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Blue Book on China's Scientific Journal Development (2021)

Academic Publishing in the Open Science Environment

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Blue Book on China's Scientific Journal Development (2021) has the theme of "academic publishing in the open science environment". Based on the major Chinese and international databases and first-hand official data, this book uses scientific methods to analyze the existing problems and to summarize the development process of China's scientific journals. In this book, the authors introduce and analyze the general situation of China's scientific and technological journals and research articles, present their overall status in the form of statistical key figures, and study the characteristics of the progress of open science, open science platform and open publishing progress. This work has thus drawn a picture of the transformation of international academic publishing in the open science environment. This Blue Book discusses the development trend of Chinese science journals in the open science environment, so as to provide reference for the founding and enhancement of the world-class scientific and technological journals in China.

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Foreword

Openness is one of the essentials of science. When the human society was in the primer period of industrial age, the scientific community still shared their knowledge with each other through personal letters; later on, scientific norms and STM Journals were gradually established in order to improve communication efficiency, strengthen intellectual property rights and encourage more innovation ideas. Even in the 17th century when the eastern and western cultures were far from each other, missionaries and scholars using *Philosophical Transactions* recorded and exchanged other sides' science and technology. Thus, STM Journal is a servant of science that is born not only for the science that is widespread but also is a promoter of science that supports science with more openness.

With the progress of information technology, open access has gradually become a new academic communication mode. There are numerous STM Journals transformed into open access journals or those that assist their authors' manuscripts in open access. Open access also solves a problem. The printed hardcopy journals could not fully record the evidence of thesis arguments, whose contribution is relevant to the efforts of the data center, data repository and data journals. That the data exchange shifts to the open data, just as a few scientists changed from letter correspondence to printed publications, requires both the consensus of the scientific community and the support of scientific journals.

The current human society is facing a series of great challenges, as COVID-19, global warming, world financial crisis etc. This highlights the importance of scientific innovation and technological application for human survival. To this end, scientists from all countries need to collaborate with each other. For this reason, the scientific communities from all countries must get the approval and support of their own societies. In this connection, almost all social sectors in one country have to understand this aspect of science, and ensure that their different voices can be paid enough attention. This requires a system wherein the scientific community can solve domestic demands under a global framework. On the one hand, the scope is wider than before, in a way that almost all social groups would participate in national scientific affairs; on the other hand, social groups could also be involved in international scientific topics. Open science was born for it, and STM journals serve it.

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Open science carries scientific knowledge to be accessed, to be known and to be used. It is a systematic engineering that researchers, publishers, funders, research institutions and other social organizations jointly connect with and forward open science advancing. For this purpose, the Chinese scientific community and organizations have taken a lot of efforts. Open science is also an international affair. Since its reform and opening up, China has always pursued the policy of opening up, sharing and cooperation. Internally, China requires the implementation of maximum reforms and externally comprehensive opening and cooperation with the outside world, which promote the formation of a new pattern of comprehensive opening. Open science does not redefine science, but accepts that people's science is still science. It is still keeping up a way for dealing with crisis for human sustainable development. At present, the concept of open science, put forward by countries with advanced science and technology, has been practiced in many groups, including China's scientific journals that open and share with international peers the effective work released and discussed with international society, its experience with practical cases and methods which may be applicable for developing countries. Inclusiveness is one of the cores of open science, which requires the innovation to have different degrees and methods according to scientific, technological development, and academic publishing levels and the scientific communication needs in different regions. In this matter, China's scientific journals are actively complying with international peer standards and energetically participating in conference activities, improving themselves to overcome their deficiencies and resolving the possible contradictions inconsistent with open science. This deepening reform is long-term sustained in China and its phased results are achieved every year.

Accumulating the owned-by-all knowledge from/for all mankind is one nature of science. Advancement in science is gained from STM journals that are built since the 17th century, which is researched by the public through the "open science communication constructor". All scientific information to open access, scientific data to open sharing, the academic platform to open service and participatory research activities are open science practice; those who experience return to enrich the open science connotation. On the basis of fully respecting the culture of intellectual property rights, open science can play its role in stimulating scientific and technological innovation and collaborative exchange. Therefore, STM journals are not only the most powerful defender of intellectual property rights but also the most powerful promoter of open communication. National laws and regulations play a role in delimiting openness borders and implementation principles, such as the copyright law, the Cyber Security law, the law on progress of science and technology, etc. China's scientific journals are adapting to these institutional changes together with relevant social organizations and integrating their practical experience, to make themselves the practical pioneer of open science.

Open science emphasizes the open access of scientific knowledge, including scientific publications, scientific data, open source software and code, open hardware etc. The core element of scientific publication, the STM journal, is meeting with the transformation in both literature field and data field from mutual reference to common cooperation, and to reciprocal combination. China's scientific Journals together with international publishing groups and actors of the global open science movement are encountering new challenges; especially, they jointly support and face major global crises through the science communication mechanism of open science, so as to make due contributions to the sustainable development of human society and the gradual accumulation of knowledge assets.

“The 14th five year plan for China’s national economic and social development and the outline of long-term objectives for 2035” point out the “14th five year period” based on a new developing phase, implementing the new developing idea of building a new developing pattern, to push ahead the high-quality development under the strategic orientation. Openness and cooperation in science area should be actively promoted, the international science collaboration strategy with a wider opening inclusiveness and more double-wins mutually beneficial could be implemented. China’s scientific development has ranked among the top in the world, Advocating and promoting open science is conducive to breaking the barriers of western countries, to establish new pattern of international science, to accelerate “common consulting, common building, and common sharing” and to forward the construction of a community with a shared future for mankind. In the context of open science above and under the initiative of academician Yang Wei, who is the director of the expert committee of this book, the *Blue Book on China’s Scientific Journal Development (2021)* is determined to focus on the “academic publishing in an open science environment”.

With the strong support of many experts and scholars from the expert committee and the Compilation Committee, the book adheres to the principle of fairness and objectivity in a realistic manner, to collect data, to select cases, to review documents, to analyze questions and to summarize regular patterns that take care of huge data and references, and strives to present the development status of China’s scientific Journals and Chinese scientific and technological articles in an all-round way. It also attempts to describe the development trend of world science and technology journals in the open science environment and the mission and contribution of Chinese STM journals. Here, we express our sincere thanks to all experts, scholars and colleagues who have worked hard for the preparation and publication of this book!

Science Press undertook the editing and publishing work of this book, and completed the publishing and printing work with high quality on schedule. Here, we extend our sincere thanks to all the above-mentioned institutions that provide data and publishing services!

Due to the limited ability of editors, mistakes and omissions are inevitable. We look forward to readers’ comments, criticism and correction.

China Association of Science and Technology (CAST)
November 2021

China Association for Science and Technology

As the largest non-governmental organization of scientific and technological professionals in China, the China Association for Science and Technology (CAST) serves as a bridge that links the Communist Party of China and the Chinese government to the country's science and technology community. Through its 210 national member societies and local branches all over the country, CAST maintains close ties with millions of Chinese scientists, engineers and other professionals working in the fields of science and technology.

The history of CAST can be traced back to the eve of the founding of the People's Republic of China in 1949 when a number of the nation's primary scientific and technological organizations gathered at a meeting to call upon the country's science and technology community to dedicate all their efforts to the building of New China. The meeting led to the birth in 1950 of two new national organizations—the All-China Federation of Natural Science Societies and the All-China Association for Science Popularization. In September 1958, the two organizations decided at their joint congress to merge into a unified single organization—the China Association for Science and Technology.

Since its inauguration, CAST has made significant contributions to the prosperity and development of science and technology, to the popularization of science and technology among the public, to the emergence of a large numbers of professional talents, and to the overall economic and social development in China.

As the bridge linking Chinese science and technology community with the Communist Party of China and the Chinese government, CAST is a constituent member of the country's top political advisory body—the Chinese People's Political Consultative Conference (CPPCC), where it joins all political parties and other social groups in the state affairs through political consultation, policy-making and democratic supervision.

CAST maintains cooperative relations with scientific and technological organizations of many countries and, as the representative of the Chinese science and technology community, is the national members of ICSU, WFEO and many other international scientific and technological organizations. In 2004, CAST was granted consultative status with the Economic and Social Council of the United Nations.

The highest leading organ of CAST is the National Congress that meets every five years and the National Committee elected by it. The President of the current National Committee is Prof. Dr. Wan Gang. The Secretariat appointed by the National Committee is responsible for the daily operation of CAST.

