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Research Article

Inequality in Funding and Productivity in the South Korean Academic System

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ABSTRACT

This study examines the research funding in South Korea's academic system. It centers on the funding distribution activities of the National Research Foundation, stressing the need to strike a balance between funding that is motivated by research quality or excellence and the equal distribution of resources. To do this, the study analyzes data spanning five years, from 2017 to 2021, and finds differences in research output and funding allocation based on organizational and individual factors. The findings show that although funding opportunities have improved over the past five years, the disparity has worsened. Research productivity appears to be positively correlated with funding levels at the individual level. Except for 2021, we see an overall rising trend in funding and publication inequality. Research productivity at the university level, except for medical and pharmaceutical science, often follows the same trend as funding allocation. A comparable pattern regarding funding inequality has been noted about publishing inequality across disciplines. Fascinatingly, university financing inequality has a pattern comparable to that of publishing inequality, except for capital-area universities in 2021. Finally, we propose various policy implications for the academic system based on the outcomes of this investigation.

Keywords: South Korea, Academic System, Research Funding, Inequality, Research Productivity, Asia, ASEAN.

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INTRODUCTION

For the past fifty years, South Korea has been recognized as a country that has built a national economy based on significant investments in R and D (Research and Development) activities. In the late 1960s, the Korean government established public research institutes and provided research funding, beginning its R and D endeavors. The 1980s saw the rise and development of private R and D efforts by major global companies like Samsung and LG. Universities became a new R and D player in the 1990s. The importance of Korean universities in the national innovation system has increased as the country's economy moves closer to the stage of creative innovation.

Along with this development of the Korean research system, the institutionalization of the funding system has evolved. The Korean research system is highly dependent on competition rather than on general support based on a formula consisting of various indicators (e.g., the number of academic staff). In doing so, the National Research Foundation (Hereafter NRF) is the main public agency responsible for providing research funding to academia. Some research programs follow a top-down approach based on RFPs (Request for Proposals) given by NRF, while the others are bottom-up competitions based on research proposals submitted by academics themselves.

Research funding, along with research personnel and equipment, are among the main factors in the function of scientific production. Research funding has steadily increased not only in Korea but also globally over the past few decades. For instance, OECD countries spent $497 billion on research funding in 2020, double the amount from 15 years ago.[1] This reflects the policy efforts of many countries to support new industries and technologies in a new environment and to increase employment opportunities.

In the realm of R and D communities, the issue of research funding inequality has become increasingly important. Particularly in science policy, the conflict between excellence-based research support and egalitarian resource distribution has been a longstanding issue.[2] An unequal distribution of research funding influences the possibility of individual researchers' acquisition of research resources. This may result in an overall decrease in

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research productivity, although a few brilliant scientists are more likely to produce outstanding research outputs comparing other ordinary colleagues. Moreover, at the individual level, this has a strong relationship with factors such as career stage, gender, and institutional reputation or prestige. Various countries are evolving their research funding support policies to strike a balance between excellence and equality.

In Korea, which has been advancing its university research system over the past 30 years, the questions of how research funding is allocated and its impacts on research productivity have become crucial. In particular, within university research systems responsible for creative basic research, there is little research on how unequal distribution of research funding affects research productivity. Moreover, it is imperative that university research funding policies are grounded in quantitative data analysis. Therefore, this study aims to explore the relationship between the concentration of research funding in the Korean university system and research productivity, addressing these academic and policy requirements.

Inequality in research funding and Scientific productivity

There has been considerable research on research funding and inequality in research funding. Research funding inequality is known to be increasing globally. This can be attributed to the increasing number of large research projects. The logic behind this phenomenon is that the best researchers should receive the most funding due to economies of scale.[3] Bloch and Sørensen have found several signs of increasing grant size.[4] They measured an increase in average grant size in several countries, including Denmark, Switzerland, and the United Kingdom, as well as increased support for research centers. On the other hand, Sörlin argues that project-based funding, tax breaks, and the commercialization of university research have led to the creation of superstar researchers, which in turn has led to a 'winner-take-all' structure.[5]

In particular, the focus on research excellence has led to an increase in the size of research funding at the global level. This allows researchers to maximize research productivity, including publications, increase scientific impact, and provide an optimal environment for new discoveries.[6] Some scholars also argue that larger research centers can provide long-term stable funding for researchers, which is associated with increased grant size.[7] However, this logic has the potential to marginalize researchers further who have not traditionally had access to funding, which could eventually undermine system-wide excellence. On the other hand, Bonaccorsi and Daraio argue that research funding inequality increases as large-scale funding is used to maximize socioeconomic impact.[8] They sought to empirically measure whether large research organizations in France increase scientific productivity. They found no empirical support for the notion that concentrated institutions increase scientific productivity by generating spillover effects, increasing face-to-face contacts, and facilitating tacit knowledge exchange.

Some researchers understand the issue of funding allocation as a question of equity, suggesting that funding concentration undermines equity among researcher groups.[2] This equity can be increased by encouraging more diverse and broad participation in research funding. A criticism of this is that science is an inherently unequal game, so equity cannot go hand in hand with it. It has also been pointed out that if funding is distributed equally, research that requires critical mass cannot be conducted. In the case of Korean research, there is a study by Cho on the inequality of research funding.[9] Cho's study empirically proves that there exists inequality and cumulative advantages in the Korean research community in terms of a number of papers, citations, and research grants. However, the study was conducted 16 years ago with a survey-sample size of 437 researchers in three scientific disciplines and is not comparable to the scope and scale of our research.

Against this backdrop, we put forward three research questions at the individual and organizational level. To begin with, how unevenly is funding allocated in South Korean academic system? Has it gotten worse over the past five years? Second, how are the research outputs are created differently during the last five years? Third, how have the last five years' research output, funding and inequality related to each other?

METHODOLOGY

We utilize integrated data on publications and academic research grants subsidized by governments, including information about recipients, institutions, grant amounts, and research periods from 2017 to 2021. We carry out descriptive statistics, including an analysis of variance and an analysis of inequalities as measured by Gini coefficients, to present trends and an overview of publication production and research grant distributions.

First, we investigate whether there has been an intensification of research funding concentration in Korean universities from a system-level perspective. We utilize the Gini coefficient, the most commonly used measure of societal inequality, which can be calculated using the Lorenz curve.

Second, we examine the research funding concentration over a period of five years based on the personal and environmental attributes of university researchers. For example, we can analyze how the Gini coefficient has changed for different groups such as men and women, junior faculty and senior faculty, universities in local areas versus those in capital areas, and faculty in science and engineering disciplines compared to those in humanities and social sciences. Through this analysis, we can diagnose how the distribution of research funding has evolved at the system level over the past five years.

