Dendrimer | 11 | Deep learning | 10 | Chaperone | 4 |
| 5 | Photocatalyst | 11 | Peptide | 9 | 1-axis active control | 4 |
| 6 | Nanoparticle | 10 | Nanomaterial | 9 | Energy conversion | 3 |
| 7 | Thin-film | 10 | Synthetic chemistry | 9 | Synthetic chemistry | 3 |
| 8 | Electrochemistry | 10 | Nanobiology | 8 | Ion conductor | 3 |
| 9 | Nanomaterial | 9 | Nanoparticle | 8 | Ribosome | 3 |
| 10 | Crystal structure | 9 | Solar cell | 8 | Translation | 3 |

| Tk | GroupIII | | GroupV | | GroupVII | |
|---|---|---|---|---|---|---|
| 1 | Signal transduction | 64 | Signal transduction | 39 | Signal transduction | 17 |
| 2 | Machine learning | 48 | Gene | 31 | Gene | 11 |
| 3 | Epigenetics | 45 | Genome | 30 | Climate change | 10 |
| 4 | Cancer | 42 | Epigenetics | 24 | Cancer | 9 |
| 5 | Neuroscience | 42 | Imaging | 21 | Cranial nerve | 9 |
| 6 | Biomarker | 38 | Simulation | 20 | Machine learning | 9 |
| 7 | Transcription factor | 36 | Plant | 20 | Epigenetics | 9 |
| 8 | Inflammation | 36 | Cancer | 19 | Strongly correlated electron system | 9 |
| 9 | iPS cells | 35 | Aging | 18 | Transcription factor | 9 |
| 10 | Simulation | 34 | Machine learning | 17 | Elementary particle experiment | 9 |

| Tb | GroupIII | | GroupV | | GroupVII | |
|---|---|---|---|---|---|---|
| 1 | Machine learning | 18 | Obesity | 14 | Exercise | 4 |
| 2 | Signal transduction | 15 | Lifestyle disease | 14 | Locomotion Interface | 4 |
| 3 | Lifestyle disease | 14 | Transcription factor | 13 | Genome | 4 |
| 4 | Transcription factor | 14 | Neuroscience | 10 | Virtual reality | 4 |
| 5 | Sleep | 14 | Inflammation | 9 | Cognitive function | 3 |
| 6 | Senior citizen | 13 | Machine learning | 9 | F-box protein | 3 |
| 7 | Simulation | 12 | Fatty hepatitis | 8 | Conservation science | 3 |
| 8 | Neuroscience | 12 | Remote sensing | 8 | Mutation | 3 |
| 9 | Radiotherapy | 12 | Gene | 8 | Environment | 3 |
| 10 | Developmental disorders | 12 | Genome | 8 | Folkloristics | 3 |

| Ng | GroupIII | | GroupV | | GroupVII | |
|---|---|---|---|---|---|---|
| 1 | Biomarker | 29 | Signal transduction | 23 | Plant | 6 |
| 2 | Inflammation | 29 | Plant | 20 | Machine learning | 6 |
| 3 | Macrophage | 24 | Developmental differentiation | 16 | Signal transduction | 6 |
| 4 | Signal transduction | 23 | Rice | 15 | Simulation | 6 |
| 5 | Mesenchymal stem cell | 19 | Neuroscience | 14 | Electronic microscope | 5 |
| 6 | Exosome | 19 | Simulation | 12 | Crystal growth | 5 |
| 7 | Arabidopsis thaliana | 19 | Mouse | 11 | Neuroscience | 5 |
| 8 | MRI | 18 | Arabidopsis thaliana | 11 | Biomaterial | 4 |
| 9 | Machine learning | 16 | Imaging | 11 | Synthetic chemistry | 4 |
| 10 | Plant | 16 | Evolution | 10 | Turbulence | 4 |

| Kb | GroupIII | | GroupV | | GroupVII | |
|---|---|---|---|---|---|---|
| 1 | Diabetes | 31 | Signal transduction | 10 | Science education | 3 |
| 2 | Inflammation | 23 | Plant | 9 | Elementary particle experiment | 3 |
| 3 | Biomarker | 21 | Science education | 9 | Electronic excited state | 2 |
| 4 | Apoptosis | 20 | Cancer | 7 | Lifetime improvement | 2 |
| 5 | Radiotherapy | 19 | Simulation | 7 | Model experiment | 2 |
| 6 | Signal transduction | 17 | Rice | 7 | Liquefaction | 2 |
| 7 | Metabolomic analysis | 17 | Genome | 7 | Election governance | 2 |
| 8 | microRNA | 16 | Photosynthesis | 6 | Administration | 2 |
| 9 | Arthrorheumatism | 15 | Exercise | 6 | Election management | 2 |
| 10 | Cancer | 15 | Medical welfare | 6 | Time zone | 2 |

