Supplement tables

Table S1. Publication titles (publication years) and the numbers of total and OA documents of top 20 journals in the multidisciplinary science discipline between 2000 and 2021 and 2021.

Publication Titles (The year started being indexed in the database)	OA / Total 2000-21	OA% 2000-21	OA / Total 2021	OA% 2021
PLOS ONE (2006-)	249,766 / 249,932	99.9%	16,033 / 16,095	99.6%
SCIENTIFIC REPORTS (2011-)	145,003 / 145,039	100.0%	23,298 / 23,301	100.0%
PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF USA (1914-)	75,452 / 75,719	99.6%	3,557 / 3,800	93.6%
NATURE COMMUNICATIONS (2010-)	40,256 / 40,287	99.9%	6,912 / 6,919	99.9%
NATURE (1869-)	14,907 / 26,293	56.7%	805 / 1,292	62.3%
SCIENCE (1880-)	7,821 / 24,421	32.0%	536 / 1,000	53.6%
NEW SCIENTIST (1956-)	27 / 24,136	0.1%	4 / 798	0.5%
ANNALS OF THE NEW YORK ACADEMY OF SCIENCES (1823-)	1,748 / 14,290	12.2%	92 / 227	40.5%
CURRENT SCIENCE (1932-)	1,205 / 12,580	9.6%	343 / 422	81.3%
PEERJ (2013-)	12,535 / 12,578	99.7%	2,086 / 2,090	99.8%
JOVE JOURNAL OF VISUALIZED EXPERIMENTS (2006-)	8,749 / 10,905	80.2%	392 / 1,049	37.4%
CHINESE SCIENCE BULLETIN (1950-)	1,896 / 8,344	22.7%	283 / 394	71.8%
HELIYON (2015-)	8,102 / 8,139	99.5%	2,707 / 2,725	99.3%
ADVANCED SCIENCE LETTERS (2008-2019)	317 / 8,135	3.9%	0 / 0	0.0%
SCIENCE ADVANCES (2015-)	7,701 / 7,728	99.7%	1,969 / 1,994	98.7%
SYMMETRY BASEL (2009-)	7,614 / 7,623	99.9%	2,418 / 2,425	99.7%
ARABIAN JOURNAL FOR SCIENCE AND ENGINEERING (1975-)	244 / 7,040	3.5%	87 / 1,487	5.9%
DATA IN BRIEF (2014-)	6,348 / 6,359	99.8%	1,033 / 1,035	99.8%
INTERNATIONAL JOURNAL OF BIFURCATION AND CHAOS (1991-)	970 / 5,763	16.8%	42 / 303	13.9%
SCIENTIFIC WORLD JOURNAL (2012-2014)	5,691 / 5,692	100.0%	0 /0	0.0%
Others	89,953 / 168,111	53.5%	15,968 / 21,327	74.9%
Sum	686,485 / 869,114	79.0%	78,565 / 88,683	88.6%

The titles of nine recently founded OA journals are shadowed in green.

Table S2. Health and medicine category

Category		Health and medicine
	General	Eight disciplines in this subcategory include healthcare science services, public environmental occupational health, health policy services, medical ethics and others. These are generally considered as public goods and OA is very widely accepted. A total of 651,253 articles or 40.6% of total are available for OA service and the recent data in 2021 is 60.6%. (Suppl. table 1)
	Basic	Twelve disciplines in basic medical science are also high in OA. A total of 915,685 articles or 39.9% are available for OA. (Suppl. table 2)
	Clinical	Thirteen disciplines are in this category. Infectious diseases, general internal medicine and primary healthcare are in the high group of OA (50-59% in 2000-2021, 74-78% in 2021). Other clinical medicine disciplines are also high. A total of 1,601,713 articles or 40.5% of total are available for OA. (Suppl. table 3, Fig. 3, Suppl. Fig. 3)
	Organ systems	Twenty-one disciplines are in this category. Every organ system has high figure of proportion and number of documents produced is also increasing. A total of 1,750,733 articles or 37.4% are available for OA. (Suppl. table 4)
OA trends		The public demands on health and wellbeing reflect this trend. Authors willingly share their research, and health professionals feel happier if they become popular for their scientific excellence. The high rates of OA in articles on infectious disease and general healthcare are manifestations of the authors' willingness to share.
Library service plans		The information on health and medicine is relatively popular to the general public and new development of library services on health would be easy. The library services on health at public library, however, may need some additional connection to medical services. The roles of subject specialist librarians will include inviting local medical and healthcare professionals as volunteers to add values for ancillary services and possible arrangement of further health care services.

A general summary of four subcategories and their open access trends and possible plans for library services.

Table S3. Eight disciplines in the general health subcategory and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA / Total 2000-21	OA % 2000-21	OA / Total 2021	OA% 2021
Health Care Sciences Services	116,286 / 225,740	51.5%	21,464 / 30,331	70.8%
Public Environmental Occupational Health	318,610 / 623,309	51.1%	49,264 / 74,215	66.4%
Health Policy Services	54,448 / 122,556	44.4%	8,781 / 14,988	58.6%
Integrative Complementary Medicine	25,067 / 65,618	38.2%	3,275 / 6,950	47.1%
Medical Ethics	6,155 / 16,907	36.4%	890 / 1,556	57.2%
Veterinary Sciences	106,137 / 338,739	31.3%	13,935 / 24,849	56.1%
Dentistry Oral Surgery Medicine	51,681 / 202,526	25.5%	7,293 / 18,534	39.3%
Nursing	36,345 / 156,595	23.2%	6,730 / 18,388	36.6%
sum	**651,253 / 1,603,834**	**40.6%**	**96,328 / 158,997**	**60.6%**

Table S4. Twelve disciplines in the basic health subcategory and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA / Total 2000-21	OA % 2000-21	OA / Total 2021	OA% 2021
Tropical Medicine	49,426 / 71,023	69.6%	4,179 / 5,395	77.5%
Parasitology	57,352 / 107,213	53.5%	5,159 / 7,484	68.9%
Medicine Research Experimental	232,095 / 466,931	49.7%	31,670 / 46,615	67.9%
Substance Abuse	33,280 / 73,610	45.2%	3,259 / 7,421	43.9%
Nutrition Dietetics	104,969 / 239,430	43.8%	13,321 / 26,051	51.1%
Physiology	97,615 / 242,077	40.3%	7,023 / 13,608	51.6%
Anatomy Morphology	16,585 / 44,179	37.5%	1,118 / 3,808	29.4%
Medical Informatics	32,943 / 91,073	36.2%	5,530 / 8,250	67.0%
Pharmacology Pharmacy	281,909 / 837,120	33.7%	40,413 / 76,779	52.6%
Pathology	59,231 / 181,309	32.7%	4,280 / 10,337	41.4%
Medical Laboratory Technology	21,083 / 72,935	28.9%	2,034 / 4,651	43.7%
Medicine Legal	5,461 / 38,381	14.2%	951 / 2,874	33.1%
sum	**915,685 / 2,295,253**	**39.9%**	**103,462 / 182,939**	**56.6%**

Table S5. Thirteen disciplines in the health, clinical medicine subcategory and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA / Total 2000-21	OA % 2000-21	OA / Total 2021	OA% 2021
Infectious Diseases	184,880 / 315,598	58.6%	21,036 / 28,239	74.5%
Medicine General Internal	384,794 / 720,985	53.4%	71,360 / 91,608	77.9%
Primary Health Care	19,805 / 39,743	49.8%	2,716 / 3,621	75.0%
Oncology	401,013 / 817,476	49.1%	48,776 / 74,632	65.4%
Geriatrics Gerontology	52,633 / 116,967	45.0%	8,139 / 13,596	59.9%
Transplantation	39,999 / 112,874	35.4%	2,704 / 6,479	41.7%
Anesthesiology	43,944 / 131,829	33.3%	4,043 / 9,293	43.5%
Radiology Nuclear Medicine Medical Imaging	154,283 / 488,115	31.6%	17,619 / 36,349	48.5%
Rehabilitation	47,825 / 160,001	29.9%	5,487 / 14,847	37.0%
Critical Care Medicine	35,847 / 130,183	27.5%	4,368 / 8,795	49.7%
Emergency Medicine	21,230 / 80,006	26.5%	3,642 / 8,049	45.2%
Pediatrics	95,805 / 366,763	26.1%	15,259 / 33,208	45.9%
Surgery	207,041 / 817,089	25.3%	24,006 / 67,499	35.6%
sum	**1,601,713 / 3,956,573**	**40.5%**	**209,337 / 344,556**	**60.8%**

Table S6. Twenty-one disciplines in the health by organ systems subcategory and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA / Total 2000-21	OA % 2000-21	OA / Total 2021	OA% 2021
Andrology	6,405 / 12,634	50.7%	837 / 1,530	54.7%
Respiratory System	108,515 / 219,503	49.4%	10,416 / 17,303	60.2%
Neuroimaging	26,558 / 55,570	47.8%	2,917 / 4,432	65.8%
Peripheral Vascular Disease	111,178 / 235,325	47.2%	6,796 / 14,778	46.0%
Rheumatology	52,552 / 111,866	47.0%	5,564 / 9,992	55.7%
Cardiac Cardiovascular Systems	213,044 / 466,015	45.7%	21,347 / 38,051	56.1%
Endocrinology Metabolism	161,998 / 373,421	43.4%	15,052 / 28,063	53.6%
Neurosciences	344,808 / 802,187	43.0%	35,091 / 59,322	59.2%
Hematology	106,557 / 258,014	41.3%	8,851 / 17,169	51.6%
Gastroenterology Hepatology	110,717 / 289,661	38.2%	12,495 / 23,005	54.3%
Psychiatry	147,370 / 408,015	36.1%	18,905 / 37,746	50.1%
Ophthalmology	76,738 / 218,614	35.1%	8,391 / 17,712	47.4%
Urology Nephrology	85,463 / 247,308	34.6%	9,233 / 18,684	49.4%
Clinical Neurology	208,492 / 608,454	34.3%	24,411 / 51,373	47.5%
Audiology Speech Language Pathology	17,178 / 51,430	33.4%	1,708 / 3,997	42.7%
Orthopedics	78,105 / 250,672	31.2%	10,339 / 23,733	43.6%
Allergy	17,970 / 63,216	28.4%	2,973 / 5,165	57.6%
Obstetrics Gynecology	74,939 / 270,016	27.8%	8,367 / 21,404	39.1%
Dermatology	49,941 / 195,503	25.5%	6,864 / 17,707	38.8%
Acoustics	38,853 / 156,984	24.7%	4,941 / 11,492	43.0%
Otorhinolaryngology	27,988 / 125,940	22.2%	4,202 / 11,013	38.2%
sum	**1,750,733 / 4,675,775**	**37.4%**	**177,316 / 340,186**	**52.1%**