Major tasks of CAST include:

(1) To carry out academic exchanges, activate academic thinking, promote the development of all scientific disciplines, and stimulate independent innovation.
(2) To organize scientific and technological professionals to contribute to the establishment of a technological innovation system that takes enterprises as the main body and can significantly enhance the enterprises' innovation ability.
(3) To carry forward the scientific spirit, popularize scientific knowledge and disseminating scientific ideas and methods according to the Law of the People's Republic of China on Science and Technology Popularization; uphold the dignity of science, promote the application of advanced technologies, encourage and organize science educational activities among children and youth, and improve the scientific literacy of all citizens.
(4) To reflect suggestions, opinions and demands of scientific and technological professionals, and safeguard their legitimate rights and interests.
(5) To push forward the establishment and improvement of a research integrity supervision mechanism, and promote the construction of scientific ethics and a fine style of study.
(6) To organize scientific and technological professionals to participate in the making of science and technology-related policies and laws; organize scientific and technological professionals to participate in the political consultation, scientifically informed decisions and democratic supervision of state affairs.
(7) To recognize and reward outstanding scientific and technological professionals, and recommend scientific and technological talents.
(8) To provide scientific augmentation and consulting services, and policy advice, facilitate the transformation of research results; undertake project evaluation and appraisal, participate in the formulation of technical standards, professional qualification accreditation.
(9) To organize international science and technology exchange programs, promote international scientific and technological cooperation, and develop cooperative relations with scientific and technological organizations and personnel worldwide.
(10) To carry out continuing education and training programs.
(11) To develop social and public welfare institutions cohering with the aim of the China Association for Science and Technology.

Contents

CHAPTER 3

Chapter 1

General Information of China's STM Journals

Peiyi LIU, Yingzhi ZHOU, Zhi WANG, Yanqin WENG, Yue XIAO, Shenyi HUANG, Junhong WU, Wanzhen XU and Xiukun SUN

Abstract

Current Situation of China's STM Journals

General Features of China's STM Journals

Based on the data from *National Journal Annual Inspection Report 2020* by National Press & Publication Administration (NPPA), there were a total of 4963 science, technology, and medical journals (STM journals hereafter) in China by the end of 2020. The general features of the journals are: (A) The numbers of STM journals published in different regions vastly vary. Regions ranked Top 5 in terms of publication volume publish more than half of the total journals (53.47%). They are: Beijing (1629 journals, 32.82%), Shanghai (355 journals, 7.15%), Jiangsu (254 journals, 5.12%), Hubei and Sichuan (both 208 journals, 4.19%). (B) In terms of publication cycle, bi-monthly journals (1941 journals, 39.11%) and monthly journals (1804 journals, 36.35%) are the majority, accounting for 3/4 of the total volume. (C) In terms of language, Chinese language journals take up the major part (4404 journals, 88.74%), and the number of English language journals is 375 (7.56% of the total). There are 184 Chinese-English journals (3.71% of the total). (D) In terms of discipline, there are 1558 journals (31.39%) in basic science, 2259 journals (45.52%) in technology & science, and 1146 journals (23.09%) in medicine and health. (E) The overall pricing of China's STM journals is relatively low, especially Chinese language journals. The average price of China's STM journals is 29.01 yuan per issue.

Distribution of Managing, Hosting and Publishing Organizations

The managing, hosting and publishing organizations of the 4963 STM journals in China are somewhat scattered. (A) There are 1311 managing organizations, each managing 3.79 journals on average. Among them, 885 managing organizations only

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manage 1 journal each (which means organizations managing only 1 journal account for 67.51%). There are only 69 managing organizations (5.26%) that manage over 10 journals each. (B) Based on the statistics of first hosting organizations, there are 3140 hosting organizations, each hosting 1.58 journals on average. There are 2449 hosting organizations that host only 1 journal each (which means organizations hosting only 1 journal account for 77.99%). (C) There are 4261 publishing organizations, each publishing 1.16 journals on average. 4069 organizations only publish 1 journal each (which means organizations publishing only 1 journal account for 95.49%). 3282 (77.02%) publishing organizations are editorial offices with only one journal, while only 10 publishing organizations publish over 10 journals each.

STM Journal Personnel

China's STM journal industry has a total personnel of 37 295 persons. In terms of employment type, the majority is permanent staff, accounting for 65.63%; in terms of job type, the majority is editorial staff (58.22%); and in terms of academic background, staff with a bachelor degree are the majority (45.07%), with English language STM journals having more PhD graduates (34.55%) and master's graduates (43.56%). In terms of professional title, staff with intermediate titles account for 27.79%, staff with vice-senior titles account for 22.24%, and staff with senior titles account for 18.77%.

Current Situation of Papers Published by China's STM Journals

Papers Published by China's SCI-Indexed Journals

Compared with the volume of papers published by Chinese authors, the volume of papers published by China's SCI-indexed STM journals (China's SCI journals hereinafter) cannot serve the needs of publication in reality. Papers published by China's SCI journals in 2020 account for 1.45% of the global total of SCI papers. For the same period, SCI papers published by Chinese authors account for 25.85% of the global total of SCI papers. In 2020, Chinese authors published 549 845 SCI papers in total, 25 766 of which were published in China's SCI journals, accounting for 4.69%. That means, Chinese authors contributed 83.81% of the papers published by China's SCI journals.

The total cites to the papers published by China's SCI journals in 2020 account for 1.71% of the total cites to the world's scientific papers for the same period. The percentage is higher than the percentage of papers published by China's STM journals against the world's total scientific papers (1.45%), and far lower than the percentage of the total cites to SCI papers published by Chinese authors against the total cites to the world's total papers (32.98%). The citation impact of papers published by China's SCI journals is 2.82; the citation impact of SCI papers published by Chinese authors is 3.04; and the citation impact of world's SCI papers for the same period is 2.39. There were 444 highly cited papers published by China's SCI journals, accounting for 2.09% of the global highly cited papers for the same period (21 264 papers). There were 7920 highly cited papers published by Chinese authors, accounting for 37.25% of the global total of highly cited papers for the same period.

In 2020, 4697 institutions from 122 countries/regions published a total of 70 464 papers in China's SCI journals (There is multiple counting for the number of papers published by institutions, because a paper co-published by multiple institutions is counted by each institution). Among the Top 100 institutions ranked by the number of papers published in China's SCI journals, 93 are Chinese institutions. Of all the papers published by Chinese institutions in China's SCI journals, the percentage of papers ranked top 1% by total cites is 1.43% and the percentage of papers ranked top 10% by total cites is 8.74%, both lower than their equivalent of all SCI papers published by Chinese institutions: 1.53% and 10.96%.

In 2020, there were 17 countries that published over 40 000 papers each. Among the Top 5 countries with the highest number of papers published by authors, China ranks 1st in terms of the number of papers published by authors, 5th in terms of the number of papers published by China's STM journals, 1st in terms of citation impact, and 3rd in terms of category normalized citation impact (CNCI hereafter); USA ranks 2nd in terms of the number of papers published by authors, 1st both in terms of the number of STM journals and number of papers published by STM journals, 4th both in terms of citation impact and CNCI; UK ranks 2nd in terms of CNCI, the number of STM journals and the number of papers published by STM journals, 3rd both in terms of the number of papers published by authors and citation impact; Germany ranks 4th in terms of the number of STM journals, the number of papers published by authors, and the number of papers published by STM journals, 5th both in terms of citation impact and CNCI; India ranks 5th in terms of the number of papers published by authors, 13th in terms of the number of papers by STM journals, 16th both in terms of citation impact and CNCI.

General Information of Papers Published by China's STM Journals Based on CNKI Data

According to CNKI data, in 2019, the 4399 CNKI-indexed STM journals in China published a total of 1.298 million citable papers. The average number of articles per journal is 294. Among 60 disciplines, 35 disciplines published over 10 000 papers each. The 35 disciplines account for 91.51% of the total volume of papers. 5 disciplines account for over 5% each: "automation technology & computer technology" (87 673 papers, 6.79%), "civil engineering" (85 376 papers, 6.61%), "transportation engineering" (74 833 papers, 5.79%), "internal medicine" (73 000 papers, 5.65%), and "nursing" (71 957 papers, 5.57%).

In 2019, the Top 5 cities ranked by the number of papers published in China's STM journals are Beijing (125 424 papers, 9.71%), Jiangsu (107 230 papers, 8.30%), Guangdong (90 647 papers, 7.02%), Henan (77 345 papers, 5.99%), and Shandong (71 366 papers, 5.53%).

In 2019, among all publishing institutions of papers in China's STM journals, higher education institutions (excluding colleges and vocational schools) accounted for 36.66%; medical institutions accounted for 28.43%; enterprises and research institutes accounted for 13.57% and 9.95%, respectively; and other institutions (public institutions, colleges/vocational schools, middle/high schools, elementary schools, and kindergartens) accounted for 11.39%.

In 2019, there were 498 843 funded papers published in China's STM journals, accounting for 38.44% of all papers in China's STM journals. Among the top 10 funds ranked by the number of papers they supported, aside from the state-level funding programs such as the National Natural Science Foundation of China, National Key R&D Program of China, China Postdoctoral Science Foundation, and the National Social Science Fund of China, provincial natural science funds such as the ones in Henan, Jiangsu, Shandong, Guangdong, Shaanxi, and Zhejiang have also provided strong support.