| Kt | GroupIII | | GroupV | | GroupVII | |
|---|---|---|---|---|---|---|
| 1 | iPS cells | 118 | iPS cells | 33 | Evolution | 9 |
| 2 | MRI | 48 | Genome | 20 | iPS cells | 8 |
| 3 | Signal transduction | 41 | Neuroscience | 20 | Machine learning | 6 |
| 4 | Diabetes | 36 | Signal transduction | 20 | Oxide | 5 |
| 5 | Simulation | 34 | Evolution | 20 | Climate change | 5 |
| 6 | Imaging | 30 | Primates | 19 | Catalyst | 5 |
| 7 | Primates | 29 | Stem cell | 19 | Genome | 5 |
| 8 | Regenerative Medicine | 28 | Transcription factor | 18 | Asia | 5 |
| 9 | Transcription factor | 27 | Imaging | 18 | Signal transduction | 5 |
| 10 | Cancer | 27 | Cancer | 16 | Epigenetics | 5 |

| Ko | GroupIII | | GroupV | | GroupVII | |
|---|---|---|---|---|---|---|
| 1 | iPS cells | 55 | Intestinal bacteria | 13 | Developmental differentiation | 4 |
| 2 | Regenerative Medicine | 41 | Regenerative medicine | 11 | Inflammation | 4 |
| 3 | Stem cell | 31 | Gene | 11 | Machine learning | 4 |
| 4 | Neural stem cell | 28 | Metabolome | 9 | Regenerative Medicine | 3 |
| 5 | Mesenchymal stem cell | 26 | Cancer | 9 | Cancer | 3 |
| 6 | Intestinal bacteria | 26 | Immunology | 8 | Neuroscience | 3 |
| 7 | Cancer | 24 | Developmental differentiation | 8 | Molecular dynamics simulation | 3 |
| 8 | Retina | 21 | Stem cell | 8 | Stem cell | 3 |
| 9 | Hypertension | 21 | Regenerative Medicine | 8 | Brain function connection | 2 |
| 10 | Biomarker | 20 | Database | 7 | Social cognition | 2 |

| Os | GroupIII | | GroupV | | GroupVII | |
|---|---|---|---|---|---|---|
| 1 | Autophagy | 55 | Cancer | 19 | Genome editing | 7 |
| 2 | Biomarker | 47 | Epigenetics | 19 | Electronic microscope | 6 |
| 3 | Diabetes | 40 | Autophagy | 16 | Immunity | 6 |
| 4 | Mitochondria | 38 | Inflammation | 15 | DNA | 5 |
| 5 | Inflammation | 35 | Mitochondria | 15 | C-H bond activation | 5 |
| 6 | Heart failure | 33 | iPS cells | 15 | CRISPR | 5 |
| 7 | Cancer stem cells | 33 | Simulation | 15 | Catalyst | 5 |
| 8 | Exosome | 32 | Nanoparticle | 14 | Glycan | 5 |
| 9 | Signal transduction | 30 | Infection | 14 | Chromosome | 5 |
| 10 | iPS cells | 30 | Regenerative Medicine | 14 | Biomarker | 5 |

| Ws | GroupIII | | GroupV | | GroupVII | |
|---|---|---|---|---|---|---|
| 1 | Machine learning | 13 | East Asia | 9 | Accelerator | 3 |
| 2 | Media | 12 | Economic policy | 6 | Metal oxide | 3 |
| 3 | Network | 10 | Media | 6 | Cancer | 3 |
| 4 | Optimization | 10 | Network | 6 | Quantum beam | 3 |
| 5 | Visualization | 9 | Social media | 5 | Electrical equipment engineering | 3 |
| 6 | China | 8 | Globalization | 5 | Superconducting material | 3 |
| 7 | Second Language Acquisition | 8 | Southeast Asia | 4 | Ribosome profiling | 2 |
| 8 | Corporate governance | 8 | Multinational corporation | 4 | Democracy | 2 |
| 9 | Japan | 7 | Machine learning | 4 | EU | 2 |
| 10 | Japanese modern literature | 7 | Cell tissue | 4 | Global warming | 2 |