Table S7. Natural science category

Category		Natural sciences
	Physics and astronomy	Twelve disciplines in this subcategory has extremes from high 88% to low 21%. Particles fields physics and astronomy are frontiers in OA movement. Some technology-oriented disciplines such as spectroscopy and optics are low in OA. The amount of publication and available OA resources are huge (1.6 million OA articles in 22 years or 33.4% of total). (Suppl. table 5, Fig. 4, Suppl. fig. 4)
	Bioscience	Twenty-three disciplines are generally high in OA. Infectious diseases related subjects like microbiology and virology are the highest up to 76% in 2021. Other subject domains are relatively high but some technology-oriented sciences like microscopy and ornithology are low in OA (31-34% in 2021). The available OA articles during 22 years are 2.4 million or 45.6% of all. (Suppl. table 6, Suppl. figs 5-6)
	Chemistry	Nine disciplines in this subcategory was low in OA (21.4% in 22 years) but the recent trends in 2021 is increasing (41.0%). The proportion of OA in multidisciplinary chemistry is 58% in 2021. Some disciplines such as organic chemistry and inorganic nuclear chemistry are still low in OA (15.4 and 16.3% in 2021). The number of OA articles available in 22-year-period is huge (834.015 articles) but the proportion is still low (21.4% of total). (Supple. table 7)
	Mathematics	Five disciplines in this subcategory is high in OA. The number of OA articles available in 22-year-period is huge (637,140 articles or 44.4% of total) and the data in 2021 is even higher (54.6%). (Supple. table 8)
	Environmental	Four disciplines in this subcategory are high in OA. A total of 463,807 OA articles or 31.3% of total are available. (Suppl. table 9, Suppl. fig 7)
	Geoscience	Six disciplines in this subcategory is high in OA. Multidisciplinary geoscience is the highest (47.6% in 2021). The number of OA articles available in 22-year-period is 299,490 articles or 31.1% of total. (Supple. table 10)
	Agriculture, fishery, forestry	Eleven disciplines are high in OA and dairy animal science limnology and forestry rank high (35-47% in 2000-2021, 48-66% in 2021). The number of OA articles available in 22-year-period is 427,452 articles or 28.9% of total. (Suppl. table 11, Suppl. figs 8-9)
OA trends		Bioscience has overlapping features with healthcare and medicine and OA is well accepted particularly on those subjects related to infectious diseases. The general trend of OA is high in every subcategories and disciplines but individual variations are present. The discipline of astronomy/physics is a peculiar case. Researchers on high-energy physics initiated their own OA projects from astrophysics and since 2014, have made collective efforts on OA. The Sponsoring Consortium for Open Access Publishing in Particle Physics (or SCOAP3) covers more than 11 journals, books, and repositories. Chemistry and industry-oriented sciences are relatively lower in OA.
Library service plans		Special libraries on environment, agriculture, fishery, forestry will the great benefit from OA resources. Natural sciences like biosciences, physics and mathematics have good condition for library services using OA resources. Chemistry and geosciences have some limitation but the recent trend becomes better on OA availability.

A general summary of seven subcategories and their open access trends and possible plans for library services.

Table S8. Twelve disciplines in the physics and astronomy subcategory and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA / Total 2000-21	OA % 2000-21	OA / Total 2021	OA% 2021
Physics Particles Fields	207,572 / 300,150	69.2%	12,762 / 14,490	88.1%
Astronomy Astrophysics	338,334 / 498,413	67.9%	21,296 / 25,628	83.1%
Meteorology Atmospheric Sciences	124,059 / 258,896	47.9%	11,744 / 20,788	56.5%
Physics Mathematical	110,184 / 232,968	47.3%	6,828 / 12,766	53.5%
Physics Nuclear	87,154 / 188,707	46.2%	3,600 / 5,691	63.3%
Physics Multidisciplinary	245,315 / 538,122	45.6%	17,214 / 30,116	57.2%
Physics Fluids Plasmas	72,624 / 202,172	35.9%	5,427 / 11,809	46.0%
Physics Atomic Molecular Chemical	96,553 / 354,453	27.2%	6,393 / 19,025	33.6%
Physics Applied	394,213 / 1,598,223	24.7%	49,827 / 108,304	46.0%
Physics Condensed Matter	175,176 / 741,392	23.6%	17,913 / 45,662	39.2%
Optics	197,209 / 934,658	21.1%	14,644 / 47,415	30.9%
Spectroscopy	21,774 / 156,597	13.9%	1,684 / 7,950	21.2%
sum	**1,564,141 / 4,685,703**	**33.4%**	**131,878 / 272,246**	**48.4%**

Table S9. Twenty-three disciplines in the biosciences subcategory of the natural sciences and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA/ Total 2000-21	OA % 2000-21	OA / Total 2021	OA% 2021
Microbiology	299,712 / 452,398	66.2%	29,965 / 39,754	75.4%
Virology	86,207 / 137,525	62.7%	7,457 / 9,747	76.5%
Developmental Biology	54,727 / 93,283	58.7%	5,497 / 7,229	76.0%
Cell Biology	343,653 / 589,209	58.3%	28,845 / 41,651	69.3%
Evolutionary Biology	65,292 / 121,120	53.9%	5,342 / 7,990	66.9%
Genetics Heredity	229,281 / 431,050	53.2%	20,154 / 29,492	68.3%
Biology	127,841 / 245,362	52.1%	15,859 / 23,600	67.2%
Immunology	261,411 / 524,218	49.9%	26,792 / 39,980	67.0%
Biochemistry Molecular Biology	594,744 / 1,242,120	47.9%	57,336 / 92,157	62.2%
Reproductive Biology	42,623 / 100,319	42.5%	2,109 / 5,728	36.8%
Biotechnology Applied Microbiology	229,180 / 546,349	41.9%	20,702 / 38,306	54.0%
Ecology	148,733 / 379,298	39.2%	15,972 / 28,236	56.6%
Biodiversity Conservation	40,475 / 105,671	38.3%	7,060 / 10,180	69.4%
Plant Sciences	177,266 / 481,791	36.8%	20,576 / 41,111	50.0%
Biochemical Research Methods	111,969 / 312,074	35.9%	7,860 / 17,151	45.8%
Mycology	14,235 / 40,876	34.8%	1,802 / 2,930	61.5%
Biophysics	95,320 / 284,663	33.5%	4,833 / 13,947	34.7%
Toxicology	66,067 / 224,949	29.4%	6,937 / 15,868	43.7%
Zoology	73,756 / 257,392	28.7%	8,935 / 19,049	46.9%
Entomology	37,347 / 136,744	27.3%	4,119 / 10,264	40.1%
Development Studies	11,531 / 42,834	26.9%	1,776 / 4,803	37.0%
Ornithology	5,950 / 25,914	23.0%	466 / 1,355	34.4%
Microscopy	5,464 / 30,396	18.0%	469 / 1,512	31.0%
sum	2,362,519 / 5,184,878	45.6%	234,480 / 376,198	62.3%

Table S10. Nine disciplines in the chemistry subcategory of the natural sciences and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA / Total 2000-21	OA % 2000-21	OA / Total 2021	OA% 2021
Chemistry Multidisciplinary	368,189 / 1,186,581	31.0%	68,731 / 118,367	58.1%
Crystallography	46,050 / 175,612	26.2%	3,209 / 7,743	41.4%
Chemistry Medicinal	61,959 / 271,366	22.8%	8,930 / 21,926	40.7%
Chemistry Analytical	107,876 / 486,100	22.2%	16,260 / 39,432	41.2%
Chemistry Physical	198,920 / 1,192,979	16.7%	27,786 / 103,010	27.0%
Electrochemistry	32,134 / 254,076	12.6%	4,268 / 17,622	24.2%
Chemistry Applied	37,071 / 302,126	12.3%	4,244 / 26,992	15.7%
Chemistry Organic	47,560/ 418,614	11.4%	3,276 / 20,072	16.3%
Chemistry Inorganic Nuclear	23,973 / 274,931	8.7%	2,350 / 15,247	15.4%
sum	**834,015 / 3,895,728**	**21.4%**	**127,198 / 310,400**	**41.0%**

Table S11. Five disciplines in the mathematics subcategory of the natural sciences and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA/ Total 2000-21	OA % 2000-21	OA / Total 2021	OA% 2021
Mathematics	307,581 / 572,146	53.8%	28,963 / 48,486	59.7%
Mathematical Computational Biology	75,530 / 154,593	48.9%	7,599 / 12,193	62.3%
Mathematics Applied	252,566 / 596,279	42.4%	22,191 / 44,689	49.7%
Statistics Probability	83,770 / 208,268	40.2%	7,655 / 16,183	47.3%
Mathematics Interdisciplinary Applications	78,058 / 204,732	38.1%	10,771 / 20,301	53.1%
sum	**637,140 / 1,434,463**	**44.4%**	**59,396 / 108,706**	**54.6%**

Table S12. Four disciplines in the environmental sciences subcategory and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA / Total 2000-21	OA % 2000-21	OA / Total 2021	OA% 2021
Environmental Studies	89,337 / 202,086	44.2%	21,881 / 31,707	69.0%
Green Sustainable Science Technology	88,732 / 219,448	40.4%	21,952 / 39,838	55.1%
Environmental Sciences	359,919 / 1,060,389	33.9%	73,607 / 142,113	51.8%
Water Resources	79,527 / 306,762	25.9%	12,217 / 27,303	44.7%
sum	**463,807 / 1,479,662**	**31.3%**	**87,502 / 176,498**	**49.6%**

Table S13. Six disciplines in the geosciences subcategory and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA/ Total 2000-21	OA % 2000-21	OA/ Total 2021	OA% 2021
Geosciences Multidisciplinary	163,002 / 505,335	32.3%	20,447 / 42,988	47.6%
Geochemistry Geophysics	68,639 / 212,912	32.2%	6,867 / 16,357	42.0%
Geography	28,751 / 90,833	31.7%	4,581 / 10,393	44.1%
Geography Physical	35,810 / 116,967	30.6%	4,460 / 8,598	51.9%
Geology	15,014 / 68,306	22.0%	2,307 / 4,811	48.0%
Area Studies	12,401 / 64,155	19.3%	1,841 / 6,317	29.1%
sum	**299,490 / 963,123**	**31.1%**	**35,759 / 77,389**	**46.2%**

Table S14. Eleven disciplines in the agriculture, fishery, and forestry subcategory and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA/ Total 2000-21	OA % 2000-21	OA/ Total 2021	OA% 2021
Agriculture Dairy Animal Science	79,307 / 168,013	47.2%	9,332 / 14,191	65.8%
Limnology	17,354 / 42,210	41.1%	1,081 / 2,868	37.7%
Forestry	39,217 / 110,650	35.4%	5,272 / 9,737	54.1%
Agriculture Multidisciplinary	48,941 / 154,290	31.7%	5,108 / 10,660	47.9%
Agricultural Economics Policy	8,775 / 30,653	28.6%	1,487 / 3,169	46.9%
Marine Freshwater Biology	61,395 / 225,369	27.2%	6,046 / 16,395	36.9%
Agronomy	58,330 / 220,263	26.5%	9,686 / 19,911	48.6%
Food Science Technology	117,773 / 455,563	25.9%	18,733 / 47,892	39.1%
Fisheries	29,307 / 119,185	24.6%	2,821 / 9,187	30.7%
Agricultural Engineering	13,394 / 75,984	17.6%	1,620 / 5,733	28.3%
Soil Science	17,272 / 100,768	17.1%	2,468 / 8,232	30.0%
sum	427,452 / 1,477,346	28.9%	55,098 / 121,890	45.2%