Third, we analyze the relationship between research funding, research productivity, and concentration at the individual and organizational levels. Research productivity is the most significant idea in measuring the results of scientific operations. It is affected by a number of variables, including environmental factors like the attributes of associated institutions, such as size, reputation, location, and mission, as well as personal aspects such as gender, age, and research area. Using this, we examine the relationship between research productivity and funding disparity.

We apply the Gini coefficient to measure the inequality of research funding. To construct the Lorenz curve, we arrange the entire population of researchers in ascending order of their research funding amounts. We set the total number of researchers as 100, with the horizontal axis representing the cumulative percentage and the vertical axis representing the cumulative percentage of total research funding accumulated by each researcher, normalized to 100. The Lorenz curve can be defined as the line connecting these cumulative population percentages and corresponding cumulative research funding percentages. The Gini coefficient is then calculated as the ratio of the area between the diagonal line and the Lorenz curve to the total area of the triangle under the diagonal line.

RESULTS AND DISCUSSION

Overview of funding and publications: descriptive statistics

Tables 1 and 2 show descriptive statistics of our data at individual and organizational level. According to Table 1, the number of researchers in engineering is the biggest, followed by social science. In terms of average funding, researchers in engineering rank top, followed by those in maritime and agricultural science. Regarding productivity, medical and pharmaceutical science and maritime and agricultural science have the most productive scientists. Moreover, male researchers get more funding in total and on average, produce more papers efficiently. Senior researchers get more funding and produce more papers efficiently.

According to Table 2, the number of universities in social science is the biggest, followed by humanities. In terms of average funding, universities in engineering rank top, followed by those in medical and pharmaceutical science. Regarding productivity, universities with medical and pharmaceutical science and engineering areas are most productive. Moreover, capital universities get more funding in total and on average, produce more papers efficiently. Private universities get more funding and produce more papers less efficiently.

Table 3 below shows the recent trend in funding size and distribution. Over the last five years, the number of projects, funding, and average project size have all increased. Furthermore, we see that the success rate, as assessed by the number of principal investigators divided by the total number of researchers, remains consistent, except for a minor drop in 2020. This could indicate that the funding situation has improved as research funding for a comparable number of researchers increases yearly. However, the median value (i.e., the 50% quartile) of financing has stayed steady over the same period, but the standard deviation has progressively increased. This suggests that the increase in funding has been centered more on the 'richer' group, whereas funding for the 'poorer' group did not increase.

Table 1: Total and average amount of funding and publications of researchers during the last five years.

Categories	No. of Researchers	Total Funding	Avg. Funding	Total Publication	Avg. Publication
Humanities	11,310	712,622,017	63,008	51,106	4.52
Social Sciences	20,610	2,200,677,026	106,777	156,285	7.58
Arts and Physical Education	7,085	444,108,862	62,683	31,441	4.44
Multi-Disciplinary	634	269,347,683	424,839	6,433	10.15
Natural Sciences	9,022	5,988,291,984	663,743	129,257	14.33
Engineering	19,293	15,205,635,490	788,143	254,005	13.17
Maritime and Agricultural Sciences	2,142	1,545,583,419	721,561	35,564	16.60
Medical and Pharmaceutical Sciences	19,494	7,380,436,726	378,600	353,627	18.14
Male	66,970	30,054,602,707	448,777	805,214	12.02
Female	22,620	3,692,100,500	163,223	212,504	9.39
Under 30s	7,700	1,741,010,564	226,105	90,002	11.69
40s	24,478	10,694,428,301	436,900	389,484	15.91
50s	30,662	15,589,476,980	508,430	391,202	12.76
Over 60s	26,750	5,721,787,362	213,899	147,030	5.50
Total	89,590	33,746,703,207	376,679	1,017,718	11.36

Table 2: Total and average amount of funding and publications of universities during the last five years.

Categories	No. of Universities	Total Funding	Avg. Funding	Total Publication	Avg. Publication
Humanities	205	712,622,017	3,476,205	50,716	247.40
Social Sciences	217	2,200,674,726	10,141,358	155,684	717.44
Arts and Physical Education	192	444,108,862	2,313,067	31,291	162.97
Multi-Disciplinary	114	269,347,683	2,362,699	6,432	56.42
Natural Sciences	181	5,988,277,984	33,084,409	129,203	713.83
Engineering	189	15,205,415,490	80,451,934	253,908	1,343.43
Maritime and Agricultural Sciences	138	1,545,583,419	11,199,880	35,563	257.70
Medical and Pharmaceutical Sciences	165	7,380,436,226	44,729,917	353,531	2,142.61
Capital	89	18,113,185,467	203,518,938	498,862	5,605.19
Non-Capital	135	15,633,280,940	115,802,081	517,466	3,833.08
Public	49	13,432,592,792	274,134,547	351,508	7,173.63
Private	175	20,313,873,615	116,079,278	664,820	3,798.97
Total	224	33,746,703,207	150,653,868	1,016,328	4,537.18

Table 3: The amount of funding, the size of the projects, and their distribution (unit: 1,000 won).

Year	2017	2018	2019	2020	2021
Total Funding	5,942,874,520	6,119,804,234	6,572,242,909	7,134,636,550	7,977,144,994
Total No of Project	102,907	101,813	104,260	103,476	107,212
Average Size of Project	57,750	60,108	63,037	68,950	74,405
Success rate for being funded	56.6%	57.0%	56.9%	55.5%	56.8%
Quartile: 25%	0	0	0	0	0
Quartile: 50%	3,070	3,500	3,500	3,000	3,300
Quartile: 75%	47,269	50,000	50,594	50,734	60,000
Standard Deviation	273,125	292,293	316,124	343,203	364,360

Individual level

We examine research funding, publications, and Gini coefficients to comprehend the individual-level inequality in the Korean academic system. The overall research funding and average values according to each research area (i.e., eight fields), gender (i.e., male or female), and age periods (i.e., under 30s, 40s, 50s, and above 60s) are shown in Tables 4 and 5 below regarding the funding for academics from NRF during the last five years. According to the trend in the two tables, both the average and total funding will rise by 2021. Nonetheless, up until 2021, total and average funding in three fields, natural science, engineering, and maritime and agricultural science, showed a consistent rise. Specifically, it is evident that the trade conflicts between Korea and Japan and COVID-19 have made a tremendous increase conceivable in the engineering and medical and pharmaceutical fields. When comparing disciplines, funding for academics in science and engineering is higher than for those in other fields. Furthermore, older or male academics are given more funding than junior or female academics, except for academics above the 60s.

The Gini coefficients show the disparity in funding between academics. Figure 1 displays the Gini coefficient values over a 5-year period for each research discipline (natural sciences, for example), gender (male or female), and age periods by 10 years. We note that the coefficients of non-science disciplines, such as the humanities and social sciences, are bigger than those of scientific and engineering disciplines, contradicting the previous results above (i.e., total and average amount of funding). Additionally, compared to male academics, female academics had a higher coefficient. When the findings from the earlier analysis above are taken into account together, academics with relatively lower average funding per principal researcher and total research funding tend to have more funding inequality or funding concentration. In fields and groups with limited funding size, funding is more likely to be focused on a smaller number of researchers.