Table 6: Comparison of each institute's achievements (by all keywords)

| I | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | | × | △ | × | × | △ | △ | × | ○ | ○ | △ | △ | 2 | 5 | 4 |
| Th | ○ | | ○ | △ | ○ | ○ | ○ | △ | ○ | ○ | ○ | ○ | 9 | 2 | 0 |
| Tk | △ | × | | × | × | △ | × | × | △ | ○ | × | △ | 1 | 4 | 6 |
| Ng | ○ | △ | ○ | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | 10 | 1 | 0 |
| Kt | ○ | × | ○ | × | | ○ | △ | × | ○ | ○ | △ | ○ | 6 | 2 | 3 |
| Os | △ | × | △ | × | × | | △ | × | ○ | ○ | △ | △ | 2 | 5 | 4 |
| Ks | △ | × | ○ | × | △ | △ | | × | ○ | ○ | △ | △ | 3 | 5 | 3 |
| Ti | ○ | △ | ○ | × | ○ | ○ | ○ | | ○ | ○ | ○ | ○ | 9 | 1 | 1 |
| Tb | × | × | △ | × | × | × | × | × | | △ | × | △ | 0 | 3 | 8 |
| Kb | × | × | × | × | × | × | × | × | △ | | × | × | 0 | 1 | 10 |
| Ko | △ | × | ○ | × | △ | △ | △ | × | ○ | ○ | | △ | 3 | 5 | 3 |
| Ws | △ | × | △ | × | × | △ | △ | × | △ | ○ | △ | | 1 | 6 | 4 |

| II | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | | ○ | ○ | △ | × | ○ | ○ | × | ○ | ○ | ○ | ○ | 8 | 1 | 2 |
| Th | × | | × | × | × | △ | ○ | × | ○ | ○ | ○ | ○ | 5 | 1 | 5 |
| Tk | × | ○ | | × | × | △ | ○ | × | ○ | ○ | ○ | ○ | 6 | 1 | 4 |
| Ng | △ | ○ | ○ | | × | ○ | ○ | × | ○ | ○ | ○ | ○ | 8 | 1 | 2 |
| Kt | ○ | ○ | ○ | ○ | | ○ | ○ | × | ○ | ○ | ○ | ○ | 10 | 0 | 1 |
| Os | × | △ | △ | × | × | | ○ | × | ○ | ○ | ○ | ○ | 5 | 2 | 4 |
| Ks | × | × | × | × | × | × | | × | ○ | △ | ○ | △ | 2 | 2 | 7 |
| Ti | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | ○ | ○ | ○ | 11 | 0 | 0 |
| Tb | × | × | × | × | × | × | × | × | | × | △ | × | 0 | 1 | 10 |
| Kb | × | × | × | × | × | × | △ | × | ○ | | ○ | △ | 2 | 2 | 7 |
| Ko | × | × | × | × | × | × | × | × | △ | × | | × | 0 | 1 | 10 |
| Ws | × | × | × | × | × | × | △ | × | ○ | △ | ○ | | 2 | 2 | 7 |

| III | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | | ○ | ○ | × | △ | ○ | ○ | × | ○ | × | ○ | × | 6 | 1 | 4 |
| Th | × | | ○ | × | × | △ | ○ | × | △ | × | ○ | × | 3 | 2 | 6 |
| Tk | × | × | | × | × | × | ○ | × | △ | × | ○ | × | 2 | 1 | 8 |
| Ng | ○ | ○ | ○ | | ○ | ○ | ○ | × | ○ | △ | ○ | × | 8 | 1 | 2 |
| Kt | △ | ○ | ○ | × | | ○ | ○ | × | ○ | × | ○ | × | 6 | 1 | 4 |
| Os | × | △ | ○ | × | × | | ○ | × | ○ | × | ○ | × | 4 | 1 | 6 |
| Ks | × | × | × | × | × | × | | × | × | × | ○ | × | 1 | 0 | 10 |
| Ti | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | ○ | ○ | △ | 10 | 1 | 0 |
| Tb | × | △ | △ | × | × | × | ○ | × | | × | ○ | × | 2 | 2 | 7 |
| Kb | ○ | ○ | ○ | △ | ○ | ○ | ○ | × | ○ | | ○ | × | 8 | 1 | 2 |
| Ko | × | × | × | × | × | × | × | × | × | × | | × | 0 | 0 | 11 |
| Ws | ○ | ○ | ○ | ○ | ○ | ○ | ○ | △ | ○ | ○ | ○ | | 10 | 1 | 0 |

| IV | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | | △ | ○ | ○ | △ | × | × | × | △ | × | ○ | △ | 3 | 4 | 4 |
| Th | △ | | △ | △ | × | × | × | × | △ | × | △ | △ | 0 | 6 | 5 |
| Tk | × | △ | | △ | × | × | × | × | △ | × | △ | △ | 0 | 5 | 6 |
| Ng | × | △ | △ | | × | × | × | × | △ | × | △ | △ | 0 | 5 | 6 |
| Kt | △ | ○ | ○ | ○ | | × | △ | × | ○ | × | ○ | △ | 5 | 3 | 3 |
| Os | ○ | ○ | ○ | ○ | ○ | | △ | △ | ○ | △ | ○ | ○ | 8 | 3 | 0 |
| Ks | ○ | ○ | ○ | ○ | △ | △ | | △ | ○ | × | ○ | △ | 6 | 4 | 1 |
| Ti | ○ | ○ | ○ | ○ | ○ | △ | △ | | ○ | △ | ○ | ○ | 8 | 3 | 0 |
| Tb | △ | △ | △ | △ | × | × | × | × | | × | △ | △ | 0 | 6 | 5 |
| Kb | ○ | ○ | ○ | ○ | ○ | △ | ○ | △ | ○ | | ○ | ○ | 9 | 2 | 0 |
| Ko | × | △ | △ | △ | × | × | × | × | △ | × | | × | 0 | 4 | 7 |
| Ws | △ | △ | △ | △ | △ | × | △ | × | △ | × | ○ | | 1 | 7 | 3 |