Table S15. Social sciences and others category

Category		Social sciences and others
	Social Sciences general	Eighteen disciplines show similar pattern of OA to other disciplines in social sciences. A total of 359,693 OA articles or 26.3% of total are available. (Suppl. table 12, Suppl. fig 13)
	Psychology	Eleven disciplines of this subcategory show medium high acceptance of OA. The number of documents produced in this discipline is not big and these disciplines are related each other. A total of 292,831 OA articles or 31.8% of total are available in 2000-2021. (Suppl. table 13)
	Education and Ethics	Five disciplines show similar pattern of OA to other disciplines in social sciences. A total of 162,213 OA articles or 24.9% of total are available. (Suppl. table 14, Suppl. Fig. 10)
	Law Economics Management	Eight disciplines are mixture of different subjects. The discipline economics shows higher rate of OA (31.9% in 2000-2021, 44.3% in 2021) and law, business and management subjects are lower in OA. A total of 432,027 OA articles or 23.8% of total are not big numbers but the available resources are increasing. (Suppl. table 15, Fig. 5, Suppl. figs. 11,12,14)
OA trends		The OA trends of social sciences, law, economics and management are relatively low and average in 2000-2021 was 23.8%. The recent data is increasing (36.2%).
Library service plans		Library services on scholarly documents on the social science is not very popular and peoples' demand is not evident. Subject specialist librarians will help users on these subjects. Someone in need may be those in international business or those in juridical process and public services will be considered for them.

General summary of four subcategories and their open access trends and possible plans for library services

Table S16. Eighteen disciplines in the general social sciences subcategory and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA/ Total 2000-21	OA % 2000-21	OA/ Total 2021	OA% 2021
Gerontology	26,198 / 65,884	39.8%	3,502 / 7,102	49.3%
Demography	9,126 / 23,409	39.0%	1,380 / 2,896	47.7%
Social Sciences Biomedical	23,596 / 63,909	36.9%	2,831 / 6,136	46.1%
Oceanography	55,615 / 151,306	36.8%	4,430 / 10,851	40.8%
Social Sciences Mathematical Methods	19,763 / 55,065	35.9%	2,335 / 4,295	54.4%
Industrial Relations Labor	6,444 / 23,714	27.2%	920 / 2,372	38.8%
Social Sciences Interdisciplinary	50,817 / 204,179	24.9%	8,672 / 17,610	49.2%
Information Science Library Science	30,011 / 120,675	24.9%	3,727 / 10,095	36.9%
Family Studies	13,506 / 55,946	24.1%	1,993 / 7,433	26.8%
Sociology	29,510 / 122,426	24.1%	4,924 / 11,724	42.0%
Social Issues	11,413 / 51,267	22.3%	1,743 / 3,997	43.6%
Social Work	11,336 / 51,830	21.9%	2,083 / 6,891	30.2%
Philosophy	28,184 / 130,910	21.5%	5,452 / 12,940	42.1%
Public Administration	10,832 / 52,181	20.8%	2,095 / 5,180	40.4%
Religion	20,062 / 97,983	20.5%	3,733 / 9,634	38.7%
Political Science	34,500 / 172,357	20.0%	6,101 / 16,079	37.9%
Women S Studies	6,518 / 37,398	17.4%	979 / 3,689	26.5%
Asian Studies	2,695 / 26,386	10.2%	307 / 2,044	15.0%
sum	**359,693 / 1,368,694**	**26.3%**	**45,918 / 110,474**	**41.6%**

Table S17. Eleven disciplines in the psychology subcategory and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA / Total 2000-21	OA % 2000-21	OA / Total 2021	OA% 2021
Psychology Mathematical	7,152 / 13,088	54.6%	667 / 1,028	64.9%
Psychology	55,088 / 140,534	39.2%	5,133 / 10,986	46.7%
Psychology Experimental	53,640 / 138,674	38.7%	5,433 / 10,931	49.7%
Psychology Multidisciplinary	69,505 / 185,382	37.5%	12,500 / 22,318	56.0%
Behavioral Sciences	44,437 / 128,016	34.7%	3,744 / 8,824	42.4%
Psychology Developmental	32,340 / 98,213	32.9%	3,906 / 10,163	38.4%
Psychology Clinical	48,257 / 155,241	31.1%	6,327 / 16,186	39.1%
Psychology Biological	9,873 / 32,705	30.2%	950 / 2,375	40.0%
Psychology Educational	11,548 / 49,909	23.1%	1,746 / 5,219	33.5%
Psychology Social	15,807 / 77,579	20.4%	2,382 / 7,033	33.9%
Criminology Penology	10,268 / 51,509	19.9%	2,087 / 7,585	27.5%
sum	**292,831 / 921,275**	**31.8%**	**34,277 / 77,712**	**44.1%**

Table S18. Five disciplines in the education and ethics subcategory and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA / Total 2000-21	OA % 2000-21	OA / Total 2021	OA% 2021
Education Scientific Disciplines	40,733 / 152,104	26.8%	5,294 / 13,596	38.9%
Ethics	12,738 / 49,545	25.7%	2,117 / 4,333	48.9%
Education Educational Research	108,025 / 442,656	24.4%	18,471 / 44,647	41.4%
Ethnic Studies	3,957 / 18,597	21.3%	843 / 2,675	31.5%
Education Special	5,832 / 30,667	19.0%	921 / 3,227	28.5%
sum	**162,213 / 651,781**	**24.9%**	**23,799 / 57,218**	**41.6%**

Table S19. Eight disciplines in the law, economics, and management subcategory and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA / Total 2000-21	OA % 2000-21	OA / Total 2021	OA% 2021
Economics	154,863 / 484,794	31.9%	18,027 / 40,724	44.3%
Communication	22,765 / 88,168	25.8%	4,161 / 11,294	36.8%
Business Finance	34,507 / 142,927	24.1%	4,980 / 14,653	34.0%
International Relations	17,415 / 86,858	20.0%	2,937 / 8,073	36.4%
Law	25,910 / 139,705	18.5%	4,370 / 13,266	32.9%
Management	59,856 / 337,419	17.7%	9,509 / 30,581	31.1%
Business	44,159 / 250,635	17.6%	7,204 / 23,773	30.3%
Operations Research Management Science	44,936 / 273,941	16.4%	6,036 / 19,981	30.2%
sum	342,027 / 1,440,011	23.8%	43,776 / 120,813	36.2%

Table S20. Engineering category

Category		Engineering
	General	Twelve disciplines are in this subcategory and they are basic subjects on engineering. Many of disciplines are relatively high in OA. Cell tissue engineering is a special group high in OA (60.1% in 2000-2021 and 69.3% in 2021). Other disciplines high in OA are remote sensing, imaging science photographic technology, quantum science technology, and instrument instrumentation. Information of these subjects would be useful to many manufacturing industries regardless of their items produced. A total of 579,970 articles are available for OA, which covers 33.4% (Suppl. table 16)
	Architecture, urban planning, construction	Six disciplines are relatively low in OA but are increasing in 2021 OA trends are not different by disciplines in this subcategory and raged 17-28% in 2000-2021 and 34-39% in 2021. A total of 114, 478 articles or 19.7% of total are available for OA. (Suppl. table 17).
	Computer	Computer engineering is another type of intellectual property rights related domain and OA rate is relatively low. A total of 712,959 articles or 18.0% of total are available for OA. (Suppl. table 18)
	Major	Sixteen disciplines in this subcategory are major industry-related domains. Average of OA in 2000-2021 was 17.1% and the most recent data in 2021 is 34.3%. The multidisciplinary and marine engineering are relatively high (57.2% and 50.2% in 2021). Chemical and geological engineering are among the lowest group (19.1% and 18.8% in 2021). A total of 1.2 million articles are available for OA but they cover 17.1% of all produced documents in this domain. (Suppl. table 19, Fig. 6, Suppl. fig. 15)
	Materials	Ten disciplines in this subcategory is also low in OA. Multidisciplinary material science, biomaterials, mineralogy, paper wood are relatively higher but at the level of 33-45% in 2021 (16-23% in 2000-2021). A total of 632,433 articles or 20.2% of total are available for OA. (Suppl. table 20)
OA trends		Engineering category is highly related to intellectual property rights and OA is not well accepted in this category. The proportion of OA articles are lower than natural sciences and health and medicine. Multidisciplinary research subjects on engineering, however, would be a glue to fill the gap between disciplines.
Library service plans		Information on specific subject domains would be acquired through toll-based subscription by companies and OA would not be very useful to those requirements. Technical information on general engineering domains would be additionally served and twelve disciplines of general engineering would be a common OA resources for those at different engineering disciplines.

General summary of five subcategories and their open access trends and possible plans for library services

Table S21. Twelve disciplines in the general engineering subcategory and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA / Total 2000-21	OA % 2000-21	OA / Total 2021	OA% 2021
Cell Tissue Engineering	27,593 / 45,917	60.1%	3,013 / 4,350	69.3%
Quantum Science Technology	17,269 / 48,677	35.5%	2,359 / 5,137	45.9%
Remote Sensing	50,798 / 210,386	24.1%	9,362 / 15,892	58.9%
Instruments Instrumentation	105,606 / 470,538	22.4%	17,008 / 35,963	47.3%
Energy Fuels	155,483 / 750,674	20.7%	24,906 / 76,225	32.7%
Imaging Science Photographic Technology	63,890 / 309,040	20.7%	13,151 / 26,113	50.4%
Mining Mineral Processing	14,007 / 68,959	20.3%	2,603 / 5,738	45.4%
Mechanics	94,149 / 465,505	20.2%	10,270 / 35,319	29.1%
Ergonomics	6,335 / 36,489	17.4%	904 / 3,452	26.2%
Robotics	34,106 / 197,283	17.3%	4,424 / 11,578	38.2%
Nuclear Science Technology	35,436 / 223,983	15.8%	2,749 / 11,342	24.2%
Thermodynamics	41,054 / 261,439	15.7%	5,544 / 23,224	23.9%
sum	**579,970 / 1,735,150**	**33.4%**	**83,271 / 213,787**	**39.0%**

Table S22. Six disciplines in the architecture, urban planning, and construction subcategory and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA / Total 2000-21	OA % 2000-21	OA / Total 2021	OA% 2021
Urban Studies	16,818 / 60,401	27.8%	2,448 / 6,300	38.9%
Transportation	18,201 / 69,792	26.1%	2,048 / 6,565	31.2%
Regional Urban Planning	15,414 / 68,717	22.4%	2,289 / 6,044	37.9%
Construction Building Technology	43,884 / 226,290	19.4%	6,662 / 23,437	28.4%
Transportation Science Technology	29,757 / 166,933	17.8%	4,025 / 13,145	30.6%
Architecture	11,760 / 67,717	17.4%	1,135 / 3,362	33.8%
sum	**114,478 / 580,902**	**19.7%**	**15,260 / 48,643**	**31.4%**