Academic Influence of China's STM Journals

The academic influence of China's Chinese language STM journals is mainly within China. Based on the data from CNKI's *China's Academic Journal Impact Factor Annual Report* 2016–2020 editions and *China Academic Journal International Citation Annual Report* 2016–2020 editions, the average citable documents per journal of Chinese language STM journals decreased from 295.44 papers in 2015 to 286.19 papers in 2019. The total times cited increased from 7 948 400 in 2015 to 8 200 400 in 2019. During the period from 2015 to 2019, the total domestic cites to Chinese language STM journals account for 95.68% of the total cites, which means the main influence of Chinese language STM journals is within China.

Chinese language STM journals have received increasing attention from the international academic community. Based on the data from CNKI's *China Academic Journal International Citation Annual Report* 2016–2020 editions, the average impact factor (without self-cites) of China's top Chinese language STM journals during 2015–2019 was increasing, with an annual increase rate of 20.14%; the average immediacy index during the 5 years was also increasing, with an annual increase rate of 26.63%. There were 1122 Chinese language STM journals indexed in *World Journal Clout Index* (*WJCI*) *of Scientific and Technological Periodicals* (*2020 Edition*) (*WJCI Report* hereafter), 85 of which were Q1 journals, accounting for 7.58% of all Chinese language STM journals indexed.

China's English language STM journals are taking an increasingly important role and status in international academic exchange. The average total domestic times cited to China's English language STM journals during 2015–2019 was 232 700 and the average total international times cited was 301 700. The total times cited by both domestic and international documents kept increasing during the 5-year period, with an annual increase rate of 13.90%. The international total times cited exceeded the domestic times cited in 2016 and kept increasing. In 2019, the times cited by international documents accounted for 69.18% of all cites. At the same time, the domestic times cited of China's English STM journals started decreasing since 2016 while the average yearly increase rate of international times cited during the 5-year period was 21.77%. The average comprehensive impact factor of China's English STM journals was increasing during the 5-year period and reached 0.837 in 2019, with an average yearly increase rate of 5.21%. The comprehensive immediacy index during the 5-year period was increasing too, reaching 0.170 in 2019, with an average yearly increase rate of 0.90%. With the rapid development of China's science and technology, China's English STM journals were indexed by an increasing number of world renowned databases.

1.1 Analysis of Current Situation of China's STM Journals

The analysis in this book is based on the data from 2020 National Journal Annual Inspection (Annual Inspection hereafter). The data were sorted using the Chinese Library Classification (CLC) Code of China's publications, with the standardized serial CN number. Relevant data on China's STM journals were taken (4931 items), with consideration to the information of newly approved journals by the state, change of journal names during 2018–2020, and revoked journals during 2017–2020. Comparisons were made with the data in China's STM Journal Directory in the *Blue Book on China's Scientific Journal Development* published during 2017–2020. The statistical results showed that the total number of China's STM journals was 4963 by the end of 2020[1].

1.1.1 Basic Facts of Journals

1.1.1.1 Distribution by Place of Publication

The numbers of STM journals published in different regions are unevenly distributed. Statistics show that the distribution of the 4963 STM journals in China by place of publication is the following: Beijing as No. 1 (1629 journals, 32.82% of all journals), Shanghai (355 journals, 7.15%), Jiangsu (254 journals, 5.12%), Hubei and Sichuan (both with 208 journals, 4.19%). 4 regions published over 200 STM journals each; 11 provinces, regions and cities published 100–200 STM journals each; and 10 provinces, regions and cities published 50–100 journals each. In summary, in terms of distribution by place of publication, 5 regions published over 200 STM journals each and 16 regions published over 100 STM journals each. For the detailed distribution of journal numbers, please refer to table 1.1.

1.1.1.2 Distribution by Publication Cycle

In terms of publication cycle, the majority of China's STM journals are monthly and bi-monthly journals. Statistics of the 4963 STM journals show that (tables 1.1 and 1.2), the Top 3 types of journals, sorted by publication cycle and ranked by the number of journals, are: bi-monthly (1941 journals, 39.11%), monthly (1804 journals, 36.35%), and quarterly (727 journals, 14.65%). Among them, bi-monthly journals and monthly journals together account for 75.46% of all journals (3745 journals). Beijing has the largest number of monthly journals (761 journals), accounting for 42.18% of all monthly journals in China. There are 132 semi-monthly journals in Beijing, accounting for 41.51% of all semi-monthly journals. When compared in terms of publication cycle, 5 regions—Beijing, Chongqing, Guangxi, Hainan, and Ningxia—have the highest percentage of monthly journals, Qinghai and Tibet have the highest percentage of quarterly journals, and other provinces, regions and cities all have bi-monthly journals as the major journal type.

1.1.1.3 Distribution by Language and Discipline

Chinese language journals account for the majority of China's STM journals. Among the 4963 STM journals, there are 4404 Chinese language journals (88.74%, among which 4362 journals are in mandarin, 18 in Uyghur, 9 in Mongolian, 6 in Kazak language, 5 in Tibetan language, 2 in north Korean language, 2 in Chinese-Tibetan language), 375 English language journals (7.56%), and 184 Chinese-English journals (3.71%) (table 1.3).

[1]The statistics of China's STM journals in this book do not include data on journals that did not participate in the 2020 annual inspection, nor the data on journals in Hong Kong, Macao, and Taiwan regions.

Tab. 1.1 – Distribution of China's STM Journals published in 2020 (by region) (Unit: no. of journal).

Serial no.	Region	Yearly	Semi-yearly	Quarterly	Bi-monthly	Monthly	Semi-monthly	Bi-weekly	Ten-day	Weekly	Semi-weekly	Total
1	Beijing	18	3	180	488	761	132	1	35	8	3	1629
2	Shanghai	1	1	58	166	119	7	0	3	0	0	355
3	Jiangsu	0	0	44	131	63	11	0	3	2	0	254
4	Hubei	3	1	20	91	74	14	0	5	0	0	208
5	Sichuan	0	0	43	91	64	5	0	4	1	0	208
6	Guangdong	0	0	21	72	65	19	0	3	0	0	180
7	Liaoning	1	0	12	91	65	5	0	3	0	0	177
8	Heilongjiang	1	0	26	67	56	8	0	4	1	0	163
9	Shaanxi	0	1	21	76	54	8	0	2	1	0	163
10	Tianjin	1	1	13	60	52	7	0	3	0	0	137
11	Hunan	0	0	23	54	44	6	0	2	1	0	130
12	Shandong	0	0	25	57	39	7	0	2	0	0	130
13	Zhejiang	0	0	27	49	38	4	0	1	0	0	119
14	Henan	2	0	19	44	34	9	0	4	2	0	114
15	Hebei	0	0	16	37	32	12	0	7	1	0	105
16	Jilin	0	0	20	38	29	10	0	6	1	0	104
17	Shanxi	0	0	15	36	27	9	0	4	0	0	91
18	Anhui	1	0	9	43	27	5	0	1	0	0	86
19	Chongqing	0	0	7	26	29	14	0	2	2	0	80
20	Guangxi	1	0	17	24	27	3	0	1	3	0	76
21	Fujian	0	2	20	31	18	0	0	0	0	0	71
22	Jiangxi	0	0	15	32	15	7	0	0	0	0	69
23	Gansu	0	0	8	41	13	4	0	0	0	0	66
24	Xinjiang	1	4	22	22	6	0	0	0	0	0	55

Tab. 1.1 – (continued).

25	Inner Mongolia	0	2	6	21	17	4	0	0	1	0	51
26	Yunnan	0	0	7	23	13	3	0	4	0	0	50
27	Guizhou	0	0	6	18	10	1	0	0	0	0	35
28	Qinghai	0	0	12	5	1	0	0	0	0	0	18
29	Hainan	0	0	4	0	5	4	0	0	0	0	13
30	Ningxia	0	0	4	1	6	0	0	0	0	0	11
31	Tibet	0	1	5	3	0	0	0	0	0	0	9
32	Xinjiang Production & Construction Corps	0	0	2	3	1	0	0	0	0	0	6
	Total	30	16	727	1941	1804	318	1	99	24	3	4963

Note: Ordered by the number of published journals.
Based on the statistics of reporting units in the national journal annual inspection, Xinjiang Production and Construction Corps was counted separately.

TAB. 1.2 – Distribution of China's 4963 STM journals in 2020 (by publication cycle) (Unit: no. of journal).

Frequency	No. of journal	% of total	Frequency	No. of journal	% of total
Bi-monthly	1941	39.11	Weekly	24	0.48
Monthly	1804	36.35	Semi-yearly	16	0.32
Quarterly	727	14.65	Semi-weekly	3	0.06
Semi-monthly	318	6.41	Bi-weekly	1	0.02
Ten-day	99	1.99	Total	4963	100.00
Yearly	30	0.60			

Mandarin STM journals are mostly in "industrial technology general introduction" (1723 journals, 39.50%), "medicine, health and comprehensive medicine & health" (981 journals, 22.49%), "agriculture, forestry, and comprehensive agricultural science" (487 journals, 11.16%), "natural science general introduction" (419 journals, 9.61%). Ethnic minority language STM journals are mostly in "agriculture, forestry, and comprehensive agricultural science" (15 journals, 35.71%), "medicine, health, and comprehensive medicine & health" (13 journals, 30.95%), and "natural science general introduction" (11 journals, 26.19%). English language STM journals are mostly in "industrial technology general introduction" (108 journals, 28.80%), "medicine, health, comprehensive medicine & health" (81 journals, 21.60%), and "mathematical & physical science and chemistry" (58 journals, 15.47%) (table 1.3).