| V | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | | ○ | ○ | × | △ | × | ○ | ○ | △ | × | × | × | 4 | 2 | 5 |
| Th | × | | × | × | × | × | △ | ○ | × | × | × | × | 1 | 1 | 9 |
| Tk | × | ○ | | × | × | × | △ | ○ | × | × | × | × | 2 | 1 | 8 |
| Ng | ○ | ○ | ○ | | ○ | × | ○ | ○ | ○ | × | △ | × | 7 | 1 | 3 |
| Kt | △ | ○ | ○ | × | | × | ○ | ○ | △ | × | × | × | 4 | 2 | 5 |
| Os | ○ | ○ | ○ | ○ | ○ | | ○ | ○ | ○ | △ | ○ | × | 9 | 1 | 1 |
| Ks | × | △ | △ | × | × | × | | ○ | × | × | × | × | 1 | 2 | 8 |
| Ti | × | × | × | × | × | × | × | | × | × | × | × | 0 | 0 | 11 |
| Tb | △ | ○ | ○ | × | △ | × | ○ | ○ | | × | △ | × | 4 | 3 | 4 |
| Kb | ○ | ○ | ○ | ○ | ○ | △ | ○ | ○ | ○ | | ○ | × | 9 | 1 | 1 |
| Ko | ○ | ○ | ○ | △ | ○ | × | ○ | ○ | △ | × | | × | 6 | 2 | 3 |
| Ws | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | 11 | 0 | 0 |

| VI | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | | ○ | ○ | ○ | ○ | △ | ○ | △ | ○ | × | ○ | × | 7 | 2 | 2 |
| Th | × | | ○ | ○ | △ | △ | ○ | △ | △ | × | ○ | × | 4 | 4 | 3 |
| Tk | × | × | | △ | × | × | △ | × | × | × | △ | × | 0 | 3 | 8 |
| Ng | × | × | △ | | × | × | △ | × | △ | × | △ | × | 0 | 4 | 7 |
| Kt | × | △ | ○ | ○ | | △ | ○ | △ | △ | × | ○ | × | 4 | 4 | 3 |
| Os | △ | △ | ○ | ○ | △ | | ○ | △ | △ | × | ○ | × | 4 | 5 | 2 |
| Ks | × | × | △ | △ | × | × | | × | × | △ | × | △ | 0 | 3 | 8 |
| Ti | △ | △ | ○ | ○ | △ | △ | ○ | | △ | × | ○ | × | 4 | 5 | 2 |
| Tb | × | △ | ○ | △ | △ | △ | ○ | △ | | × | ○ | × | 3 | 5 | 3 |
| Kb | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | △ | 10 | 1 | 0 |
| Ko | × | × | △ | △ | × | × | △ | × | × | × | | × | 0 | 3 | 8 |
| Ws | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | △ | ○ | | 10 | 1 | 0 |

| VII | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | | ○ | ○ | ○ | ○ | ○ | ○ | △ | △ | ○ | △ | 7 | 4 | 0 | |
| Th | × | | △ | × | △ | × | △ | × | × | × | △ | × | 0 | 4 | 7 |
| Tk | × | △ | | × | × | × | △ | × | × | × | △ | × | 0 | 3 | 8 |
| Ng | × | ○ | ○ | | ○ | △ | ○ | × | × | × | ○ | △ | 5 | 2 | 4 |
| Kt | × | △ | ○ | × | | × | △ | × | × | × | △ | × | 1 | 3 | 7 |
| Os | × | ○ | ○ | △ | ○ | | ○ | × | × | × | ○ | △ | 5 | 2 | 4 |
| Ks | × | △ | △ | × | △ | × | | × | × | × | △ | × | 0 | 4 | 7 |
| Ti | △ | ○ | ○ | ○ | ○ | ○ | ○ | | △ | △ | ○ | △ | 7 | 4 | 0 |
| Tb | △ | ○ | ○ | ○ | ○ | ○ | ○ | △ | | △ | ○ | ○ | 8 | 3 | 0 |
| Kb | △ | ○ | ○ | ○ | ○ | ○ | ○ | △ | △ | | ○ | ○ | 8 | 3 | 0 |
| Ko | × | △ | △ | × | △ | × | △ | × | × | × | | × | 0 | 4 | 7 |
| Ws | △ | ○ | ○ | △ | ○ | △ | ○ | △ | × | × | ○ | | 5 | 4 | 2 |