Table S23. Nine disciplines in the computer engineering subcategory and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA / Total 2000-21	OA % 2000-21	OA / Total 2021	OA% 2021
Computer Science Information Systems	220,397 / 923,310	23.9%	36,493 / 73,070	49.9%
Computer Science Software Engineering	92,820 / 444,024	20.9%	10,210 / 30,332	33.7%
Computer Science Theory Methods	196,592 / 1,064,426	18.5%	15,279 / 48,818	31.3%
Computer Science Interdisciplinary Applications	115,245 / 624,063	18.5%	12,638 / 42,580	29.7%
Telecommunications	159,867 / 912,505	17.5%	23,997 / 56,989	42.1%
Computer Science Artificial Intelligence	152,926 / 1,025,027	14.9%	21,436 / 67,926	31.6%
Automation Control Systems	78,852 / 574,448	13.7%	9,446 / 30,899	30.6%
Computer Science Cybernetics	16,449 / 125,085	13.2%	1,694 / 8,096	20.9%
Computer Science Hardware Architecture	44,490 / 357,240	12.5%	3,897 / 18,377	21.2%
sum	**712,959 / 3,954,395**	**18.0%**	**84,288 / 228,652**	**36.9%**

Table S24. Sixteen disciplines in the major engineering subcategory and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA / Total 2000-21	OA % 2000-21	OA / Total 2021	OA% 2021
Engineering Multidisciplinary	135,126 / 413,959	32.6%	25,028 / 43,733	57.2%
Nanoscience Nanotechnology	149,217 / 639,231	23.3%	21,029 / 60,428	34.8%
Metallurgy Metallurgical Engineering	88,145 / 420,813	20.9%	15,998 / 35,999	44.4%
Engineering Biomedical	77,029 / 376,110	20.5%	9,527 / 25,617	37.2%
Engineering Ocean	10,382 / 54,881	18.9%	2,097 / 4,899	42.8%
Engineering Marine	9,261 / 49,320	18.8%	2,397 / 4,775	50.2%
Engineering Environmental	62,129 / 350,353	17.7%	8,731 / 38,851	22.5%
Engineering Civil	72,512 / 444,173	16.3%	10,947 / 43,651	25.1%
Engineering Petroleum	8,547 / 56,408	15.2%	1,191 / 4,079	29.2%
Engineering Manufacturing	37,432 / 252,566	14.8%	3,366 / 13,597	24.8%
Engineering Industrial	31,559 / 218,966	14.4%	2,783 / 13,690	20.3%
Engineering Mechanical	98,422 / 700,777	14.0%	9,980 / 39,672	25.2%
Engineering Electrical Electronic	429,428 / 3,083,074	13.9%	59,027 / 171,894	34.3%
Engineering Aerospace	20,360 / 152,040	13.4%	2,374 / 8,898	26.7%
Engineering Geological	13,618 / 110,163	12.4%	2,015 / 10,736	18.8%
Engineering Chemical	75,098 / 639,660	11.7%	11,669 / 61,123	19.1%
sum	**1,206,647 / 7,058,382**	**17.1%**	**171,621 / 500,285**	**34.3%**

Table S25. Ten disciplines in the materials engineering subcategory and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA / Total 2000-21	OA % 2000-21	OA / Total 2021	OA% 2021
Materials Science Multidisciplinary	489,177 / 2,135,321	22.9%	75,583 / 192,776	39.2%
Materials Science Biomaterials	30,254 / 135,252	22.4%	4,107 / 12,494	32.9%
Mineralogy	11,976 / 63,412	18.9%	2,177 / 5,151	42.3%
Materials Science Paper Wood	7,295 / 44,924	16.2%	1,210 / 2,709	44.7%
Polymer Science	63,332 / 404,011	15.7%	10,554 / 32,692	32.3%
Materials Science Coatings Films	18,961 / 173,976	10.9%	3,220 / 11,981	26.9%
Materials Science Ceramics	15,329 / 144,512	10.6%	1,554 / 9,256	16.8%
Materials Science Composites	11,207 / 113,382	9.9%	1,551 / 9,109	17.0%
Materials Science Textiles	5,063 / 56,183	9.0%	960 / 5,512	17.4%
Materials Science Characterization Testing	8,825 / 108,062	8.2%	1,182 / 6,202	19.1%
sum	**632,433 / 3,129,774**	**20.2%**	**94,708 / 259,976**	**36.4%**

Table S26. Humanities and arts category

Category		Humanities and arts
	General	Disciplines of logic, linguistics, anthropology and others are in this subcategory. OA proportion is generally high in this subcategory and OA was 35-47% in 2021. A total of 103,800 articles (22.2%. of total) are available for OA. (Suppl. table 21, Suppl. fig. 16)
	History	OA was high (51% in 2021) in philosophical history discipline but low in classic and other history disciplines (24-40%). Limited number of articles (66,306 articles or 19.7% of total) are available for OA. (Suppl. table 22)
	Literature	Ten disciplines on different aspects of literature are generally low in OA. Limited numbers of articles (19,770 articles or 11.6% of total) are available for OA. (Suppl. table 23, Fig. 7)
	Arts	Eight disciplines of different aspects of arts are in this subcategory. OA proportion was generally low and 108,873 articles (19.3% of total) are available for OA. (Suppl. table 24)
OA trends		Academic research papers on humanities are valuable resources although major parts of artefacts are more often published on monographs. Articles on the basic parts like logic and linguistics are published recently as OA but the general trend of OA is still low.
Library service plans		The publication on the literature, history and arts are usually on monographs and books are major resources for library services on humanities. The users favor electronic or analog versions of books, and digital transformation in these subject domains are slower. It is necessary, however, to keep old literature available online so that it can be searched by those who want to get the knowledge details. Wikipedia and other types of on-line resources are used for these subjects, and open access documents will add more value to these existing knowledge resources.

General summary of four subcategories and their open access trends and possible plans for library services.

Table S27. Seven disciplines in the general humanitiessubcategory and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA / Total 2000-21	OA % 2000-21	OA / Total 2021	OA% 2021
Logic	10,321 / 24,952	41.4%	918 / 1,966	46.7%
Linguistics	29,323 / 123,520	23.7%	4,224 / 12,383	34.1%
Language Linguistics	27,478 / 120,096	22.9%	4,476 / 11,687	38.3%
Anthropology	15,721 / 75,086	20.9%	2,079 / 5,509	37.7%
Archaeology	11,454 / 59,887	19.1%	1,949 / 5,276	36.9%
Humanities Multidisciplinary	27,367 / 144,219	19.0%	4,962 / 12,751	38.9%
Folklore	969 / 6,741	14.4%	141 / 400	35.3%
sum	**103,800 / 468,470**	**22.2%**	**14,978 / 39,530**	**37.9%**

Table S28. Six disciplines in the history subcategory and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA / Total 2000-21	OA % 2000-21	OA / Total 2021	OA% 2021
History Philosophy of Science	15,693 / 53,113	29.5%	2,592 / 5,073	51.1%
Paleontology	11,430 / 54,297	21.1%	1,163 / 3,894	29.9%
History of Social Sciences	3,891 / 19,716	19.7%	503 / 1,649	30.5%
History	32,343 / 182,053	17.8%	4,973 / 14,536	34.2%
Medieval Renaissance Studies	3,395 / 20,044	16.9%	628 / 1,497	42.0%
Classics	1,816 / 20,131	9.0%	242 / 994	24.3%
sum	**66,306 / 336,673**	**19.7%**	**8,994 / 24,362**	**36.9%**

Table S29. Ten disciplines in the literature subcategory of the humanities and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA/ Total 2000-21	OA % 2000-21	OA/ Total 2021	OA% 2021
Literature Romance	7,541 / 41,276	18.3%	984 / 2,776	35.4%
Literature Slavic	1,371 / 9,329	14.7%	268 / 535	50.1%
Literature	8,980 / 82,925	10.8%	1,451 / 5,353	27.1%
Literary Theory Criticism	1,814 / 24,102	7.5%	317 / 1,386	22.9%
Literature British Isles	578 / 9,065	6.4%	68 / 368	18.5%
Poetry	353 / 5,648	6.3%	25 / 171	14.6%
Literature African Australian Canadian	193 / 4,225	4.6%	22 / 137	16.1%
Literature German Dutch Scandinavian	487 / 11,582	4.2%	72 / 515	14.0%
Literature American	287 / 8,192	3.5%	27 / 434	6.2%
Literary Reviews	914 / 39,616	2.3%	22 / 1,373	1.6%
sum	19,770 / 171,127	11.6%	2,864 / 9,957	28.8%

Table S30. Eight disciplines in the arts subcategory and the numbers of total and OA documents in 2000–2021 and 2021

Disciplines	OA/ Total 2000-21	OA % 2000-21	OA/ Total 2021	OA% 2021
Horticulture	24,875 / 113,751	21.9%	2,274 / 5,377	42.3%
Hospitality Leisure Sport Tourism	14,262 / 68,188	20.9%	2,974 / 10,355	28.7%
Cultural Studies	4,413 / 27,722	15.9%	789 / 2,782	28.4%
Film Radio Television	2,959 / 25,838	11.5%	397 / 1,714	23.2%
Theater	2,001 / 18,466	10.8%	197 / 1,136	17.3%
Art	7,096 / 69,261	10.2%	764 / 3,229	23.7%
Music	4,554 / 47,677	9.6%	686 / 2,585	26.5%
Dance	205 / 9,617	2.1%	30 / 223	13.5%
sum	**108,873 / 564,252**	**19.3%**	**13,267/ 38,240**	**34.7%**

Table S31. The four types of economic status of journal goods according to Ostrom

	Excludable	Non-excludable
Rivalrous consumption	***Private goods*** Paper journal from personal subscription	***Common-pool resources*** Traditional library services on paper journals
Non-rivalrous consumption	***Club goods*** Paywalled e-journals	***Public goods*** Open access journals