Based on the distribution by discipline of the 4963 STM journals in China, there are 1558 journals in "basic science" (31.39%), including 462 journals in "natural science general introduction", 205 journals in "mathematical & physical science and chemistry", 249 journals in "astronomy and geosciences", 108 journals in "biological science", and 534 journals in "agriculture, forestry and comprehensive agricultural science"; 2259 journals in "technical science" (45.52%), including 1871 journals in "industrial technology general introduction", 222 journals in "transportation", 76 journals in "aeronautics and spaceship", 90 journals in "environmental science and safety science"; and 1146 journals in "medicine & health" (23.09%) (table 1.3).

1.1.1.4 Distribution by Pricing

The pricing of China's STM journals is relatively low, especially Chinese language journals. Among the 4963 STM journals in China, 4927 journals provided data on pricing. Among them, 25 journals' pricing was filled as "0" in the annual inspection data. The average pricing for the 4927 journals is 29.01 yuan per issue, the median pricing being 16 yuan per issue, the lowest pricing 1.6 yuan per issue (only 1 journal), and the highest pricing 1000 yuan per issue (1 journal, *China Chemical Industry Yearbook*). There are 147 pricings, with journals priced at 10–20 (not including 20) yuan per issue being the majority (2035 journals, 41.30% of total). There are 1027 journals (20.84% of total) priced at 20–30 (not including 30) yuan per issue (table 1.4). The average pricing of mandarin STM journals is 23.47 yuan per issue, the median pricing being 15 yuan. The pricing of ethnic minority language STM journals is lower, with the average pricing being 7.50 yuan per issue, and

Tab. 1.3 – Distribution of China's 4963 STM Journals in 2020 (by language and discipline) (Unit: no. of journal).

Category	Discipline	Mandarin	English	Chinese-English	Ethnic minority language	Total
Basic Science (1558)	N Natural Science General Intro	419	20	12	11	462
	O Mathematical & Physical Science and Chemistry	135	58	12	0	205
	P Astronomy, Geosciences	200	40	9	0	249
	Q Biological Science	67	32	9	0	108
	S Agriculture, Forestry, Comprehensive Agricultural Science	487	17	15	15	534
Technical Science (2259)	T Industrial Technology General Intro	1723	108	39	1	1871
	U Transportation	205	6	11	0	222
	V Aeronautics, Spaceship	68	5	3	0	76
	X Environmental Science, Safety Science	77	8	3	2	90
Medicine & Health (1146)	R Medicine, Health, Comprehensive Medicine & Health	981	81	71	13	1146
	Total	4362	375	184	42	4963

Note: "Ethnic minority language" mainly refers to Tibetan language, Kazak language, Mongolian, and Uyghur.

median pricing being 6 yuan per issue. The pricing of English STM language journals is higher, with the average pricing being 101.00 yuan per issue, and the median pricing being 80 yuan per issue.

TAB. 1.4 – Distribution of 4927 China's STM journals in 2020 (by pricing).

Price/Yuan	No. of journal	% of total	Price/Yuan	No. of journal	% of total
<10	636	12.91	80 ~	63	1.28
10 ~	2035	41.30	90 ~	18	0.37
20 ~	1027	20.84	100 ~	123	2.50
30 ~	426	8.65	150 ~	37	0.75
40 ~	164	3.33	200 ~	55	1.12
50 ~	177	3.59	300 ~	27	0.55
60 ~	114	2.31	500 ~ 1000	7	0.14
70 ~	18	0.37	Total	4927	100.00

Note: In the 2020 journal annual inspection data, 4927 journals provided pricing information, 25 of which had a pricing of "0".

1.1.1.5 Distribution by Managing, Hosting and Publishing Organizations

The managing, hosting and publishing organizations of China's STM journals are scattered, with most publishing organizations being the editorial office of a single journal. According to statistics, the 4963 STM journals in China have 1311 managing organizations in total, which means each organization manages 3.79 journals on average. 885 organizations (67.51% of all managing organizations) only manage 1 journal each; 193 organizations (14.72%) manage 2 journals each; and 164 organizations (12.51%) manage 3–10 (not including 10) journals each. 69 organizations (5.25%) manage over 10 journals each. The Top 10 managing organizations of STM journals, ranked by the number of journals, are: China Association for Science and Technology (CAST) (472 journals), Ministry of Education (440 journals), Chinese Academy of Sciences (CAS) (289 journals), National Health Commission (216 journals), Ministry of Agriculture and Rural Affairs (93 journals), China Machinery Industry Federation (65 journals), Ministry of Industry and Information Technology (63 journals), Ministry of Housing and Urban-Rural Development (51 journals), Jiangsu Education Department (50 journals), and China National Light Industry Council (47 journals).

Based on the statistics on the first hosting organization, the 4963 STM journals in China have 3140 hosting organizations, each organization hosting 1.58 journals on average. 2449 organizations (77.99% of all hosting organizations) host only 1 journal each, 376 organizations (11.97%) host 2 journals each, and 283 organizations (9.01%) host 3–10 (not including 10) journals. 32 organizations (1.02%) host 10 (and above) journals each. There are 12 hosting organizations ranked Top 10, based on the number of journals hosted: Chinese Medical Association (CMA) (146 journals), Chinese Preventive Medicine Association (CPMA) (35 journals), Chinese Medical Doctor Association (CMDA) (26 journals), Zhejiang University (24 journals), Chinese Academy of Sciences (CAS) (20 journals, only including journals that had CAS as the hosting organization, not including those hosted by subordinate institutions of CAS), Beijing Promonion Publishing Co. Ltd. (19 journals), Higher Education Press Limited Company (18 journals), Tsinghua University (18 journals), Chinese Academy of Medical Sciences (CAMS) (18 journals), Sichuan University (17 journals), Xi'an Jiaotong University (17 Journals), and Central South University (17 journals).

The 4963 STM journals in China are published by 4261 organizations, each organization publishing 1.16 journals on average. 4069 organizations (95.49% of all publishing organizations) publish only 1 journal each. 3282 publishing organizations are the editorial office of a single journal, accounting for 77.02% of the total. The Top 10 publishing organizations, ranked by the number of journals published, are: China Science Publishing & Media Ltd. (CSPM) (Science Press, 143 journals), Chinese Medical Association Publishing House Co. Ltd. (138 journals), Beijing Promonion Publishing Co. Ltd. (20 journals), Higher Education Press Limited Company (20 journals), Science China Press Co. Ltd. (17 journals), Tsinghua University Publishing House Co. Ltd. (17 journals), Zhejiang University Publishing House Co. Ltd. (17 journals), China Railway Publishing Housing Co. Ltd. (12 journals), Boyuan Publishing Co., Ltd., Central Iron and Steel Research Institute (12 journals), and China InfoCom Media Group Co. Ltd. (10 journals).

1.1.2 Journal-Running Conditions and Human Resource

1.1.2.1 Journal Operation Location

China's STM journals have stable locations for operations. Among the 4931 journals that participated in the 2020 journal annual inspection, excluding 75 invalid data, 4856 journals filled in the data on operation area and property right. The data included journals that did not fill in specific numbers and journals that owned over 2 types of operation locations. 3604 journals (74.22% of all journals) have operation locations provided by their higher level authorities and the operation area is mostly between 25 and 75 m^2 (not including 75 m^2). 630 journals (12.97%) own their operation locations, and the operation area is mostly between 50 and 75 m^2 (not including 75 m^2). 681 journals (14.02%) rent their office for operations (table 1.5).

1.1.2.2 Human Resource

1.1.2.2.1 Analysis of China's STM Journal Personnel

The size of China's STM journal personnel was showing a slight and steady increase. Among the 4931 STM journals that participated in the 2020 annual journal inspection, 4910 journals filled in personnel information and 18 items of data were invalid. Hence there were 4892 valid data with personnel information. Statistics from the above data show that there are 37 295 persons working for China's STM journals. Statistics also show that 2168 journals (major type being bi-monthly journals, 1102 in number) have 4–7 (not including 7) staff members per journal and they account for 44.32% of all the journals that filled in valid data; 950 journals (19.42%) have 10 (and above) staff members (table 1.5); and 69 journals (1.41%) have over 30 (and above) staff members (table 1.6).

1.1.2.2.2 China's STM Journal Personnel Analysis—Permanent and Non-Permanent Staff

The majority of China's STM journal personnel are permanent staff. Among the 4931 journals that participated in the 2020 annual inspection, 4910 journals filled in information of permanent and non-permanent staff. After 18 invalid data were deleted, there were 4892 valid data on the number of permanent staff and non-permanent staff. Statistics based on

TAB. 1.5 – Operation area of China's STM journals 2020.