Table 4: Total amount of funding to academics according to personal characteristics (unit: 1,000 won).

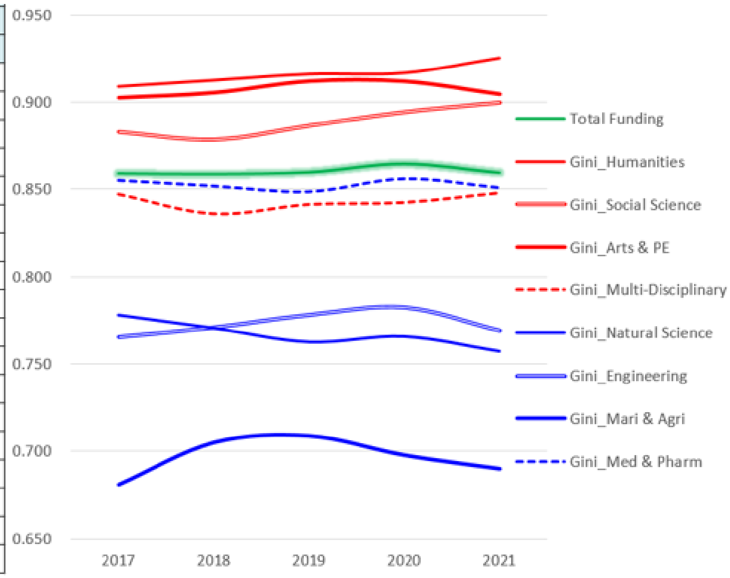
Year	2017	2018	2019	2020	2021
Total Funding	5,942,874,520	6,119,804,234	6,572,242,909	7,134,636,550	7,977,144,994
Total Funding_Humanities	135,361,746	135,688,675	147,382,578	135,736,174	158,452,844
Total Funding_Social Science	419,334,685	416,295,526	430,741,540	447,544,521	486,760,754
Total Funding_Arts and PE	94,125,359	84,067,525	94,857,162	82,296,248	88,762,568
Total Funding_Multi-Disciplinary	44,481,902	50,412,458	51,419,929	59,083,037	63,950,357
Total Funding_Natural Science	1,071,390,903	1,099,012,311	1,143,716,052	1,262,278,547	1,411,894,171
Total Funding_Engineering	2,663,050,303	2,723,580,501	2,948,461,056	3,265,317,897	3,605,225,733
Total Funding_Mari and Agri	267,193,141	295,442,908	309,827,591	312,551,956	360,567,823
Total Funding_Med and Pharm	1,247,936,481	1,315,304,330	1,445,837,001	1,569,828,170	1,801,530,744
Total Funding_Male	5,330,863,408	5,476,796,790	5,855,143,052	6,353,617,439	7,038,182,018
Total Funding_Female	612,011,112	643,007,444	717,099,857	781,019,111	938,962,976
Under 30s	293,649,996	319,649,460	316,006,386	378,524,369	433,180,353
40s	2,056,972,251	1,990,059,959	2,057,542,887	2,170,878,955	2,418,974,249
50s	2,656,629,509	2,789,606,496	3,052,699,801	3,385,971,386	3,704,569,788
Above 60s	935,622,764	1,020,488,319	1,145,993,835	1,199,261,840	1,420,420,604

Table 5: Average amount of funding to academics according to personal characteristics (unit: 1,000 won).

Year	2017	2018	2019	2020	2021
Average Funding	80,103	83,308	89,101	95,366	107,858
Average Funding_Humanities	14,052	14,506	15,982	14,997	18,365
Average Funding_Social Science	24,649	24,889	25,571	26,067	28,823
Average Funding_Arts and PE	15,648	14,324	16,182	13,906	15,264
Average Funding_Multi-Disciplinary	86,709	100,624	102,635	111,477	117,772
Average Funding_Natural Science	139,814	144,493	152,414	166,747	189,643
Average Funding_Engineering	170,109	173,886	185,321	200,437	221,751
Average Funding_Mari and Agri	148,194	165,329	173,088	177,284	209,389
Average Funding_Med and Pharm	78,506	82,444	89,648	95,020	108,129
Average Funding_Male	94,065	98,334	105,746	114,348	129,229
Average Funding_Female	34,936	36,197	38,990	40,575	48,159
Under 30s	43,504	50,778	49,938	56,111	67,212
40s	83,845	84,228	89,179	94,575	107,812
50s	93,847	98,576	107,206	117,129	128,493
Above 60s	64,088	66,966	72,134	74,006	87,427

Tables 6 and 7 display the total and average number of publications Korean academics have produced during the past five years, broken down by eight fields (such as the humanities), gender, and career periods. The number of publications and their average values show a consistent upward trend, with a minor decline in 2018 and 2019. As seen by the rise in research funding over the same time period (see Tables 4 and 5), the engineering and medical and pharmaceutical fields have seen a particularly notable increase in publications. Within the disciplines, there are about twice as many publications in the fields of engineering and medical and pharmaceuticals than there are in the natural sciences and social sciences together. The productivity of the medical and pharmaceutical fields, or the number of publications produced by each researcher, also held the top spot. Compared to their female counterparts, male academics published a greater number of articles and were more productive. A similar pattern is seen with senior professors.

Year	2017	2018	2019	2020	2021
Total Funding	**0.859**	**0.859**	**0.860**	**0.865**	**0.859**
Gini_Humanities	0.909	0.913	0.916	0.917	0.925
Gini_Social Science	0.883	0.879	0.887	0.894	0.900
Gini_Arts & PE	0.902	0.905	0.912	0.912	0.905
Gini_Multi-Disciplinary	0.847	0.836	0.841	0.842	0.848
Gini_Natural Science	0.778	0.771	0.763	0.766	0.757
Gini_Engineering	0.765	0.771	0.778	0.783	0.769
Gini_Mari & Agri	0.681	0.705	0.709	0.698	0.690
Gini_Med & Pharm	0.855	0.852	0.848	0.856	0.851
Gini_Male	0.846	0.846	0.847	0.851	0.844
Gini_Female	0.883	0.881	0.882	0.888	0.889
Gini_Under 30s	0.821	0.817	0.814	0.817	0.790
Gini_40s	0.825	0.818	0.820	0.826	0.817
Gini_50s	0.863	0.865	0.865	0.871	0.867
Gini_60s and older	0.905	0.903	0.902	0.905	0.906
Quartile: 25%	0	0	0	0	0
Quartile: 50%	3,070	3,500	3,500	3,000	3,300
Quartile: 75%	47,269	50,000	50,594	50,734	60,000
Standard Deviation	273,125	292,293	316,124	343,203	364,360