Supplement figures

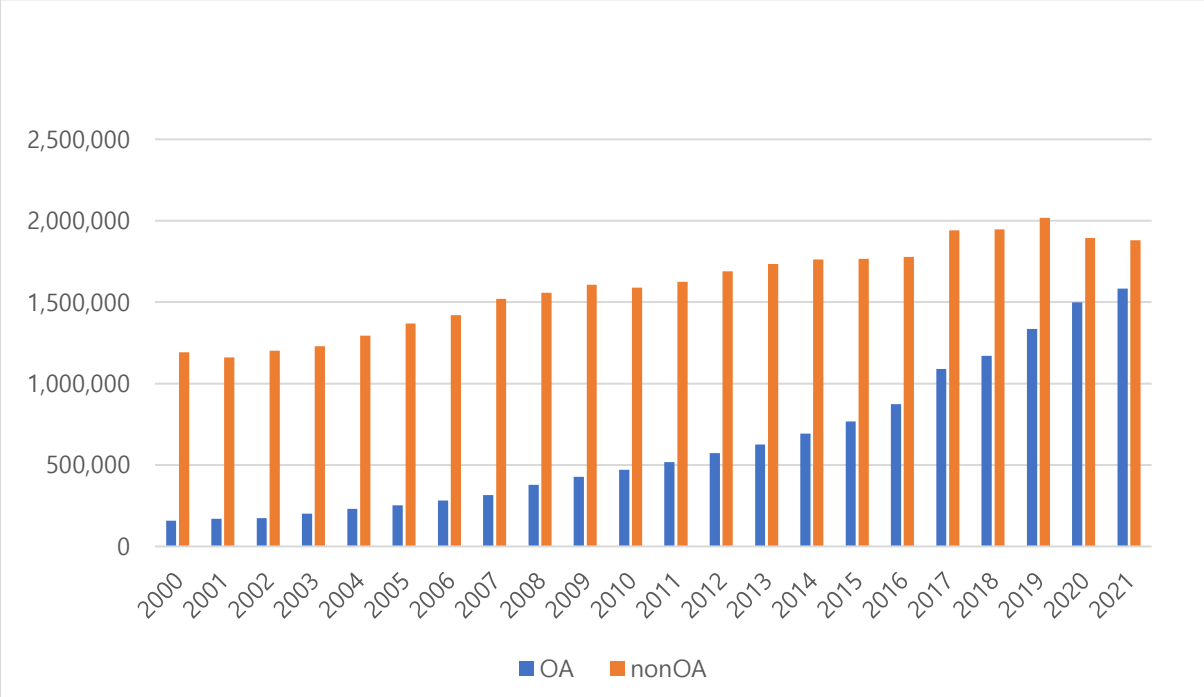
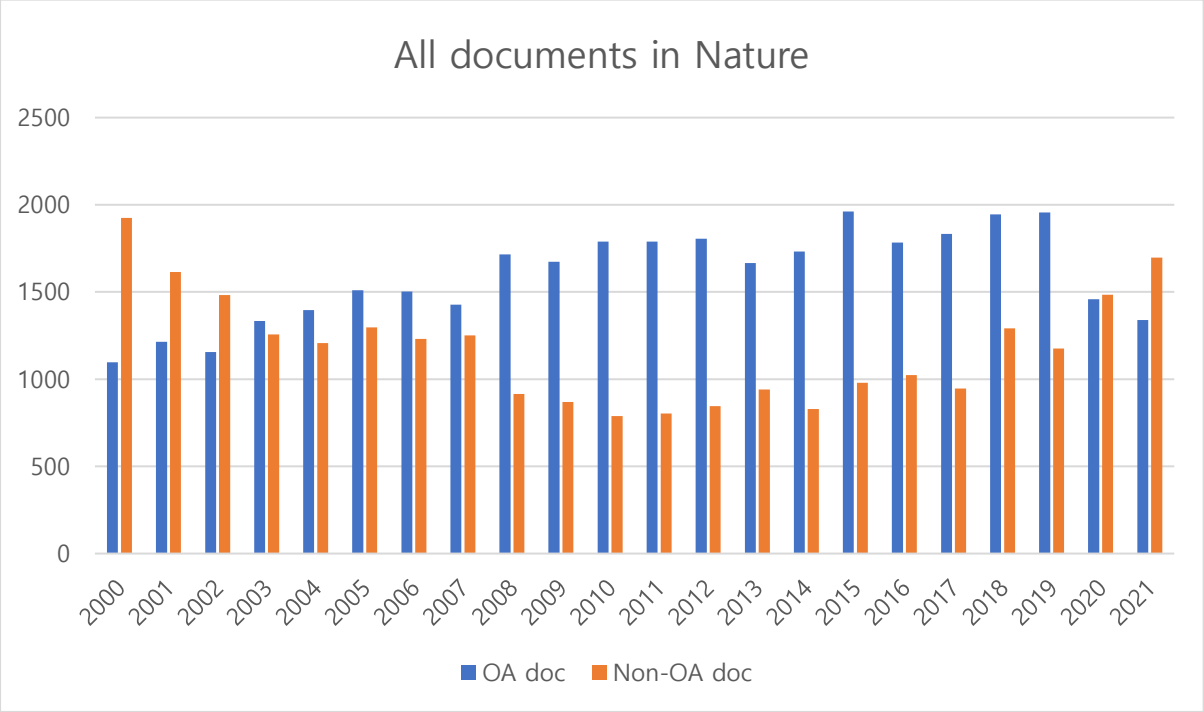


Fig. S1. Total numbers of open access (OA) and non-OA documents with all 43 types of documents in years 2000–2021.



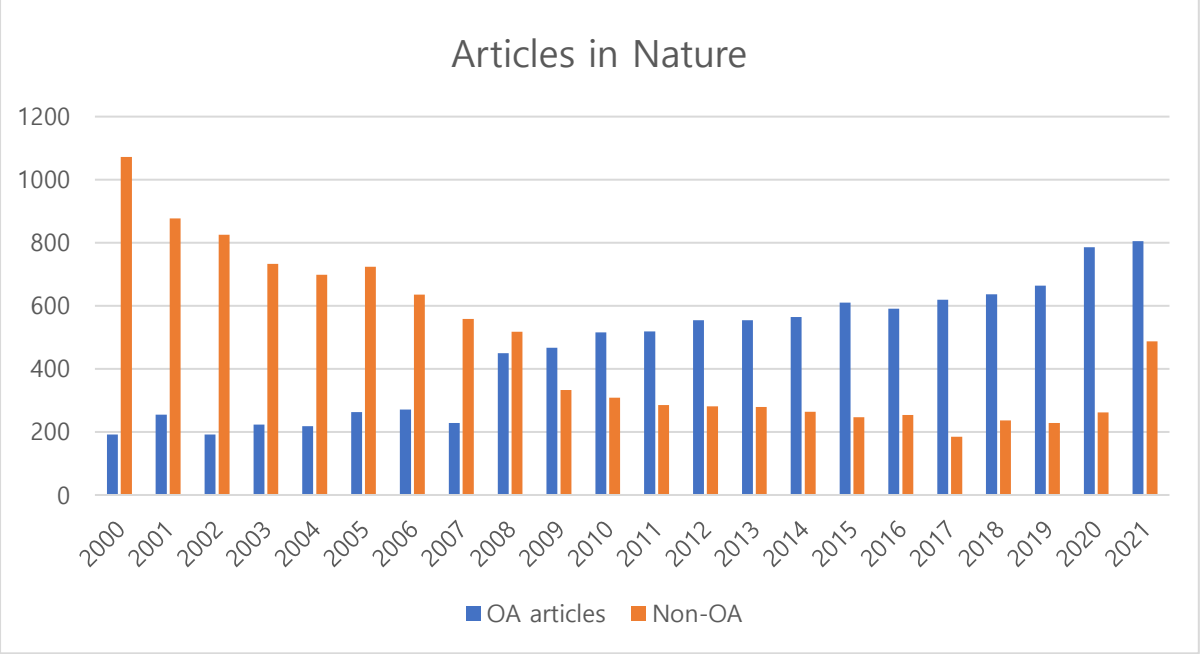


Fig. S2. Yearly numbers of open access (OA) and non-OA documents in *Nature*. (A) The numbers of all types of documents in *Nature* are shown. The proportion of OA documents was 44.1% in 2021. (B) The numbers of the document type "articles" are shown. The proportion of OA documents was high (62.3%) when we counted articles only.

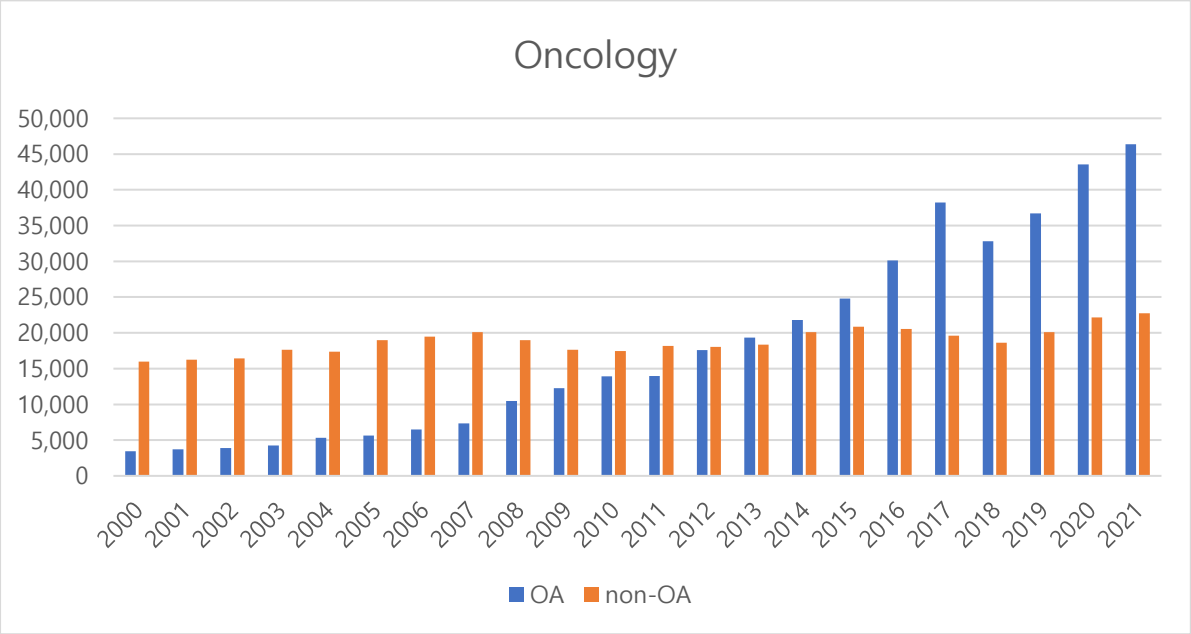


Fig. S3. The discipline of oncology and the numbers of open access (OA) and non-OA documents in 2000–2021.