Operation area/m^2	Self-owned location		Location provided by higher level authority		Rented location		Total	
	No. of journal	% of total	No. of journal	% of total	No. of journal	% of total	No. of journal	% of total
<25	52	8.25	304	8.44	37	5.43	393	8.00
25～	115	18.25	1026	28.47	110	16.15	1251	25.45
50～	146	23.17	911	25.28	121	17.77	1178	23.97
75～	76	12.06	383	10.63	65	9.54	524	10.66
100～	107	16.98	488	13.54	107	15.71	702	14.28
125～	24	3.81	67	1.86	28	4.11	119	2.42
150～	22	3.49	144	4.00	69	10.13	235	4.78
200～	32	5.08	169	4.69	81	11.89	282	5.74
300～	21	3.33	69	1.91	43	6.31	133	2.71
500～	34	5.40	33	0.92	20	2.94	87	1.77
Data not provided	1	0.16	10	0.28	0	0.00	11	0.22
Total	630	100.00	3604	100.00	681	100.00	4915	100.00

Note: Among the 4931 data provided for 2020 annual inspection, 75 were invalid, hence there were 4856 valid data, including journals that did not fill in the data for operation area and journals that owned more than 2 types of operation locations.

the above data show that the total number of persons working in China's STM journals is 37 295, among which 24 478 people (65.63%) are permanent staff and 12 817 are non-permanent (34.37%). The statistics of China's STM journal personnel in different regions show that 10 regions each have STM personnel of over 1000 people, with Beijing having the most—13 723 people (36.80% of the total personnel). Among the 32 provinces, regions and cities, plus Xinjiang production and construction corps, 26 regions have permanent staff of over 60%, with the highest percentage being 89.72%. Guangxi and Hainan have permanent staff of below 50%, with the lower being 44.39% (table 1.7). 1888 journals have all staff members as permanent staff, which account for 38.59% of all journals that provided valid data. 294 journals (6.01%) have all staff members as non-permanent.

1.1.2.2.3 Analysis of Personnel Composition of China's STM Journals

Among the 4931 journals that participated in the 2020 annual inspection, 4884 journals filled in the information of the composition of STM journal personnel. After 34 data were deleted due to invalidity, there were 4850 valid data. According to the items in the annual inspection, STM journal personnel consist of editorial, new media, administrative, advertisement, distribution, and other staff. Since some personnel have multiple functions, the total number of persons based on the composition is larger than the actual number.

Editorial staff account for the biggest portion of China's STM journal personnel. Editorial staff normally are responsible for topic selection, paper organization and processing. They form the majority of STM journal personnel—58.22%. Administrative staff are responsible for the daily management of the editorial office, and distribution staff are

Tab. 1.6 – Distribution of China's STM journal personnel in 2020 (by publication cycle) (Unit: no. of journal).

No. of staff per journal	Publication cycle										Total
	Yearly	Semi-yearly	Quarterly	Bi-monthly	Monthly	Semi-monthly	Bi-weekly	Ten-day	Weekly	Semi-weekly	
1 ∼	7	5	198	299	121	3	0	3	0	0	636
4 ∼	11	8	377	1102	621	35	0	11	3	0	2168
7 ∼	5	2	92	371	571	81	0	12	4	0	1138
10 ∼	5	1	21	96	258	75	0	25	1	0	482
13 ∼	0	0	7	19	90	41	0	10	3	0	170
16 ∼	0	0	0	9	48	33	1	6	1	0	98
19 ∼	1	0	2	5	18	19	0	9	3	0	57
22 ∼	0	0	3	11	33	14	0	11	2	0	74
30 ∼	1	0	0	4	9	10	0	8	2	0	34
40 ∼	0	0	1	1	8	2	0	3	1	0	16
50 ∼	0	0	1	0	1	0	0	0	2	0	4
≥70	0	0	0	3	5	2	0	1	1	3	15
Total	30	16	702	1920	1783	315	1	99	23	3	4892

Note: Among the 4931 data obtained from 2020 annual inspection, there were 18 invalid data, and 21 data had no content, hence there were 4892 valid data in total.

TAB. 1.7 – Permanent staff of China's STM journals in different regions 2020.

Region	Total personnel	Permanent staff	% of total
Beijing	13 723	8114	59.13
Shanghai	2426	1702	70.16
Jiangsu	1669	1276	76.45
Guangdong	1533	817	53.29
Hubei	1400	911	65.07
Sichuan	1369	968	70.71
Shaanxi	1180	827	70.08
Liaoning	1163	864	74.29
Heilongjiang	1020	800	78.43
Henan	1002	768	76.65
Tianjin	946	800	84.57
Shandong	887	701	79.03
Hunan	875	553	63.20
Shanxi	846	588	69.50
Hebei	824	496	60.19
Chongqing	806	446	55.33
Guangxi	748	332	44.39
Zhejiang	738	548	74.25
Anhui	681	408	59.91
Jilin	670	490	73.13
Jiangxi	466	318	68.24
Fujian	439	328	74.72
Inner Mongolia	397	294	74.06
Gansu	367	303	82.56
Yunnan	341	230	67.45
Xinjiang	214	192	89.72
Guizhou	203	147	72.41
Hainan	119	57	47.90
Qinghai	89	75	84.27
Ningxia	64	47	73.44
Tibet	48	43	89.58
Xinjiang Production & Construction Corps	42	35	83.33
Total	37 295	24 478	65.63

Note: Among the 4931 data collected in 2020, 18 data were invalid, 21 data had no content, hence there were 4892 valid data left.

responsible for marketing and promotions. The above two types account for 12.65% and 8.34%, respectively, of the total personnel. Advertising staff are responsible for running advertisement, and new media staff are responsible for academic content promotions. These two types account for the lowest portion of the total personnel (6.38% and 6.47% respectively) (table 1.8). Statistics show that 2388 journals (49.24%) have no distribution staff, 3157 journals (65.09%) have no advertisement staff, and 3386 journals (69.81%) have no new media staff.

TAB. 1.8 – Personnel composition of China's STM journals in 2020.

Personnel composition	Mandarin journal		English journal		Chi-Eng journal		Others*		Total	
	Persons	%	Persons	%	Persons	%	Persons	%	Persons	%
Editorial	19 704	57.77	1303	64.25	793	59.13	118	68.60	21 918	58.22
New media	2209	6.48	135	6.66	83	6.19	10	5.81	2437	6.47
Administrative	4363	12.79	219	10.80	163	12.16	19	11.05	4764	12.65
Advertisement	2296	6.73	31	1.53	71	5.29	2	1.16	2400	6.38
Distribution	2902	8.51	131	6.46	101	7.53	6	3.49	3140	8.34
Others	2631	7.71	209	10.31	130	9.69	17	9.88	2987	7.94
Total	34 105	100.00	2028	100.00	1341	100.00	172	100.00	37 646**	100.00

Note: Among the 4931 data provided for 2020 annual inspection, 34 data were invalid, 47 data had no content, hence there were 4850 valid data left.

*Others refer to journals in ethnic minority languages such as Tibetan language, Hazak language, Mongolian, or Uighur, bi-lingual journals with such a language with Chinese and/or English language.

**Staff of some journals have multiple positions/functions, hence the total number of personnel is larger than the actual number of people working in this industry. For example, the actual number of personnel for mandarin journals is 33 772, English journals 2026, Chi-English journals 1329, and others 168.

1.1.2.2.4 Academic Background Analysis of China's STM Journal Personnel

The majority of China's Chinese language STM journal personnel have an undergraduate degree. The majority of English language journal personnel have master's degrees. Among the 4931 journals that participated in the 2020 annual inspection, 4911 journals provided information of the personnel's academic background. 52 data were deleted due to invalidity, hence 4859 valid data were left. Based on the valid data, the majority of China's STM journal personnel have bachelor's and master's degrees, with a total number of 27 946 persons, accounting for 75.77% of all personnel. Mandarin journals have the largest number of personnel with 33 416 persons, accounting for 90.54%. The majority of mandarin journal personnel have bachelor's degrees, with a total of 15 706 persons, accounting for 47.00% of all personnel in mandarin journals. English language journals have a personnel of 2020 persons, the majority of which have master's degrees, with a number of 880 persons, accounting for 43.56% of all personnel in English language journals (table 1.9).

TAB. 1.9 – Academic background of China's STM journal personnel in 2020.

Academic background	Mandarin journal		English journal		Chi-Eng journal		Others*		Total	
	Person	%	Person	%	Person	%	Person	%	Person	%
Ph.D	3924	11.74	698	34.55	276	21.13	14	8.48	4912	13.31
Master's	9984	29.88	880	43.56	429	32.85	37	22.42	11 330	30.70
Bachelor's	15 706	47.00	351	17.38	472	36.14	105	63.64	16 634	45.07
College degree and under	3802	11.38	91	4.50	129	9.88	9	5.45	4031	10.92
Total	33 416	100.00	2020	100.00	1306	100.00	165	100.00	36 907	100.00

Note: 4931 data were provided for 2020. 52 data were invalid and 20 data had no content, hence there were 4859 valid data left.