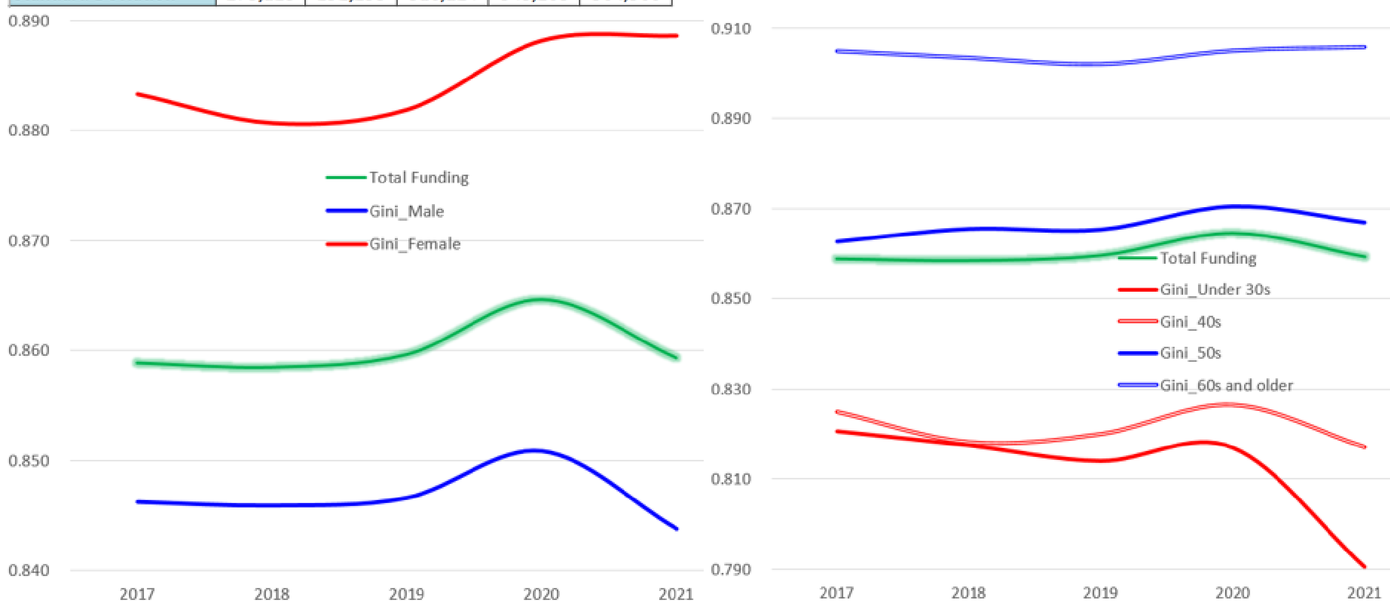


Figure 1: Inequality of funding for academics according to personal characteristics.

The production disparities among Korean academics by personal attributes, including gender, career time, and discipline, are depicted in Figure 2 below. In general, across the period, the productivity gap has widened. More inequality is shown in non-scientific fields like the arts and physical education and humanities than in fields of sciences like the natural sciences and engineering. This could imply that the structure of inequality is greater in productive areas than in less productive areas. Male academics are more unequal than female academics in terms of production, and group inequality for male groups has been increasing over time while it temporarily decreased for female groups in 2018. Senior academics in the 50s and 60s groups also exhibit a similar pattern, while junior groups in the 30s and 40s show a slight decrease in 2018 and 2019.

In summary, at the individual level, analysis reveals disparities in funding allocation and productivity across disciplines, genders, and career stages during the last five years. Funding tends to concentrate on academics in science and engineering disciplines such as engineering and medical and pharmaceutical science, with male and senior academics in the 50s receiving more funding support. Research productivity also correlates with funding levels, with engineering and science fields exhibiting higher publication rates. However, academics in medical and pharmaceutical science and maritime and agricultural science have produced more papers than those in engineering on average. In addition, academics in their 40s publish, on average, more than those in their 50s.

Regarding funding inequality, disparity of non-science disciplines, such as the humanities and social sciences, are

Table 6: Total no. of publications of academics according to personal characteristics.

Year	2017	2018	2019	2020	2021
Total Publications	201,621	198,130	199,592	205,749	212,626
Total Publications_Humanities	10,615	10,488	10,054	10,064	9,885
Total Publications_Social Science	31,389	31,163	30,845	31,041	31,847
Total Publications_Arts and PE	6,068	5,872	6,084	6,677	6,740
Total Publications_Multi-Disciplinary	1,346	1,248	1,171	1,240	1,428
Total Publications_Natural Science	26,409	25,686	25,656	25,603	25,903
Total Publications_Engineering	49,300	49,175	50,052	51,943	53,535
Total Publications_Mari and Agri	7,136	6,852	7,033	7,038	7,505
Total Publications_Med and Pharm	69,358	67,646	68,697	72,143	75,783
Total Publications_Male	161,890	158,138	158,115	161,738	165,333
Total Publications_Female	39,731	39,992	41,477	44,011	47,293
Under 30s	17,829	17,128	17,250	18,693	19,102
40s	80,892	76,815	75,493	77,192	79,092
50s	75,187	75,457	77,194	79,879	83,485
Above 60s	27,713	28,730	29,655	29,985	30,947

Table 7: Average no. of publications of academics according to personal characteristics.

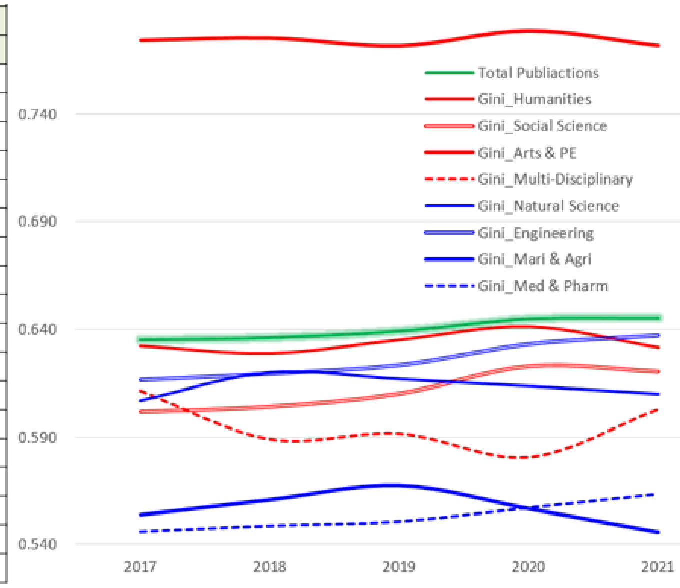
Year	2017	2018	2019	2020	2021
Avg. Publications	2.72	2.70	2.71	2.75	2.87
Avg. Publications_Humanities	1.10	1.12	1.09	1.11	1.15
Avg. Publications_Social Science	1.85	1.86	1.83	1.81	1.89
Avg. Publications_Arts and PE	1.01	1.00	1.04	1.13	1.16
Avg. Publications_Multi-Disciplinary	2.62	2.49	2.34	2.34	2.63
Avg. Publications_Natural Science	3.45	3.38	3.42	3.38	3.48
Avg. Publications_Engineering	3.15	3.14	3.15	3.19	3.29
Avg. Publications_Mari and Agri	3.96	3.83	3.93	3.99	4.36
Avg. Publications_Med and Pharm	4.36	4.24	4.26	4.37	4.55
Avg. Publications_Male	2.86	2.84	2.86	2.91	3.04
Avg. Publications_Female	2.27	2.25	2.26	2.29	2.43
Under 30s	2.64	2.72	2.73	2.77	2.96
40s	3.30	3.25	3.27	3.36	3.53
50s	2.66	2.67	2.71	2.76	2.90
Above 60s	1.90	1.89	1.87	1.85	1.90