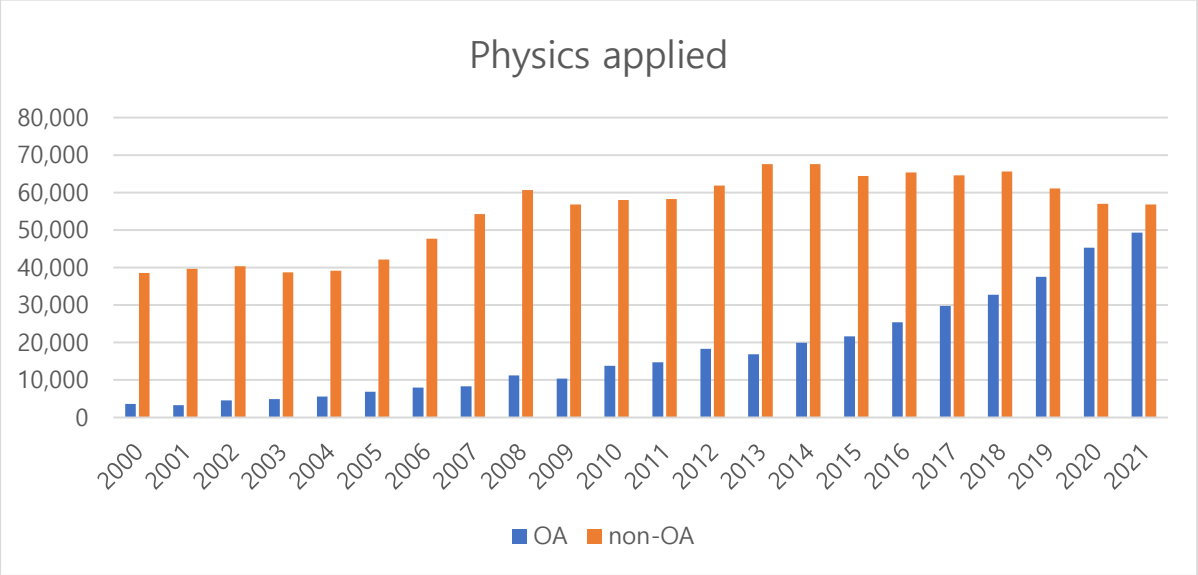


Fig. S4. The discipline of applied physics and the numbers of open access (OA) and non-OA documents in 2000–2021.

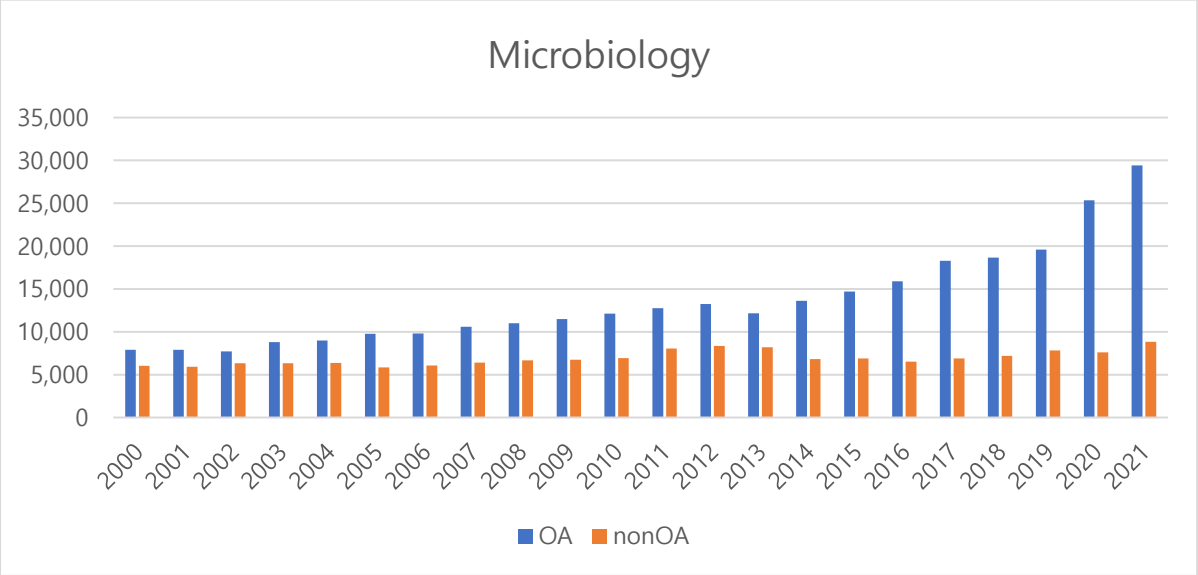


Fig. S5. The discipline of microbiology and the numbers of open access (OA) and non-OA documents in 2000–2021.

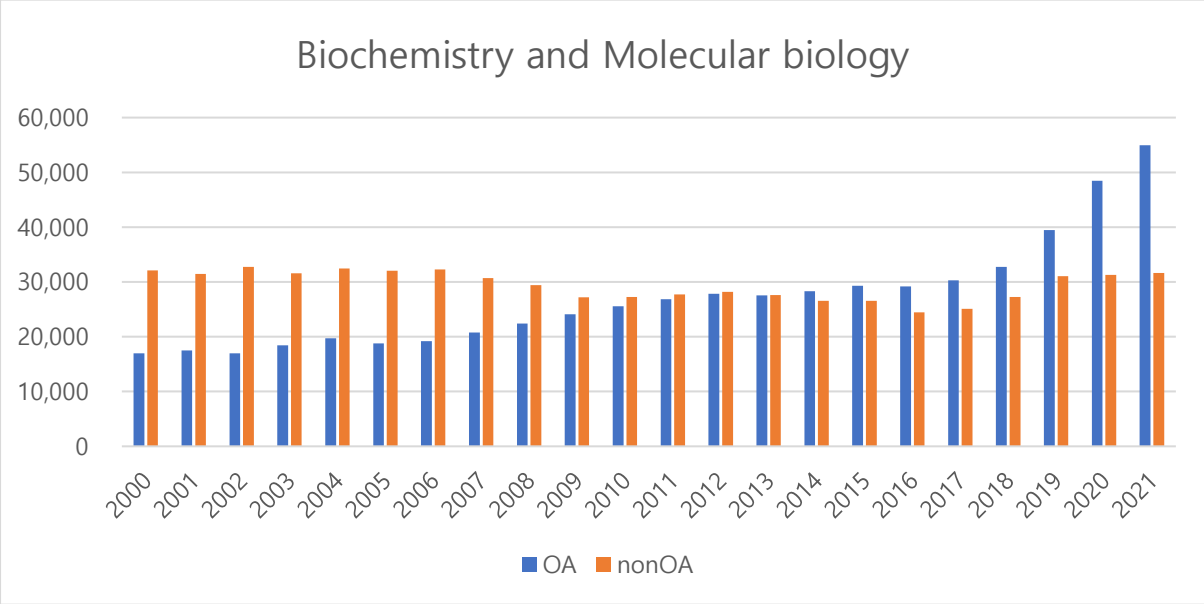


Fig. S6. The discipline of biochemistry/molecular biology and the numbers of open access (OA) and non-OA documents in 2000–2021.

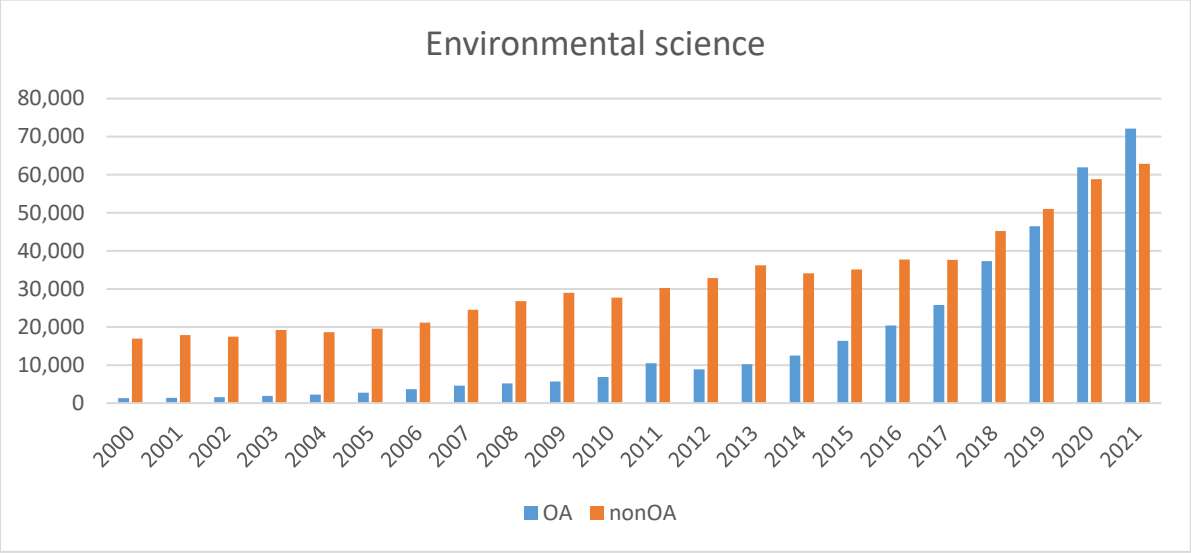


Fig. S7. The discipline of environmental science and the numbers of open access (OA) and non-OA documents in 2000–2021.

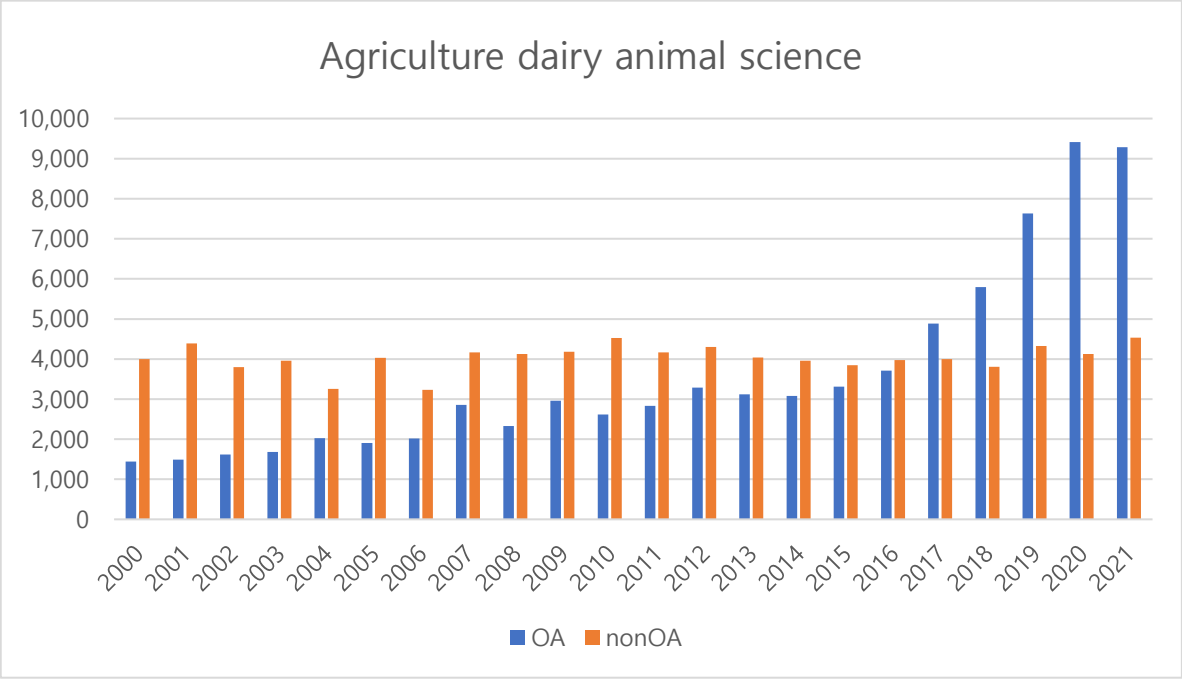


Fig. S8. The discipline of agriculture–dairy animal science and the numbers of open access (OA) and non-OA documents in 2000–2021.