| VIII | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | | △ | ○ | × | ○ | △ | △ | ○ | △ | △ | ○ | × | 4 | 5 | 2 |
| Th | △ | | △ | × | △ | △ | △ | ○ | × | △ | ○ | × | 2 | 6 | 3 |
| Tk | × | △ | | × | △ | × | × | ○ | × | △ | ○ | × | 2 | 3 | 6 |
| Ng | ○ | ○ | ○ | | ○ | ○ | ○ | ○ | △ | △ | ○ | × | 8 | 2 | 1 |
| Kt | × | △ | △ | × | | × | × | △ | × | △ | △ | × | 0 | 5 | 6 |
| Os | △ | △ | ○ | × | ○ | | △ | ○ | × | △ | ○ | × | 4 | 4 | 3 |
| Ks | △ | △ | ○ | × | ○ | △ | | ○ | △ | △ | ○ | × | 4 | 5 | 2 |
| Ti | × | × | × | × | △ | × | × | | × | × | △ | × | 0 | 2 | 9 |
| Tb | △ | ○ | ○ | △ | ○ | ○ | △ | ○ | | △ | ○ | × | 6 | 4 | 1 |
| Kb | △ | △ | △ | △ | △ | △ | ○ | △ | | | △ | × | 1 | 9 | 1 |
| Ko | × | × | × | × | △ | × | × | △ | × | △ | | × | 0 | 3 | 8 |
| Ws | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | 11 | 0 | 0 |

| IX | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | | ○ | ○ | ○ | ○ | ○ | △ | △ | ○ | ○ | ○ | △ | 8 | 3 | 0 |
| Th | × | | × | △ | × | △ | × | × | × | △ | × | × | 0 | 3 | 8 |
| Tk | × | ○ | | ○ | △ | ○ | × | × | △ | △ | △ | △ | 3 | 5 | 3 |
| Ng | × | △ | × | | × | △ | △ | × | × | △ | △ | △ | 0 | 6 | 5 |
| Kt | × | ○ | △ | ○ | | ○ | △ | △ | △ | △ | △ | △ | 3 | 7 | 1 |
| Os | × | △ | × | △ | × | | × | × | × | △ | △ | × | 0 | 4 | 7 |
| Ks | △ | ○ | ○ | ○ | △ | ○ | | △ | △ | △ | △ | △ | 4 | 7 | 0 |
| Ti | △ | ○ | ○ | ○ | △ | ○ | △ | | ○ | ○ | △ | △ | 6 | 5 | 0 |
| Tb | × | ○ | △ | △ | △ | ○ | △ | × | | △ | △ | △ | 2 | 7 | 2 |
| Kb | × | △ | △ | △ | △ | △ | △ | × | △ | | △ | △ | 0 | 9 | 2 |
| Ko | × | ○ | △ | △ | △ | △ | △ | △ | △ | △ | | △ | 1 | 9 | 1 |
| Ws | △ | ○ | △ | △ | △ | ○ | △ | △ | △ | △ | △ | | 2 | 9 | 0 |

| X | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | 11 | 0 | 0 |
| Th | × | | ○ | △ | ○ | ○ | ○ | × | △ | △ | △ | × | 4 | 4 | 3 |
| Tk | × | × | | × | △ | △ | △ | × | △ | △ | △ | × | 0 | 6 | 5 |
| Ng | × | △ | ○ | | ○ | ○ | ○ | × | △ | ○ | ○ | × | 6 | 2 | 3 |
| Kt | × | × | △ | × | | △ | △ | × | △ | △ | △ | × | 0 | 6 | 5 |
| Os | × | × | △ | × | △ | | △ | × | △ | △ | △ | × | 0 | 6 | 5 |
| Ks | × | × | △ | × | △ | △ | | × | △ | △ | △ | × | 0 | 6 | 5 |
| Ti | × | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | ○ | ○ | × | 9 | 0 | 2 |
| Tb | × | △ | △ | △ | △ | △ | △ | × | | △ | △ | × | 0 | 8 | 3 |
| Kb | × | △ | △ | × | △ | △ | △ | × | △ | | △ | × | 0 | 7 | 4 |
| Ko | × | △ | △ | × | △ | △ | △ | × | △ | △ | | × | 0 | 7 | 4 |
| Ws | × | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | 10 | 0 | 1 |