stronger than those of science and engineering disciplines (e.g. medical and pharmaceutical science). Moreover, female or senior academics in the 50s or 60s are experiencing stronger inequality. With regard to publication inequality, non-science disciplines such as arts and physical education, as well as humanities, show higher levels of disparity than science and engineering disciplines such as maritime and agricultural science. Furthermore, we see a stronger inequality for male and senior professors in the 50s and 60s. Overall, we observe an increasing trend of inequality regarding both funding and publication except 2021.

University level

In order to understand the inequality of the Korean academic system at the organization level, we investigate research funding, publications, and Gini coefficients. Tables 8 and 9 show an overall consistent increase in the total and average funding received by universities. Engineering is the discipline that has had the biggest increase in both average and total terms. In terms of average funding increases, capital and public universities outperform non-capital and private universities; nevertheless, the overall increase in funding amounts is comparable because each group

Year	2017	2018	2019	2020	2021
Total Publiactions	**0.635**	**0.636**	**0.639**	**0.645**	**0.645**
Gini_Humanities	0.632	0.629	0.635	0.641	0.632
Gini_Social Science	0.602	0.604	0.610	0.623	0.620
Gini_Arts & PE	0.774	0.775	0.772	0.778	0.772
Gini_Multi-Disciplinary	0.611	0.589	0.592	0.581	0.603
Gini_Natural Science	0.607	0.620	0.617	0.613	0.610
Gini_Engineering	0.617	0.619	0.623	0.633	0.637
Gini_Mari & Agri	0.554	0.561	0.567	0.557	0.546
Gini_Med & Pharm	0.546	0.549	0.551	0.557	0.563
Gini_Male	0.640	0.643	0.645	0.650	0.651
Gini_Female	0.609	0.605	0.610	0.620	0.619
Gini_Under 30s	0.627	0.618	0.617	0.632	0.621
Gini_40s	0.577	0.576	0.577	0.582	0.584
Gini_50s	0.638	0.640	0.643	0.646	0.647
Gini_60s and older	0.722	0.721	0.722	0.729	0.728
Quartile: 25%	0.00	0.00	0.00	0.00	0.00
Quartile: 50%	1.00	1.00	1.00	1.00	1.00
Quartile: 75%	4.00	4.00	4.00	4.00	4.00
Standard Deviation	4.191	4.341	4.345	4.328	4.535



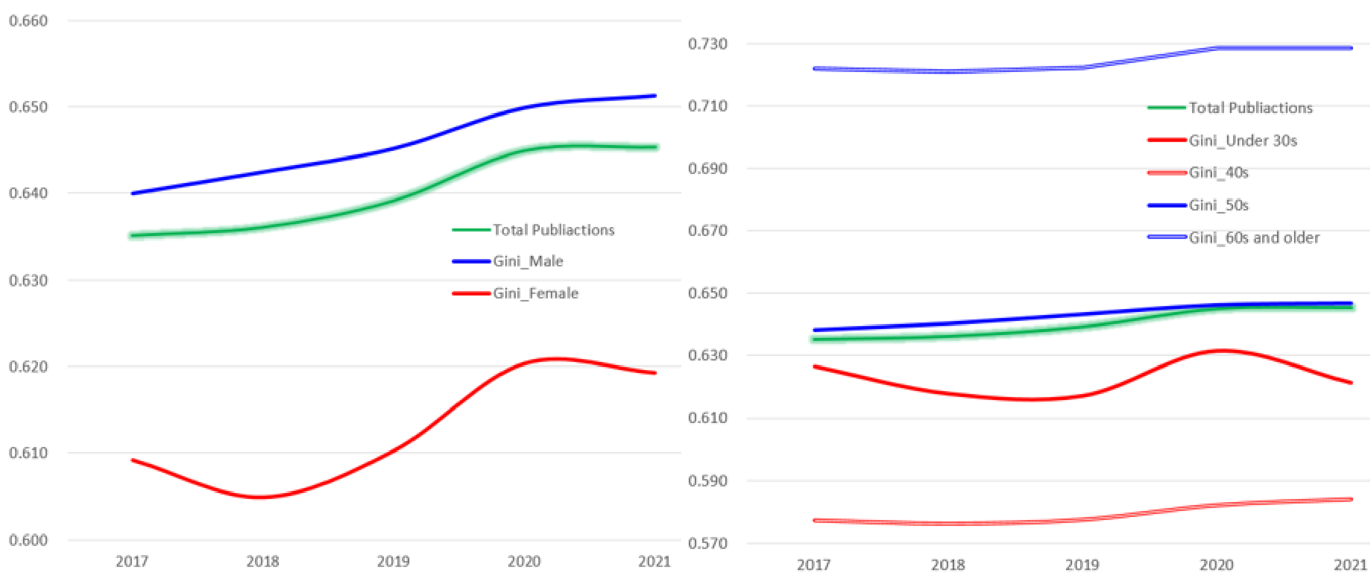


Figure 2: Inequality of publications from academics according to personal characteristics.

of universities (i.e. public and private) comprises a different number of universities. In particular, there is a steady increase in the average funding difference between the two categories (i.e. legal status and locations).

The following Figure 3 illustrates the disparity in funding amongst Korean universities based on organizational attributes such as research focus, location, and legal status. Multi-disciplinary science has the greatest Gini coefficient, or inequality, followed by pharmaceutical and medical science. Compared to non-science fields like the humanities and social sciences, there is a greater funding disparity between universities in science and engineering fields like medicine and pharmaceutical science. Compared to their peer groups, there is a greater and growing disparity in both non-capital and private university groups. Nonetheless, during the last five years, the overall level of inequality has remained stable.

The total and average numbers of publications produced by Korean universities over the previous five years are displayed in Tables 10 and 11. In terms of total and average numbers, we see consistent growth through 2021, following a modest decline in 2018 and 2019. Universities in the fields of medical and pharmaceutical science and engineering produced the greatest and second-largest numbers of publications overall and in terms of productivity (i.e., number of publications per university). Up until 2020, universities outside of capital areas generated more papers than those inside. However, starting in 2021, universities inside of capital areas began to produce more papers. This may be due to the fact that the average number of publications of capital universities has increased remarkably. Public universities

Table 8: Total amount of funding to universities according to organizational characteristics (unit: 1,000 won).