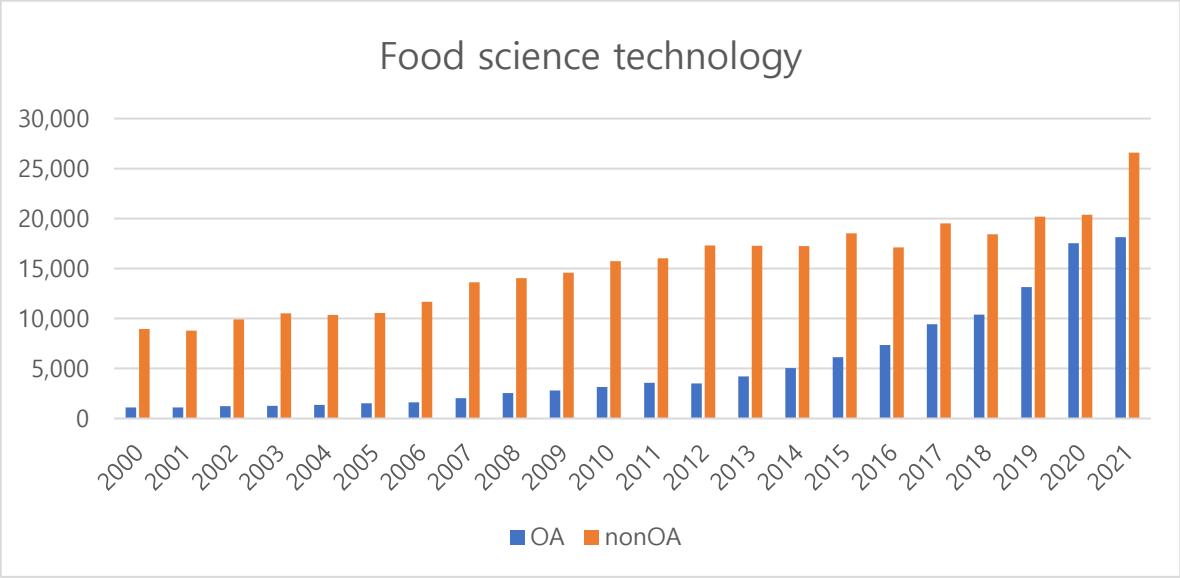


Fig. S9. The discipline of food science technology, and the numbers of open access (OA) and non-OA documents in 2000–2021.

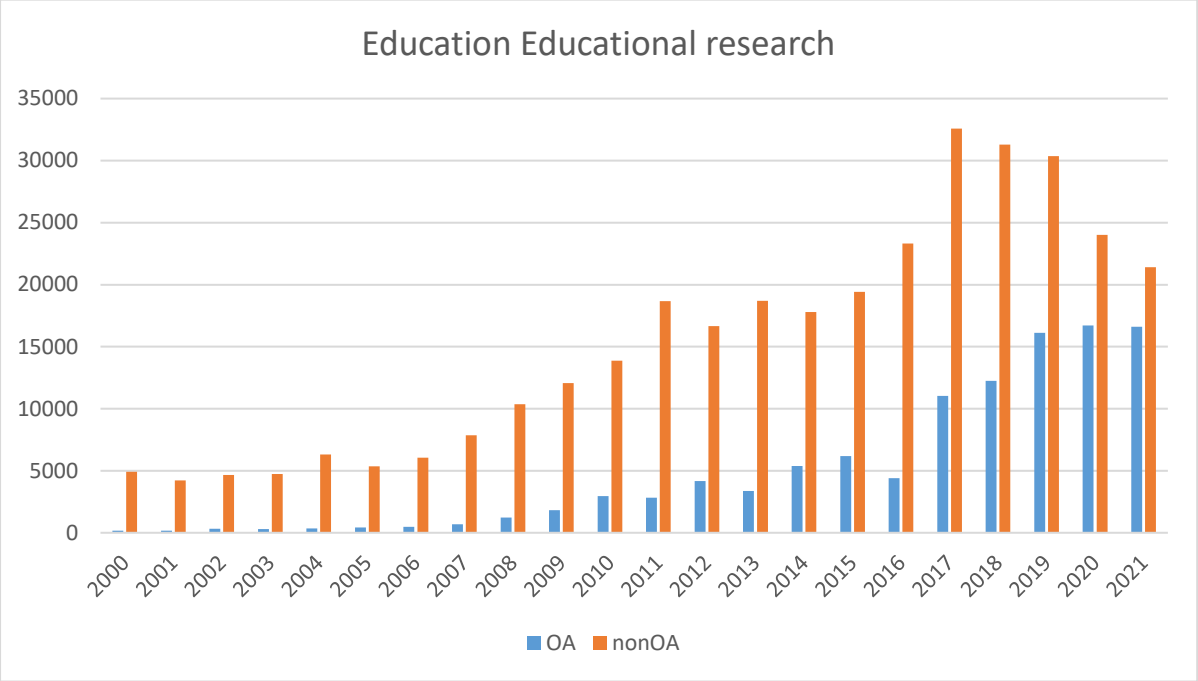


Fig. S10. The discipline of education/educational research and the numbers of open access (OA) and non-OA documents in 2000–2021.

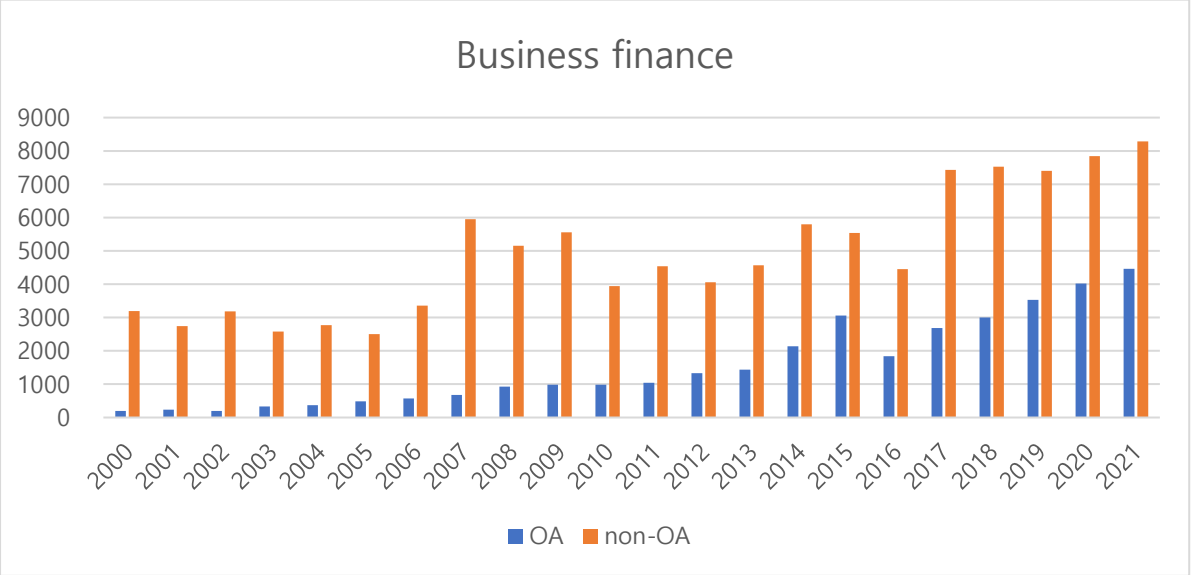


Fig. S11. The discipline of business finance and the numbers of open access (OA) and non-OA documents in 2000–2021.

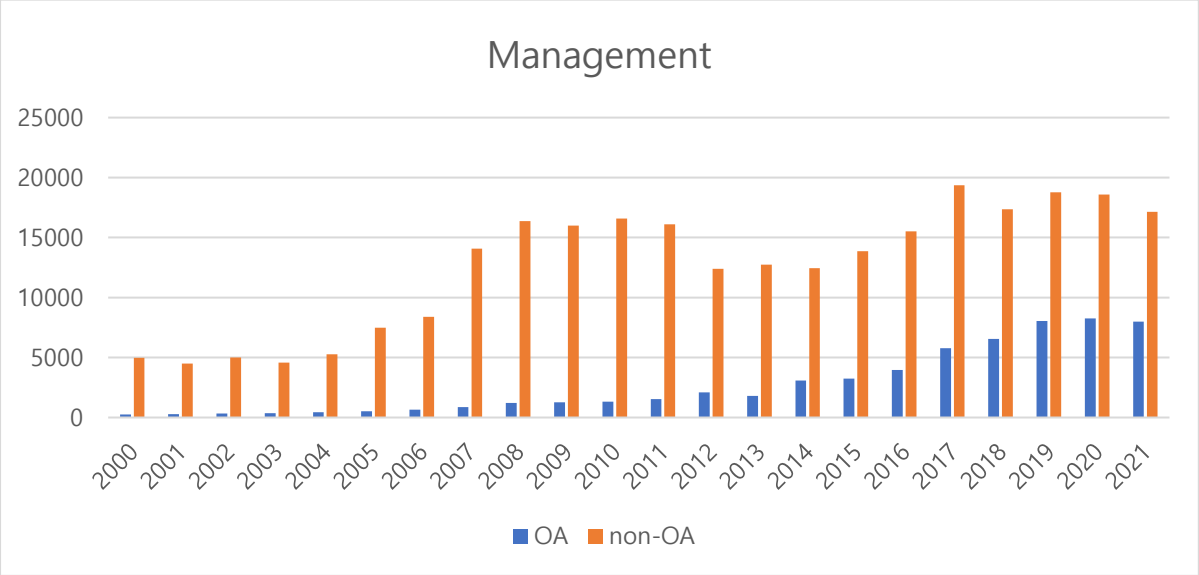


Fig. S12. The discipline of management and the numbers of open access (OA) and non-OA documents in 2000–2021.