Table 7: Number of keywords in Th and Kt projects in Group Ⅱ

| | **Tohoku Univ. (Th)** | **Kyoto Univ. (Kt)** |
|---|---|---|
| Projects | 2,784 | 3,810 |
| Common keywords | 2,787 | |
| Unique keywords | 10,930 | 15,926 |
| Total keywords | 13,717 | 18,713 |

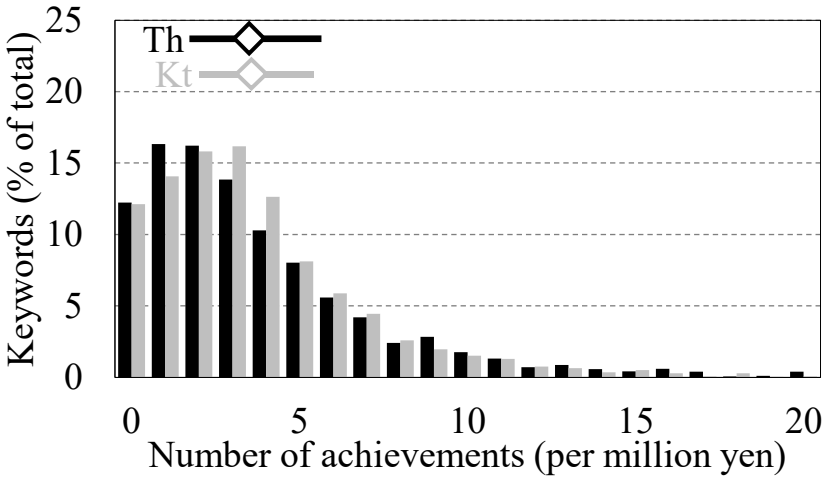


Figure 4: Histogram for common keywords

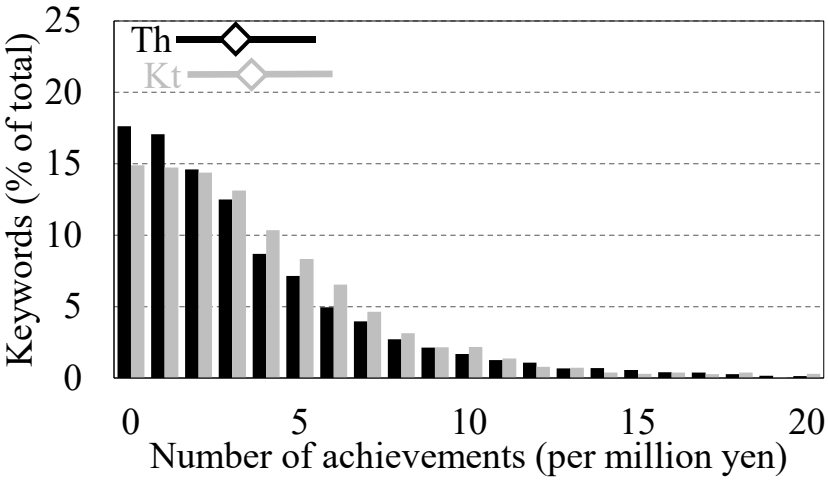


Figure 5: Histogram for unique keywords

The histogram peaks are significantly different in Figures 4 and 5. Results for common keywords tend to be higher than those for unique keywords. This trend may be because the KAKEN database can refer to the results of other studies comprising the common keywords. If there are previous studies that comprise the common keywords as the ongoing project, their performance will serve as a benchmark. Since we can compare the amount of research output based on common keywords, researchers are expected to produce at least the same level of performance as previous studies. The projects related to unique keywords are valuable in differentiating the institute from others. However, if their performance is inferior, it will trigger a reconsideration of their necessity. Tables 8 presents the survey results, divided into common and unique keywords, for all combinations of institutes in Groups III, V, and VII.

Table 8: Comparison of each institute's achievements
(by common keywords or unique keywords)

(Common keywords)

| Ⅲ | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | | ○ | ○ | △ | ○ | ○ | ○ | ○ | ○ | △ | ○ | ○ | 9 | 2 | 0 |
| Th | × | | ○ | × | △ | △ | △ | △ | ○ | △ | ○ | △ | 3 | 6 | 2 |
| Tk | × | × | | × | △ | △ | △ | × | ○ | × | ○ | × | 2 | 3 | 6 |
| Ng | △ | ○ | ○ | | ○ | ○ | ○ | △ | ○ | △ | ○ | △ | 7 | 4 | 0 |
| Kt | × | △ | △ | × | | △ | △ | △ | ○ | × | ○ | × | 2 | 5 | 4 |
| Os | × | △ | △ | × | △ | | △ | ○ | ○ | × | ○ | △ | 3 | 5 | 3 |
| Ks | × | △ | △ | × | △ | △ | | △ | ○ | × | ○ | △ | 2 | 6 | 3 |
| Ti | × | △ | ○ | △ | △ | × | △ | | △ | △ | ○ | △ | 2 | 7 | 2 |
| Tb | × | × | × | × | × | × | × | △ | | × | △ | △ | 0 | 3 | 8 |
| Kb | △ | △ | ○ | △ | ○ | ○ | ○ | △ | ○ | | ○ | ○ | 7 | 4 | 0 |
| Ko | × | × | × | × | × | × | × | × | △ | × | | △ | 0 | 2 | 9 |
| Ws | × | △ | ○ | △ | ○ | △ | △ | △ | △ | × | △ | | 2 | 7 | 2 |