*Others refer to journals in ethnic minority languages such as Tibetan language, Hazak language, Mongolian, or Uighur, and bi-lingual journals of such a language with Chinese or English.

1.1.2.2.5 Analysis of Professional Titles of China's STM Journal Personnel

Among the 4931 journals that participated in 2020 annual inspection, 4904 journals provided information of the personnel's professional titles. 40 data were deleted due to invalidity, hence 4864 valid data were left. Statistics show that 25 329 people (68.80% of all personnel) have intermediate titles and above, among which 15 099 people (41.01%) have senior titles (table 1.10).

TAB. 1.10 – Professional titles of China's STM journal personnel in 2020.

Professional title	No. of personnel	% of total personnel
Senior	6911	18.77
Associate senior	8188	22.24
Intermediate	10 230	27.79
Junior and under	11 488	31.20
Total	36 817	100.00

Note: Among the 4931 data provided for 2020, 40 data were invalid, 27 data had no content, hence 4864 valid data were left.

1.1.3 Publication Management and Content Censorship

Among the 4931 STM journals that participated in 2020 annual inspection, 4910 journals provided information of the publication management and content censorship. The statistics show that apart from new media content inspection, there have been solid implementation effects of the management and censorship of China's STM journals (table 1.11).

TAB. 1.11 – Facts of China's STM journal management regulations in 2020.

Management regulations	Yes		No		Not clear	
	No. of journal	%	No. of journal	%	No. of journal	%
Continuous guidance/management from managing/hosting organizations	4870	99.19	10	0.20	30	0.61
Implementation: "3 inspections 3 proofreadings"	4891	99.61	5	0.10	14	0.29
Implementation: regulations on registration of major topic selection	4874	99.27	16	0.33	20	0.41
Implementation: regulations on avoiding academic misconduct and protecting academic ethics*	4391	94.31	72	1.55	193	4.15
Implementation: new media content censorship	3790	77.19	208	4.24	912**	18.57
Implementation: editorial separated from business operations	4666	95.03	159	3.24	85	1.73

Note: 4931 data were provided for 2020 annual inspection, among which 21 data had no content.
*The statistics did not include the data of 254 non-academic journals.
**The new media of many journals is still under construction.

(a) Guidance and management from managing and/or hosting organizations. 4870 journals (99.19%) indicated that they had received regular guidance and management from their managing and/or hosting organizations; 10 journals indicated that they did not receive any guidance from their management/hosting organizations; and 30 journals did not make it clear.

(b) Policy of "3 inspections 3 proofreadings". 4891 journals (99.61%) indicated that they implemented this policy; 5 journals did not implement this policy; and 14 journals did not make it clear.

(c) Regulations for publishing organizations on registration of major topic selections. 4874 journals (99.27%) implemented such regulations; 16 journals did not implement such regulations; and 20 journals did not make it clear.

(d) Regulations for academic journals on avoiding academic misconduct and protecting academic ethics. 4391 journals (94.31%) implemented such regulations; 72 journals indicated that they did not have such regulations, and 193 journals did not make it clear.
(e) Regulations on new media content censorship. 3790 journals (77.19%) implemented relations on new media content censorship; 208 journals did not implement such regulations (including journals without new media); 912 journals did not make it clear.
(f) Regulations on separating editorial operations from business operations. 4666 journals (95.03%) indicated that their editorial operations and business operations were separate; 159 journals did not separate their editorial and business operations; and 85 journals did not make it clear.

1.2 Analysis of Papers Published by China's STM Journals

1.2.1 Papers Published by China's SCI Journals

Based on InCites database[2], this section gives objective descriptions on papers published by China's SCI journals, with regard to quantitative data including distribution by discipline, distribution by institution, international cooperation, and academic influence. Comparisons are made with papers published by Chinese authors in international journals and those published by the entire world's journals or by major scientific paper output countries. Analyses are done from different aspects on the comparisons. It aims to record and reveal the international status and development trends of China's STM journals, while emerging into the view of the international community.

1.2.1.1 Distribution by Discipline of Papers Published by China's STM Journals

Using academic indices including the volume of papers, times cited, citation impact, highly cited papers, and international cooperation papers of papers, statistical analysis was done, from the aspect of disciplines, on the data of papers published worldwide in 2020, papers published by China's SCI journals, papers published by Chinese authors, and papers published by Chinese authors in China's SCI journals.

[2]InCites is an international database launched by Clarivate Analytics based on gathering and analyzing the data in Web of Science (WoS). It combines a variety of quantitative indicators and the international equivalent data of each discipline in each year, to build an analytical tool for disciplines and scientific performance. The categorization of disciplines in this section used the categorization model of Essential Science Indicators (ESI). This model is based on journals, and is a relatively broad-ranged categorization of disciplines. It consists of 22 disciplines in natural sciences and social sciences. So each discipline belongs to one of the 22 ESI discipline. The database was last updated on July 1st, 2021. The data from WoS were last updated on May 31st, 2021, with the retrieval date being July 9th, 2021.

1.2.1.1.1 Volume of Papers Published by China's SCI Journals—By Discipline
Compared with the volume of papers published by Chinese authors, the volume of papers published by China's SCI journals cannot meet the needs of publication. In 2020, the 213[3] SCI journals in China published 30 742 papers, accounting for 1.45% of the world's total volume of papers published (2 126 916). For the same period, Chinese authors published 549 845 SCI papers, accounting for 25.85% of the world's total. 25 766 of those papers by Chinese authors were published in China's SCI journals, contributing 83.81% of the total papers published in China's SCI journals.

As shown in table 1.12, in terms of discipline, the average percentage of papers published by China's SCI journals of each discipline against the world's total for that discipline is lower than 5.00%. The Top 5 disciplines with the highest percentages are: "physics" (4.15%), "geosciences" (3.90%), "material science" (3.11%), "chemistry" (2.56%), and "mathematics" (1.72%). Apart from "psychiatry & psychology" and "social science", both of which account for 0%, the 5 disciplines with the lowest percentages are "economics & business" (0.09%), "multidisciplinary" (0.26%), "microbiology" (0.36%), "clinical medicine" (0.40%), and "biology & biochemistry" (0.59%).

In 2020, the disciplines with the percentage of papers published by Chinese authors against the world's total higher than 30.00% are: "material science" (43.24%), "engineering" (39.31%), "computer science" (36.78%), "molecular biology & genetics" (34.41%), "chemistry" (33.36%), and "geosciences" (31.88%). Compared with the volume of papers in each discipline published by China's STM journals, the percentage of paper volume of journals in "molecular biology and genetics", "computer science" and "engineering" is relatively low, 0.81%, 1.43%, and 1.44%, respectively. The percentage of the paper volume in the remaining 3 disciplines is higher than 2.00%.

With regard to the percentage of papers published by Chinese authors in China's SCI journals against the world's total number of Chinese authors' papers, there are 2 disciplines with the percentage higher than 10.00%: "physics" (11.99%) and "geosciences" (10.16%). Chinese authors are the primary contributors to the papers in China's SCI journals, with the percentage higher than 85.00% in 9 disciplines: "multidisciplinary" (100.00%), "chemistry" (94.42%), "biology and biochemistry" (92.92%), "microbiology" (89.42%), "material science" (88.76%), "computer science" (87.60%), "pharmacology & toxicology" (87.47%), "physics" (86.59%), and "molecular biology & genetics" (86.09%).

1.2.1.1.2 Analysis of Academic Influence of Papers Published by China's SCI Journals
1.2.1.1.2.1 Total Times Cited of Papers. The total times cited in 2020 of papers published by China's SCI journals is 86 574, accounting for 1.71% of the total times cited of papers published worldwide (5 074 169) for the same period. The percentage is higher than that of the papers published by China's STM journals against the world's total papers for the same period (1.45%). The total times cited of SCI papers published by Chinese authors account for 32.98% of the total times cited of world's total papers. The percentage is higher than the percentage of papers published by Chinese authors against the total papers published worldwide (25.85%) for the same period (table 1.13).

[3]267 journals from China were retrieved from InCites. 54 journals had no CN code, hence there were only 213 journals included in the statistics.

TAB. 1.12 – No. of SCI papers in each discipline published worldwide, by China's STM journals, and by Chinese authors in 2020.