Year	2017	2018	2019	2020	2021
Total Funding	5,942,874,520	6,119,801,934	6,572,008,909	7,134,636,550	7,977,144,494
Total Funding_Humanities	135,361,746	135,688,675	147,382,578	135,736,174	158,452,844
Total Funding_Social Science	419,334,685	416,293,226	430,741,540	447,544,521	486,760,754
Total Funding_Arts and PE	94,125,359	84,067,525	94,857,162	82,296,248	88,762,568
Total Funding_Multi-Disciplinary	44,481,902	50,412,458	51,419,929	59,083,037	63,950,357
Total Funding_Natural Science	1,102,064,746	1,099,012,311	1,143,702,052	1,262,278,547	1,411,894,171
Total Funding_Engineering	2,663,050,303	2,723,580,501	2,948,241,056	3,265,317,897	3,605,225,733
Total Funding_Mari and Agri	267,193,141	295,442,908	309,827,591	312,551,956	360,567,823
Total Funding_Med and Pharm	1,247,936,481	1,315,304,330	1,445,837,001	1,569,828,170	1,801,530,244
Total Funding_Capital	3,216,067,864	3,281,253,720	3,512,313,423	3,796,371,418	4,307,179,042
Total Funding_Non-Capital	2,726,806,656	2,838,548,214	3,059,695,486	3,338,265,132	3,669,965,452
Total Funding_Public	2,325,015,403	2,428,767,019	2,601,432,765	2,894,498,174	3,182,879,431
Total Funding_Private	3,617,859,117	3,691,034,915	3,970,576,144	4,240,138,376	4,794,265,063

Table 9: Average amount of funding to universities according to organizational characteristics (unit: 1,000 won).

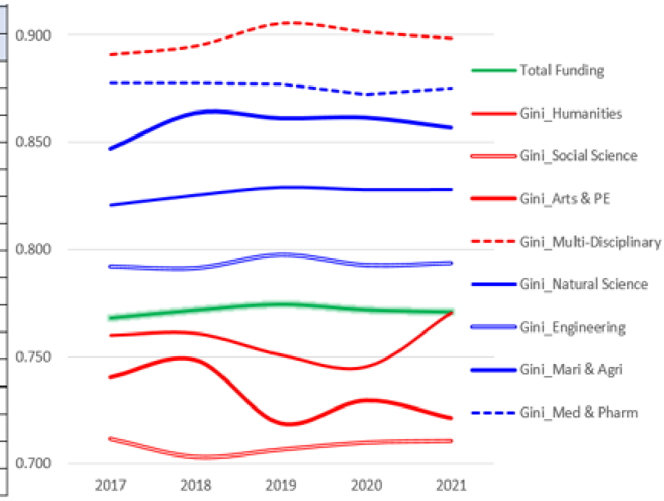
Year	2017	2018	2019	2020	2021
Average Funding	28,299,402	29,003,801	31,748,835	34,973,709	39,103,649
Average Funding_Humanities	720,009	725,608	818,792	741,728	870,620
Average Funding_Social Science	2,107,209	2,071,111	2,164,530	2,306,931	2,470,867
Average Funding_Arts and PE	547,240	491,623	554,720	498,765	547,917
Average Funding_Multi-Disciplinary	444,819	542,069	565,054	649,264	666,150
Average Funding_Natural Science	6,339,591	6,580,912	6,767,468	7,989,105	8,661,927
Average Funding_Engineering	15,217,430	15,652,762	17,140,936	19,207,752	20,960,615
Average Funding_Mari and Agri	2,264,349	2,591,604	2,670,928	2,671,384	3,081,776
Average Funding_Med and Pharm	8,210,108	8,653,318	9,575,079	10,535,760	11,774,707
Average Funding_Capital	38,286,522	39,062,544	42,833,091	46,868,783	53,839,738
Average Funding_Non-Capital	21,641,323	22,350,773	24,477,564	27,140,367	29,596,496
Average Funding_Public	48,437,821	51,675,894	55,349,633	64,322,182	70,730,654
Average Funding_Private	22,332,464	22,506,310	24,816,101	26,667,537	30,152,610

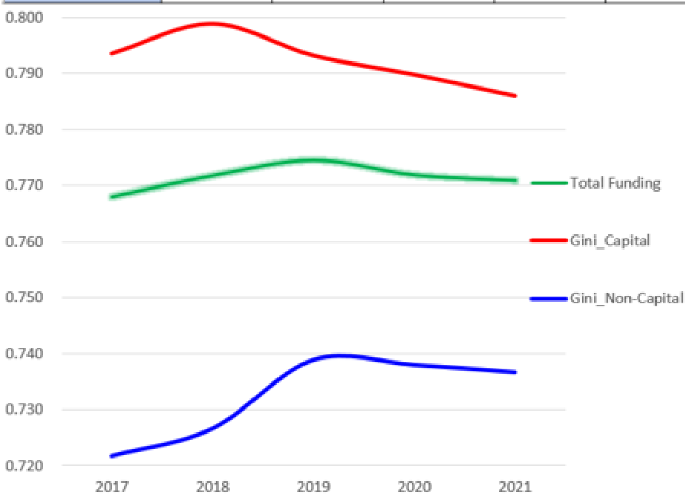
display a higher productivity (i.e. number of publications per a university), although private universities have produced more papers overall.

The productivity disparity among Korean universities is depicted in Figure 4 below based on organizational attributes such as research focus, locations, and legal status. Over the past five years, there has been little change in the productivity gap compared to the funding gap. Compared to non-science fields like the humanities and social sciences, there is a greater production gap across universities in science and engineering fields like medical and pharmaceutical science. Higher levels of inequality have been observed in capital-area universities compared to non-capital-area universities, and both groups' levels of inequality have been rising over time. Furthermore, compared to public institutions, private universities exhibit greater inequality. Interestingly, public universities have seen a decline in inequality, despite private universities experiencing an increase in it. This indicates that for the past five years, competition among private institutions has gotten more intense.