(Unique keywords)

| Ⅲ | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | | ○ | ○ | × | × | △ | ○ | × | ○ | × | ○ | × | 5 | 1 | 5 |
| Th | × | | △ | × | × | × | ○ | × | △ | × | ○ | × | 2 | 2 | 7 |
| Tk | × | △ | | × | × | × | ○ | × | × | × | ○ | × | 2 | 1 | 8 |
| Ng | ○ | ○ | ○ | | △ | ○ | ○ | × | ○ | △ | ○ | × | 7 | 2 | 2 |
| Kt | ○ | ○ | ○ | △ | | ○ | ○ | × | ○ | × | ○ | × | 7 | 1 | 3 |
| Os | △ | ○ | ○ | × | × | | ○ | × | △ | × | ○ | × | 4 | 2 | 5 |
| Ks | × | × | × | × | × | × | | × | × | × | ○ | × | 1 | 0 | 10 |
| Ti | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | ○ | ○ | △ | 10 | 1 | 0 |
| Tb | × | △ | ○ | × | × | △ | ○ | × | | × | ○ | × | 3 | 2 | 6 |
| Kb | ○ | ○ | ○ | △ | ○ | ○ | ○ | × | ○ | | ○ | × | 8 | 1 | 2 |
| Ko | × | × | × | × | × | × | × | × | × | × | | × | 0 | 0 | 11 |
| Ws | ○ | ○ | ○ | ○ | ○ | ○ | ○ | △ | ○ | ○ | ○ | | 10 | 1 | 0 |

| V | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | | △ | △ | △ | △ | × | △ | ○ | ○ | △ | △ | ○ | 3 | 7 | 1 |
| Th | △ | | △ | △ | △ | × | △ | △ | △ | △ | △ | △ | 0 | 10 | 1 |
| Tk | △ | △ | | × | × | × | △ | △ | △ | △ | △ | △ | 0 | 8 | 3 |
| Ng | △ | △ | ○ | | △ | × | △ | △ | △ | △ | △ | △ | 1 | 9 | 1 |
| Kt | △ | △ | ○ | △ | | × | △ | △ | ○ | △ | △ | △ | 2 | 8 | 1 |
| Os | ○ | ○ | ○ | ○ | ○ | | ○ | ○ | ○ | ○ | △ | ○ | 10 | 1 | 0 |
| Ks | △ | △ | △ | △ | △ | × | | △ | ○ | △ | △ | △ | 1 | 9 | 1 |
| Ti | × | △ | △ | △ | △ | × | △ | | △ | △ | △ | △ | 0 | 9 | 2 |
| Tb | × | △ | △ | △ | × | × | × | △ | | △ | × | △ | 0 | 6 | 5 |
| Kb | △ | △ | △ | △ | △ | × | △ | △ | △ | | △ | △ | 0 | 10 | 1 |
| Ko | △ | △ | △ | △ | △ | △ | △ | △ | ○ | △ | | △ | 1 | 10 | 0 |
| Ws | × | △ | △ | △ | △ | × | △ | △ | △ | △ | △ | | 0 | 9 | 2 |

| V | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | | ○ | △ | × | △ | × | ○ | ○ | △ | × | × | × | 3 | 3 | 5 |
| Th | × | | × | × | × | × | △ | ○ | × | × | × | × | 1 | 1 | 9 |
| Tk | △ | ○ | | × | △ | × | ○ | ○ | × | × | × | × | 3 | 2 | 6 |
| Ng | ○ | ○ | ○ | | ○ | × | ○ | ○ | △ | × | △ | × | 6 | 2 | 3 |
| Kt | △ | ○ | △ | × | | × | ○ | ○ | △ | × | × | × | 3 | 3 | 5 |
| Os | ○ | ○ | ○ | ○ | ○ | | ○ | ○ | ○ | × | ○ | × | 9 | 0 | 2 |
| Ks | × | △ | × | × | × | × | | ○ | × | × | × | × | 1 | 1 | 9 |
| Ti | × | × | × | × | × | × | × | | × | × | × | × | 0 | 0 | 11 |
| Tb | △ | ○ | ○ | △ | △ | × | ○ | ○ | | × | △ | × | 4 | 4 | 3 |
| Kb | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | × | 10 | 0 | 1 |
| Ko | ○ | ○ | ○ | △ | ○ | × | ○ | ○ | △ | × | | × | 6 | 2 | 3 |
| Ws | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | 11 | 0 | 0 |