Serial no.	Discipline	No. of World's papers (A)	No. of papers by China's STM journals (B)	% (B/A × 100%)	No. of papers by Chinese authors (C)	% (C/A × 100%)	No. of papers by Chinese authors in China's STM journals (D)	% (D/C × 100%)	% (D/B × 100%)
1	Agricultural science	62 659	842	1.34	15 367	24.52	647	4.21	76.84
2	Biology & biochemistry	93 411	551	0.59	23 817	25.50	512	2.15	92.92
3	Chemistry	215 184	5498	2.56	71 792	33.36	5191	7.23	94.42
4	Clinical medicine	379 966	1509	0.40	64 116	16.87	1124	1.75	74.49
5	Computer science	59 722	855	1.43	21 967	36.78	749	3.41	87.60
6	Economics & business	41 003	36	0.09	5821	14.20	30	0.52	83.33
7	Engineering	240 078	3460	1.44	94 377	39.31	2683	2.84	77.54
8	Environment & ecology	103 523	1226	1.18	28 831	27.85	939	3.26	76.59
9	Geosciences	67 115	2618	3.90	21 397	31.88	2173	10.16	83.00
10	Immunology	32 827	329	1.00	5852	17.83	186	3.18	56.53
11	Material science	144 684	4500	3.11	62 559	43.24	3994	6.38	88.76
12	Mathematics	57 292	984	1.72	15 316	26.73	816	5.33	82.93
13	Microbiology	28 701	104	0.36	6099	21.25	93	1.52	89.42

Tab. 1.12 – (continued).

14	Molecular biology & genetics	56 857	460	0.81	19 565	34.41	396	2.02	86.09
15	Multidisciplinary	2690	7	0.26	411	15.28	7	1.70	100.00
16	Neuroscience & behavior	62 239	496	0.80	9045	14.53	327	3.62	65.93
17	Pharmacology & toxicology	56 829	798	1.40	15 975	28.11	698	4.37	87.47
18	Physics	113 364	4706	4.15	33 979	29.97	4075	11.99	86.59
19	Plant & animal science	92 934	1551	1.67	17 289	18.60	960	5.55	61.90
20	Psychiatry & psychology	60 333	0	0.00	4660	7.72	0	0.00	–
21	Social science	138 885	0	0.00	9045	6.51	0	0.00	–
22	Space science	16 620	212	1.28	2565	15.43	166	6.47	78.30
	Total	2 126 916	30 742	1.45	549 845	25.85	25 766	4.69	83.81

Note: Retrieval method—search for "research areas" in InCites, within time period 2020; using discipline categorizations of ESI; choose "research article" and "review" for article type; and then choose "worldwide", "Chinese authors", "China's STM journals", and "Chinese authors in China's STM journals" respectively to obtain data.

Tab. 1.13 – Times cited of SCI papers in each discipline published worldwide, by China's STM journals, and by Chinese authors in 2020.

Serial no.	Discipline	Times cited of world's papers (A)	Times cited of papers published by China's STM journals (B)	% (B/A × 100%)	Times cited of papers published by Chinese authors (C)	% (C/A × 100%)	Times cited of papers published by Chinese authors in China's STM journals (D)	% (D/C × 100%)	% (D/B × 100%)
1	Agricultural science	121 929	1798	1.47	37 179	30.49	1250	3.36	69.52
2	Biology & biochemistry	261 033	2531	0.97	63 556	24.35	2405	3.78	95.02
3	Chemistry	600 589	16 380	2.73	245 332	40.85	15 107	6.16	92.23
4	Clinical medicine	965 327	11 184	1.16	243 287	25.20	10 205	4.19	91.25
5	Computer science	130 755	1524	1.17	63 510	48.57	1298	2.04	85.17
6	Economics & business	63 236	31	0.05	11 121	17.59	25	0.22	80.65
7	Engineering	551 444	6328	1.15	254 113	46.08	4792	1.89	75.73
8	Environment & ecology	260 945	2460	0.94	88 929	34.08	1996	2.24	81.14
9	Geosciences	129 951	3539	2.72	44 346	34.13	2541	5.73	71.80
10	Immunology	151 324	2658	1.76	44 401	29.34	2115	4.76	79.57
11	Material science	463 965	12 932	2.79	242 841	52.34	11 474	4.72	88.73
12	Mathematics	53 549	538	1.00	20 268	37.85	469	2.31	87.17
13	Microbiology	119 091	858	0.72	45 018	37.80	822	1.83	95.80

Tab. 1.13 – (continued).

14	Molecular biology & genetics	197 226	3811	1.93	60 853	30.85	3058	5.03	80.24
15	Multidisciplinary	10 493	59	0.56	2989	28.49	59	1.97	100.00
16	Neuroscience & behavior	150 896	1932	1.28	22 175	14.70	1117	5.04	57.82
17	Pharmacology & toxicology	133 156	4001	3.00	38 442	28.87	3581	9.32	89.50
18	Physics	233 354	9581	4.11	74 121	31.76	7722	10.42	80.60
19	Plant & animal science	131 817	4159	3.16	30 348	23.02	3000	9.89	72.13
20	Psychiatry & psychology	113 382	0	0.00	12 643	11.15	0	0.00	–
21	Social science	181 047	0	0.00	18 874	10.42	0	0.00	–
22	Space science	49 660	270	0.54	8952	18.03	233	2.60	86.30
	Total	5 074 169	86 574	1.71	1 673 298	32.98	73 269	4.38	84.63

Note: Retrieval method—search for "research areas" in InCites, within time period 2020; using discipline categorizations of ESI; choose "research article" and "review" for article type; and then choose "worldwide", "Chinese authors", "China's STM journals", and "Chinese authors in China's STM journals" respectively to obtain data.

For 14 disciplines, the percentage of the times cited of papers published by China's SCI journals in each discipline against the world's total is higher than 1.00%. They are: "physics" (4.11%), "plant & animal science" (3.16%), 'pharmacology & toxicology" (3.00%), "material science" (2.79%), "chemistry" (2.73%), "geosciences" (2.72%), "molecular biology & genetics" (1.93%), "immunology" (1.76%), "agricultural science" (1.47%), "neuroscience & behavior" (1.28%), "computer science" (1.17%), "clinical medicine" (1.16%), "engineering" (1.15%), and "mathematics" (1.00%). For 11 disciplines, the percentage of the times cited of papers published by Chinese authors in each discipline against the world's total is higher than 30.00%. They are: "material science" (52.34%), "computer science" (48.57%), "engineering" (46.08%), "chemistry" (40.85%), "mathematics" (37.85%), "microbiology" (37.80%), "geosciences" (34.13%), "environment & ecology" (34.08%), "physics" (31.76%), "molecular biology & genetics" (30.85%), and "agricultural science" (30.49%).

For 10 disciplines, the percentage of the times cited of papers published by Chinese authors in China's STM journal against the total times cited of China's STM journals is higher than 85.00%. 5 of the disciplines—"material science", "computer science", "chemistry", "mathematics", and "microbiology"—have relatively higher percentage of times cited of Chinese authors' papers against the world's total. Another 5 disciplines —"pharmacology & toxicology", "multidisciplinary", "clinical medicine", "biology & biochemistry", and "space science"—have relatively low percentage of the times cited of Chinese authors' papers against the world's total.

1.2.1.1.2.2 Citation Impact. In 2020, the citation impact of papers published by China's SCI journals is 2.82 and the citation impact of SCI papers published by Chinese authors is 3.04. Both of the above are higher than the citation impact of SCI papers worldwide (2.39) for the same period.

As shown in table 1.14, for 11 disciplines out of the 22 disciplines, the citation impact of papers published by China's SCI journals is higher than the citation impact of papers worldwide. They are: "agricultural science", "biology & biochemistry", "chemistry", "clinical medicine", "immunology", "microbiology", "molecular biology and genetics", "multidisciplinary", "neuroscience & behavior", "pharmacology & toxicology", and "plant & animal science". For the other 11 disciplines, the citation impact is lower than the world's average. The papers published by Chinese authors have outstanding performance in each discipline. For 20 disciplines, the citation impact of Chinese authors' papers in each discipline is higher than the world's average. For only 2 disciplines, the citation impact of Chinese authors' papers is a little lower than the world's average. They are: "biology & biochemistry", 0.12 percentage point lower than the world's average, and "molecular biology & genetics", 0.36 percentage point lower than the world's average. There are 4 disciplines for which the citation impact of papers published by China's STM journals is above 8.00. They are: "multidisciplinary" (8.43), "molecular biology & genetics" (8.28), "microbiology" (8.25), and "immunology" (8.08).

The citation impact of papers published by Chinese authors in China's SCI journals in the following disciplines is higher than the average citation impact of all papers published by Chinese authors in these disciplines: "biology & biochemistry", "clinical medicine", "immunology", "microbiology", "molecular biology & genetics", "multidisciplinary",

Tab. 1.14 – Citation impact of papers published worldwide, by China's STM journals, and by Chinese authors in each discipline in 2020, and percentage of cited papers in each discipline.