In summary, at the university level, analysis reveals disparities in funding allocation and productivity across research focus, locations, and legal status during the last five years. Research funding concentrates on universities in science and engineering in both total and average terms. Capital universities show remarkable funding increases, while peer groups show a modest increase relatively. Public universities get two times more funding than private universities. Research productivity shows a similar

Year	2017	2018	2019	2020	2021
Total Funding	**0.768**	**0.772**	**0.775**	**0.772**	**0.771**
Gini_Humanities	0.760	0.761	0.751	0.745	0.771
Gini_Social Science	0.712	0.703	0.707	0.710	0.711
Gini_Arts & PE	0.740	0.749	0.719	0.730	0.721
Gini_Multi-Disciplin	0.891	0.895	0.905	0.901	0.898
Gini_Natural Science	0.820	0.825	0.829	0.828	0.828
Gini_Engineering	0.792	0.791	0.798	0.793	0.794
Gini_Mari & Agri	0.847	0.864	0.861	0.861	0.857
Gini_Med & Pharm	0.878	0.877	0.877	0.872	0.875
Gini_Capital	0.794	0.799	0.793	0.790	0.786
Gini_Non-Capital	0.722	0.727	0.739	0.738	0.737
Gini_Public	0.693	0.684	0.688	0.674	0.666
Gini_Private	0.782	0.788	0.793	0.791	0.793
Quartile: 25%	739,117	809,143	925,061	741,621	1,119,533
Quartile: 50%	6,210,557	6,126,878	6,184,494	6,370,835	6,941,800
Quartile: 75%	24,662,808	27,308,644	28,239,874	31,530,327	38,435,585
Standard Deviation	62,434,810	65,177,759	70,993,150	76,791,801	85,255,437





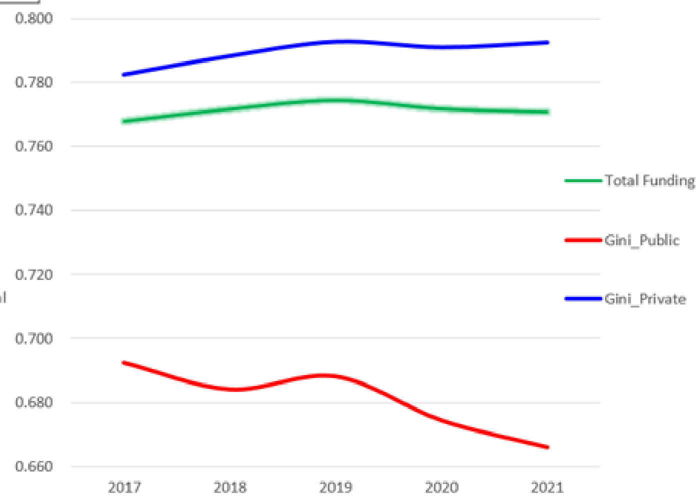
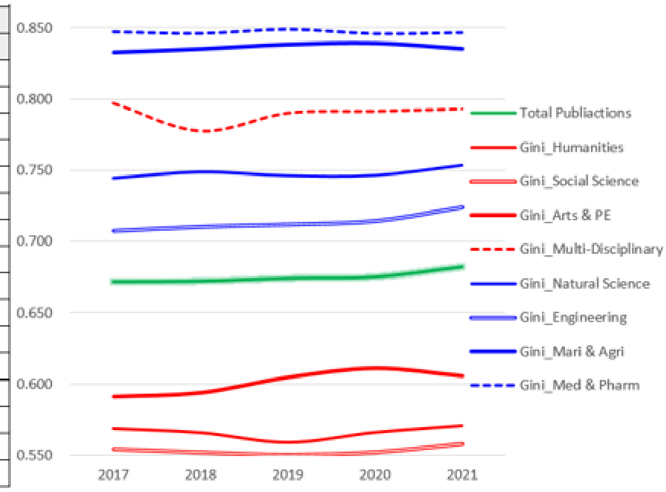


Figure 3: Inequality of funding for universities according to organizational characteristics.

Table 10: Total No. of publications of universities according to organizational characteristics.

Year	2017	2018	2019	2020	2021
Total Publications	201,417	198,001	199,277	205,307	212,326
Total Publications_Humanities	10,559	10,453	9,900	9,965	9,839
Total Publications_Social Science	31,282	31,102	30,752	30,847	31,701
Total Publications_Arts and PE	6,057	5,867	6,051	6,613	6,703
Total Publications_Multi-Disciplinary	1,346	1,248	1,170	1,240	1,428
Total Publications_Natural Science	26,402	25,677	25,651	25,589	25,884
Total Publications_Engineering	49,291	49,169	50,043	51,899	53,506
Total Publications_Mari and Agri	7,136	6,851	7,033	7,038	7,505
Total Publications_Med and Pharm	69,344	67,634	68,677	72,116	75,760
Total Publications_Capital	97,649	95,706	97,811	100,791	106,905
Total Publications_Non-Capital	103,768	102,295	101,466	104,516	105,421
Total Publications_Public	69,786	68,725	68,040	70,907	74,050
Total Publications_Private	131,631	129,276	131,237	134,400	138,276

Year	2017	2018	2019	2020	2021
Total Publiactions	**0.672**	**0.672**	**0.674**	**0.675**	**0.682**
Gini_Humanities	0.568	0.566	0.559	0.566	0.570
Gini_Social Science	0.554	0.552	0.551	0.552	0.558
Gini_Arts & PE	0.591	0.594	0.605	0.611	0.606
Gini_Multi-Disciplinary	0.797	0.777	0.790	0.791	0.793
Gini_Natural Science	0.744	0.749	0.746	0.746	0.753
Gini_Engineering	0.708	0.711	0.712	0.714	0.724
Gini_Mari & Agri	0.832	0.835	0.838	0.839	0.835
Gini_Med & Pharm	0.847	0.846	0.849	0.846	0.846
Gini_Capital	0.719	0.723	0.722	0.719	0.722
Gini_Non-Capital	0.618	0.614	0.616	0.622	0.628
Gini_Public	0.635	0.619	0.622	0.610	0.613
Gini_Private	0.673	0.678	0.681	0.685	0.693
Quartile: 25%	132.25	124.50	125.50	143.75	128.75
Quartile: 50%	334.50	320.00	322.00	343.00	337.50
Quartile: 75%	1058.25	1010.50	973.50	1068.25	1102.50
Standard Deviation	1641.11	1606.67	1647.76	1718.65	1814.95