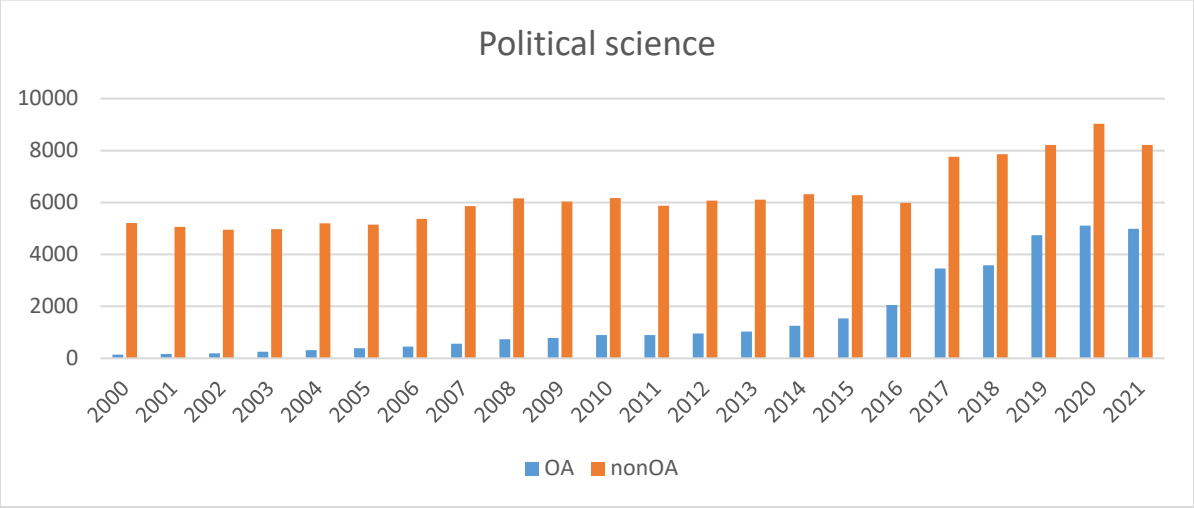


Fig. S13. The discipline of political science and the numbers of open access (OA) and non-OA documents in 2000–2021.

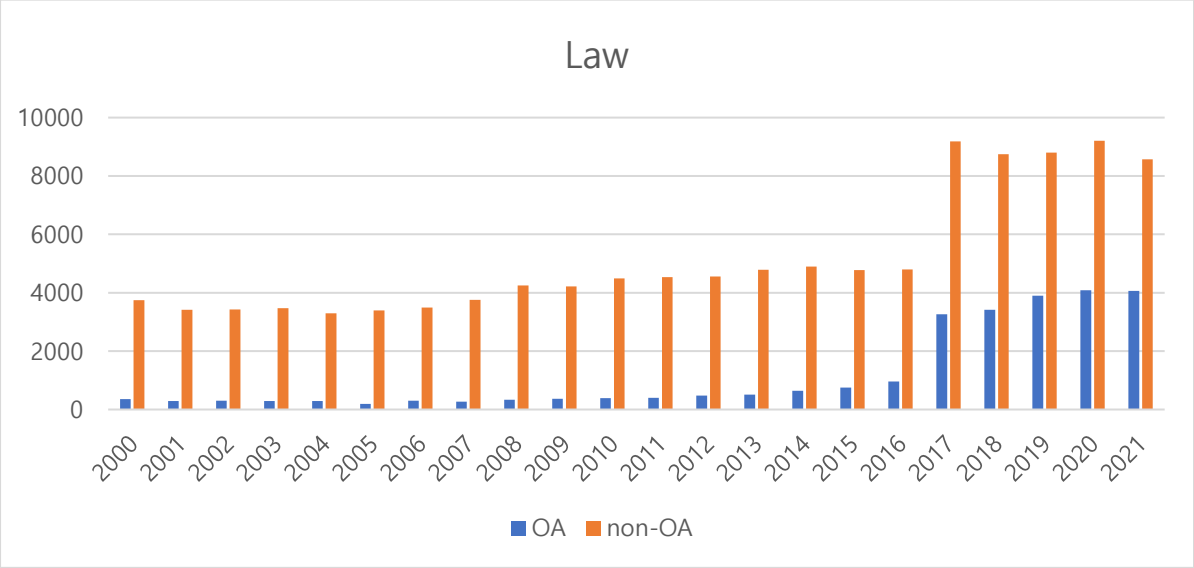


Fig. S14. The discipline of law and the numbers of open access (OA) and non-OA documents in 2000–2021.

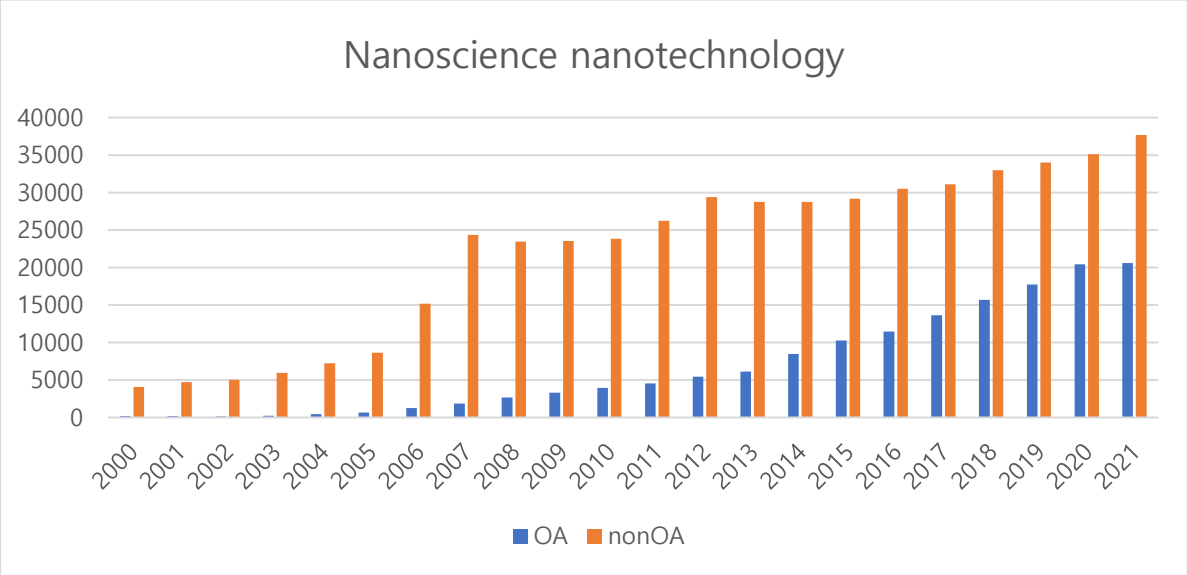


Fig. S15. The discipline of nanoscience/nanotechnology and the numbers of open access (OA) and non-OA documents in 2000–2021.

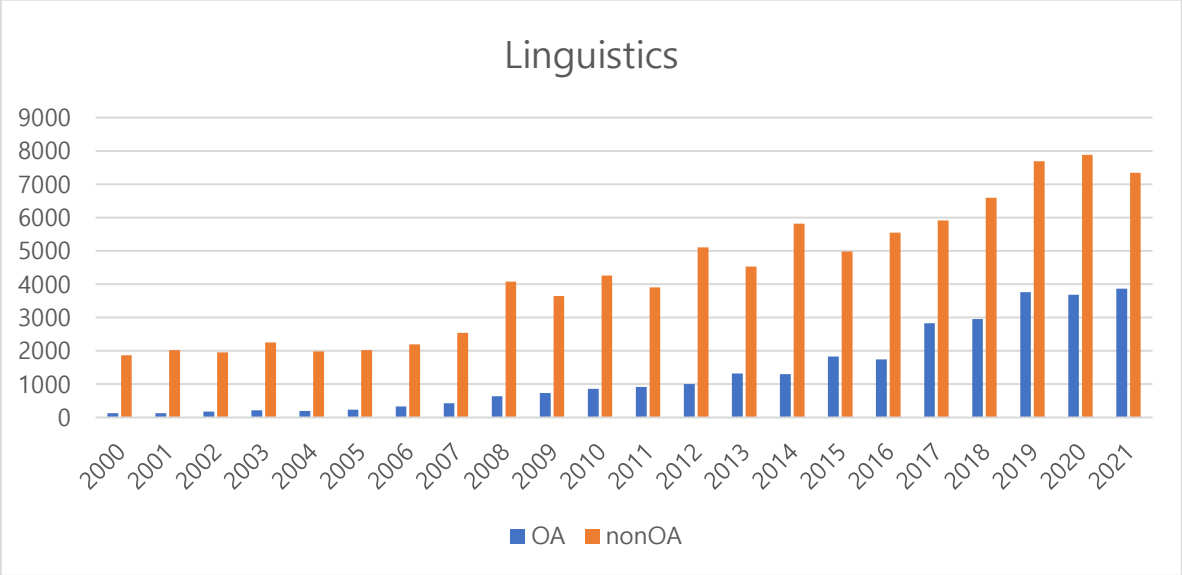


Fig. S16. The discipline of linguistics and the numbers of open access (OA) and non-OA documents in 2000–2021.

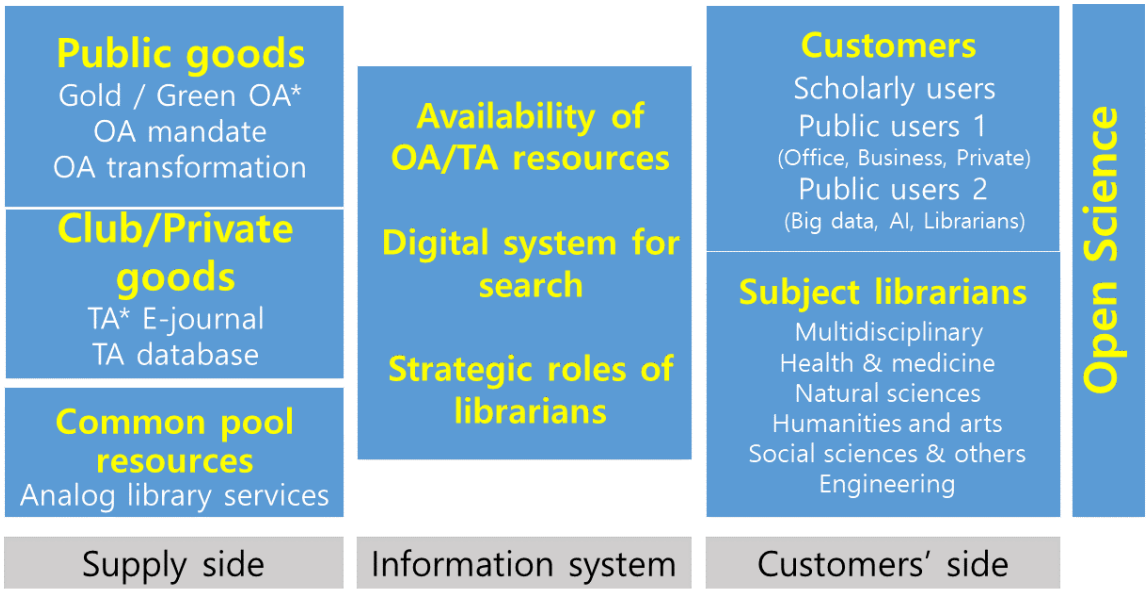


Fig. S17. A scholarly information system bridges the supply side to the customers' side. The supply side of scholarly information could be a form of common pool resources (CPR), club/private goods, or public goods depending on the mode of availability. The recognition of public users in addition to scholarly users is important for customers. Subject specialist librarians will meet the demands of users. open access (OA) enables people to become members of open science. TA, toll access.