| Ⅶ | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | | △ | △ | △ | △ | × | △ | △ | × | △ | △ | △ | 0 | 9 | 2 |
| Th | △ | | △ | ○ | ○ | △ | △ | △ | △ | △ | △ | △ | 2 | 9 | 0 |
| Tk | △ | △ | | △ | ○ | × | △ | × | × | △ | △ | △ | 1 | 7 | 3 |
| Ng | △ | × | △ | | △ | × | × | × | × | △ | △ | △ | 0 | 6 | 5 |
| Kt | △ | × | × | △ | | × | × | × | × | △ | △ | △ | 0 | 5 | 6 |
| Os | ○ | △ | ○ | ○ | ○ | | △ | △ | △ | △ | ○ | △ | 5 | 6 | 0 |
| Ks | △ | △ | △ | ○ | ○ | △ | | △ | △ | △ | △ | ○ | 3 | 8 | 0 |
| Ti | △ | △ | ○ | ○ | ○ | △ | △ | | △ | △ | △ | △ | 3 | 8 | 0 |
| Tb | ○ | △ | ○ | ○ | ○ | △ | △ | △ | | − | ○ | ○ | 6 | 4 | 0 |
| Kb | △ | △ | △ | △ | △ | △ | △ | △ | − | | − | − | 0 | 8 | 0 |
| Ko | △ | △ | △ | △ | △ | × | △ | △ | × | − | | △ | 0 | 8 | 2 |
| Ws | △ | △ | △ | △ | △ | △ | × | △ | × | − | △ | | 0 | 8 | 2 |

| Ⅶ | Hk | Th | Tk | Ng | Kt | Os | Ks | Ti | Tb | Kb | Ko | Ws | ○ | △ | × |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hk | | ○ | ○ | ○ | ○ | ○ | ○ | △ | △ | △ | ○ | ○ | 8 | 3 | 0 |
| Th | × | | △ | × | △ | × | △ | × | × | × | △ | × | 0 | 4 | 7 |
| Tk | × | △ | | × | × | × | △ | × | × | × | △ | × | 0 | 3 | 8 |
| Ng | × | ○ | ○ | | △ | △ | ○ | × | × | × | ○ | △ | 4 | 3 | 4 |
| Kt | × | △ | ○ | △ | | × | △ | × | × | × | △ | × | 1 | 4 | 6 |
| Os | × | ○ | ○ | △ | ○ | | ○ | △ | × | × | ○ | △ | 5 | 3 | 3 |
| Ks | × | △ | △ | × | △ | × | | × | × | × | △ | × | 0 | 4 | 7 |
| Ti | △ | ○ | ○ | ○ | ○ | △ | ○ | | △ | △ | ○ | △ | 6 | 5 | 0 |
| Tb | △ | ○ | ○ | ○ | ○ | ○ | ○ | △ | | △ | ○ | △ | 7 | 4 | 0 |
| Kb | △ | ○ | ○ | ○ | ○ | ○ | ○ | △ | △ | | ○ | ○ | 8 | 3 | 0 |
| Ko | × | △ | △ | × | △ | × | △ | × | × | × | | × | 0 | 4 | 7 |
| Ws | × | ○ | ○ | △ | ○ | △ | ○ | △ | △ | × | ○ | | 5 | 4 | 2 |

Compare the left and right sides of Table 8, the left has more △. It means there are more combinations on the left that are not clearly superior or inferior. One of the reasons for this difference may be that researchers strive not to be inferior to their competitors' research achievements. However, the differences in achievements related to keywords not handled by other institutions create differences in the performance of the institutes.

## 4 Future Work

In the case of Th and Kt in Group II, presented in Table 7, there were 2,787 common keywords, which is lesser than expected. The authors believe this is because the orthographical variants of the keywords were not fully corrected. In the future, it is expected that correcting the variants and increasing the number of common keywords will help clarify the characteristics of keywords unique to each institution. To solve this problem, it is possible to utilize judgments based on cosine similarity between keywords. Shimbaru investigated the relationship between the cosine similarity between sentences as short as keywords and their content agreement. An exhaustive study revealed that in 70% of the short sentence combinations with a cosine similarity of 0.85, the content of both sentences matched. Furthermore, the number of pairs with matching content increased as the cosine similarity increased [13][14]. It may be possible to determine keywords with the same meaning based on the cosine similarity between keywords. More reliable results are expected to be obtained by improving the determination accuracy of the same keywords.

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