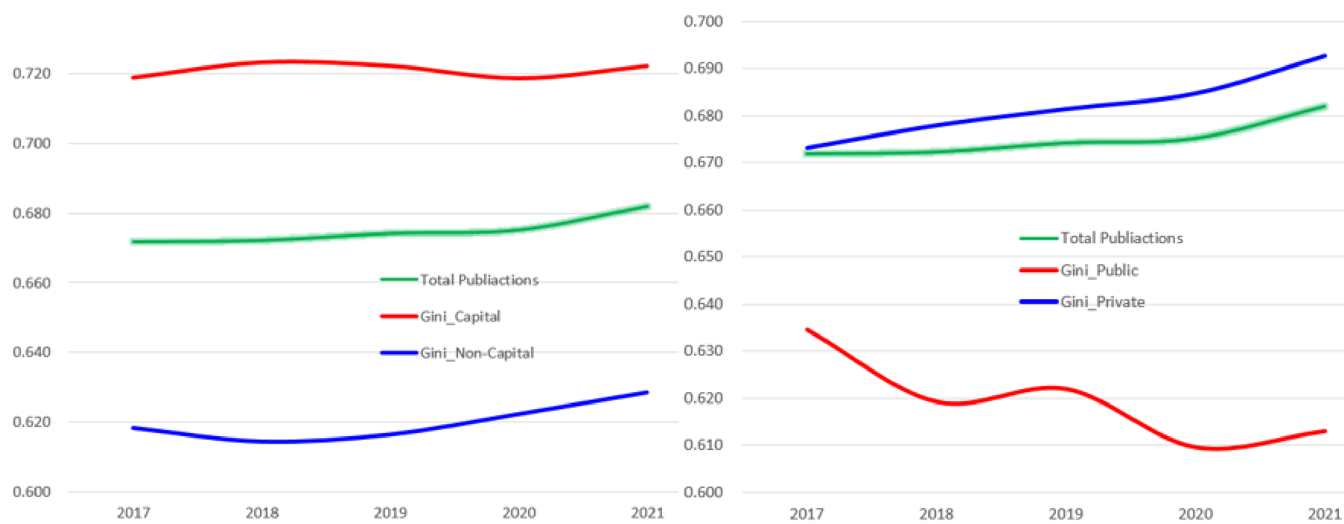


Figure 4: Inequality of publications from universities according to organizational characteristics.

Table 11: Average No. of publications of universities according to organizational characteristics.

Year	2017	2018	2019	2020	2021
Avg. Publications	959.13	938.39	962.69	1,006.41	1,040.81
Avg. Publications_Humanities	50.28	49.54	47.83	48.85	48.23
Avg. Publications_Social Science	148.96	147.40	148.56	151.21	155.40
Avg. Publications_Arts and PE	28.84	27.81	29.23	32.42	32.86
Avg. Publications_Multi-Disciplinary	6.41	5.91	5.65	6.08	7.00
Avg. Publications_Natural Science	125.72	121.69	123.92	125.44	126.88
Avg. Publications_Engineering	234.72	233.03	241.75	254.41	262.28
Avg. Publications_Mari and Agri	33.98	32.47	33.98	34.50	36.79
Avg. Publications_Med and Pharm	330.21	320.54	331.77	353.51	371.37
Avg. Publications_Capital	1,162.49	1,139.36	1,192.82	1,244.33	1,336.31
Avg. Publications_Non-Capital	823.56	805.47	811.73	849.72	850.17
Avg. Publications_Public	1,453.88	1,462.23	1,447.66	1,575.71	1,645.56
Avg. Publications_Private	812.54	788.27	820.23	845.28	869.66

pattern to funding allocation in average terms except for medical and pharmaceutical science.

Regarding funding inequality, non-science disciplines, such as the humanities and social sciences, are weaker than those of science and engineering disciplines. Moreover, disparities persist, with capital and private universities receiving more funding and producing more publications than their counterparts. However, the inequality coefficient for capital universities has increased, while that for private universities is in a reverse trend. Moreover, the study finds that funding inequality levels remain relatively stable over the years. Regarding publication inequality in disciplines, a similar pattern has observed to funding inequality. Interestingly, funding inequality for universities also shows a similar trend to publication inequality except that of capital-area universities in 2021.

CONCLUSION

In this study, we examine the disparities in funding, publications, and the academic system in Korea from both an individual and an organizational perspective. This study, which draws support for its conclusions from methodological rigor and empirical data, offers a thorough picture of the research funding landscape in South Korea and its consequences for scientific performances.

First, a resource concentration on science and engineering fields, such as engineering and medical and pharmaceutical sciences, is evident in the overall features of the Korean academic system, as outlined in Section 4.1. This is seen in the number of academics, funding, and publications in these fields. In terms of personal traits, research funding and publications are dominated by senior male professors in their 50s. Furthermore, compared to their peer universities, on average, public and capital-area universities generate twice as much funding and publish twice as many articles. The quantity and scope of projects have grown substantially over the past five years, while the number and percentage of supported scholars have stayed constant. Nonetheless, there has been a notable increase in the standard deviation of financing amounts. This indicates that financial inequality has worsened even if financing opportunities have improved over the past five years.

Second, our analysis shows differences in funding distribution and productivity during the past five years between fields, genders, and career stages at the individual level. Academics in scientific and engineering fields often receive the majority of funding. Funding levels and research productivity are usually correlated. Disparities in funding across non-science fields (e.g. the humanities and social sciences) are more pronounced than those between science and engineering fields. Science and engineering disciplines exhibit lower levels of discrepancy regarding publishing inequality than non-science subjects. Except for 2021, we see an overall rising trend in funding and publication inequality.

Thirdly, the analysis conducted at the university level has shown differences in funding distribution and productivity among research areas, geographical regions, and legal status during the past five years. The average term pattern of research productivity and budget allocation is comparable, except for medical and pharmaceutical science. In terms of funding inequality, the differences in levels have remained mostly constant throughout time. A comparable pattern regarding funding inequality has been noted with regard to publishing inequality across disciplines. Fascinatingly, university funding inequality has a pattern that is comparable to that of publishing inequality, apart from capital-area universities in 2021.

These analysis results shed light on the complex dynamics of research funding and productivity in South Korean academia, emphasizing the need for policies that balance excellence and equity in resource allocation. In this vein, we put forward some policy implications.

First, despite an increase in financing and publications overall and on average over the past five years, we have discovered that inequality, as determined by the Gini coefficient and standard deviation, has worsened. Thus, inequality is located in a distinct policy dimension of science and technology than that of publications and funding. Because this feature is a sensitive predictor of superior research systems, careful and persistent regulation of this policy variable is necessary.

Second, when it comes to funding disparities between disciplines, scientific and engineering fields receive significantly higher overall and average funding than non-science fields. Remarkably, disciplines indicate that organizational inequality exhibits a different tendency than individual inequality. Put differently, scientists and engineers exhibit lower levels of inequality at the individual level and higher levels of inequality at the organizational. On the other hand, universities in non-science fields have weaker organizational inequality, while their academics in those fields exhibit larger individual inequality. This implies that there should be a distinction made between the funding policies for individuals and universities.

Thirdly, certain groups, such as private universities, require greater policy action. However, we also need to consider organizational factors like location and legal status in order to support the scientific and engineering disciplines. Particularly, more attention needs to be paid to capital-area and private universities.

Lastly, we suggest some limitations of this study and upcoming future studies. First, in terms of the definition of inequality in policy practices, what happens when a research group grows because of a pressing need for policy? Is it detrimental to a nation's scientific system or other groups? There could be a 'good' inequality for the overall academic system. Secondly, we need an econometric model that uses inequality as a predictor of research productivity to perform a more sophisticated statistical analysis.

By comprehending the impact of inequality, we may improve the efficient distribution of funds throughout the academic research system.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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