Serial no.	Discipline	Citation impact				% of cited papers			
		Papers	Papers published by China's STM journals	Papers published by Chinese authors	Papers published by Chinese authors in China's STM journals	Papers	Papers published by China's STM journals	Papers published by Chinese authors	Papers published by Chinese authors in China's STM journals
1	Agricultural science	1.95	2.14	2.42	1.93	58.42	69.83	65.18	68.47
2	Biology & biochemistry	2.79	4.59	2.67	4.70	65.65	55.54	60.91	53.91
3	Chemistry	2.79	2.98	3.42	2.91	66.42	54.37	68.72	53.13
4	Clinical medicine	2.54	7.41	3.79	9.08	53.46	57.19	50.78	55.96
5	Computer science	2.19	1.78	2.89	1.73	53.18	48.07	55.84	47.53
6	Economics & business	1.54	0.86	1.91	0.83	49.19	50.00	51.74	46.67
7	Engineering	2.30	1.83	2.69	1.79	58.39	53.27	58.92	50.91
8	Environment & ecology	2.52	2.01	3.08	2.13	63.63	59.87	65.47	59.64
9	Geosciences	1.94	1.35	2.07	1.17	60.13	46.75	59.60	42.94
10	Immunology	4.61	8.08	7.59	11.37	65.43	77.81	64.42	81.72
11	Material science	3.21	2.87	3.88	2.87	67.98	56.60	70.55	54.53
12	Mathematics	0.93	0.55	1.32	0.57	36.13	26.83	38.24	27.45
13	Microbiology	4.15	8.25	7.38	8.84	65.05	55.77	62.08	52.69

Tab. 1.14 – (continued).

Serial no.	Discipline	Citation impact				% of cited papers			
		Papers	Papers published by China's STM journals	Papers published by Chinese authors	Papers published by Chinese authors in China's STM journals	Papers	Papers published by China's STM journals	Papers published by Chinese authors	Papers published by Chinese authors in China's STM journals
14	Molecular biology & genetics	3.47	8.28	3.11	7.72	65.09	82.17	61.93	82.07
15	Multidisciplinary	3.90	8.43	7.27	8.43	52.12	100.00	51.82	100.00
16	Neuroscience & behavior	2.42	3.90	2.45	3.42	62.24	78.83	59.03	76.45
17	Pharmacology & toxicology	2.34	5.01	2.41	5.13	62.11	74.94	62.64	74.64
18	Physics	2.06	2.04	2.18	1.89	57.74	50.57	57.45	47.58
19	Plant & animal science	1.42	2.68	1.76	3.13	51.51	61.64	56.01	60.42
20	Psychiatry & psychology	1.88	0.00	2.71	0.00	54.20	0.00	52.98	0.00
21	Social science	1.30	0.00	2.09	0.00	45.14	0.00	53.21	0.00
22	Space science	2.99	1.27	3.49	1.40	67.67	41.51	64.44	44.58
	Total	2.39	2.82	3.04	2.84	58.02	54.97	60.43	52.91

Note: Retrieval method—search for "research areas" in InCites, within time period 2020; using discipline categorizations of ESI; choose "research article" and "review" for article type; and then choose "worldwide", "Chinese authors", "China's STM journals", and "Chinese authors in China's STM journals", respectively, to obtain data.

The data on citation impact and percentage of cited papers of all disciplines used the baseline value.

"neuroscience & behavior", "pharmacology & toxicology", and "plant & animal science". China's SCI journals in these 9 disciplines attracted more high-level papers from Chinese authors.

In 2020, of all the papers published by China's STM journals, the percentage of cited papers is 54.97%; of all the papers published by Chinese authors, the percentage of cited papers is 60.43%; of all the papers published worldwide, the percentage of cited papers is 58.02%. For 9 disciplines, the percentage of cited papers published by China's SCI journals in each discipline is higher than the equivalent of world's papers: "agricultural science", "clinical medicine", "economics & business", "immunology", "molecular biology & genetics", "multidisciplinary", "neuroscience & behavior", "pharmacology & toxicology", and "plant & animal science". For the remaining 13 disciplines, the percentage of papers cited in each discipline is lower than the world's percentage. In addition, for 11 disciplines, the percentage of cited papers published by Chinese authors is higher than the percentage of cited papers against the world's total: "agricultural science", "chemistry", "computer science", "economics & business", "engineering", "environment & ecology", "material science", "mathematics", "pharmacology & toxicology", "plant & animal science", and "social science". For 4 disciplines—"agricultural science", "economics & business", "pharmacology & toxicology", "plant & animal science"—the percentage of cited papers published by Chinese authors, and the percentage of cite papers published by China's SCI journals, are both higher than the percentage of cited papers worldwide.

1.2.1.1.2.3 Category Normalized Citation Impact. In 2020, the category normalized citation impact (CNCI) of papers published by China's SCI journals in 2020 is 1.10[4] and the CNCI of papers published by Chinese authors is 1.25.

Among the papers published by China's SCI journals, the CNCI of papers in "clinical medicine" (2.84), "multidisciplinary" (2.18), "molecular biology & genetics" (2.10), "pharmacology & toxicology" (2.05), "plant & animal science" (1.85), "microbiology" (1.81), "immunology" (1.69), "biology & biochemistry" (1.65), "neuroscience & behavior" (1.40), "agricultural science" (1.09) and "chemistry" (1.04) is above 1.0. The CNCI of the remaining 11 disciplines is <1. Among them, for 8 disciplines: $0.5 \leq \text{CNCI} < 1$, for 1 discipline: $0 < \text{CNCI} < 0.5$, and for 2 disciplines: $\text{CNCI} = 0$.

The CNCI of papers published by Chinese authors in China's SCI journals is similar to the CNCI of all papers published by China's SCI journals. For 17 disciplines: the difference between the 2 numbers is $-0.10 \sim 0.10$. For the 4 disciplines—"immunology", "clinical medicine", "plant & animal science", and "microbiology"—the CNCI of papers published by Chinese authors in China's SCI journals is higher than the CNCI of papers published by all China's SCI journals, the difference being 0.75, 0.64, 0.30, and 0.16, respectively. For the disciplines of "geosciences" and "molecular biology & genetics", the CNCI of papers published by Chinese authors in China's SCI journals is 0.10 lower on average than the CNCI of papers published by all China's SCI journals.

[4]CNCI reflects a paper's citation impact, through the times cited after its publication. Due to the different increase rates of citations with time in different disciplines, it is necessary to "normalize" the numbers based on the categories and publication year, and then take the average number. The world's average number is always 1.0 for datum reference.

In terms of CNCI of papers by Chinese authors, the impact of papers by Chinese authors in 20 disciplines is higher than the average impact of papers in each discipline. In addition, even for the disciplines with CNCI below 1.0, the impact of Chinese authors' paper is very close to the disciplinary average.

For disciplines of "biology & biochemistry", "clinical medicine", "microbiology", "multidisciplinary", "neuroscience & behavior", "pharmacology & toxicology", and "plant & animal science", the CNCI of papers published by Chinese authors in China's SCI journals ≥ CNCI of papers published by China's SCI journals > CNCI of papers published by Chinese authors. For the discipline of "molecular biology & genetics", the CNCI of papers published by China's SCI journals (2.10) is higher than that of papers published by Chinese authors (0.92) (figure 1.1).

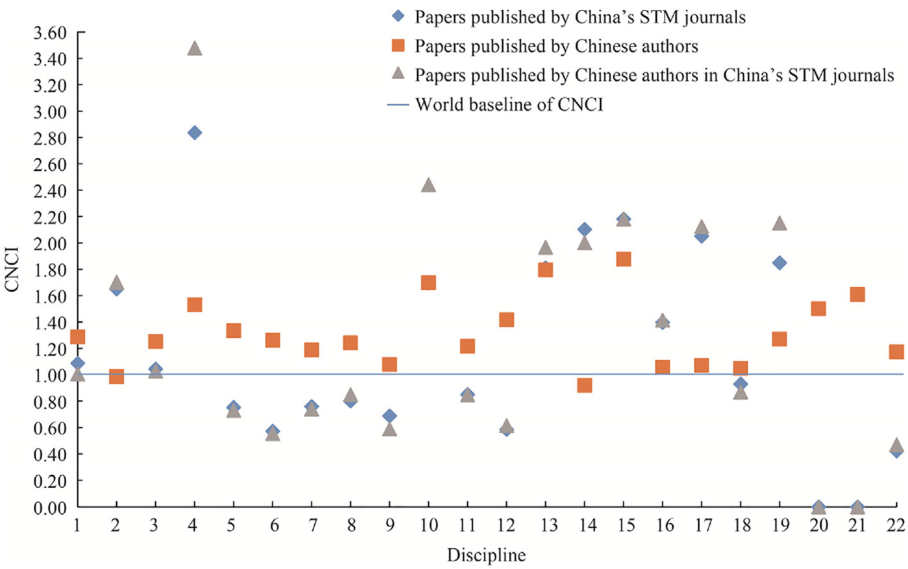

FIG. 1.1 – CNCI of papers published by China's STM journals, by Chinese authors and by Chinese authors in China's STM journals in 2020.

1. Agricultural science; 2. Biology & biochemistry; 3. Chemistry; 4. Clinical medicine; 5. Computer science; 6. Economy & business; 7. Engineering; 8. Environment & ecology; 9. Geosciences; 10. Immunology; 11. Material science; 12. Mathematics; 13. Microbiology; 14. Molecular biology & genetics; 15. Multidisciplinary; 16. Neuroscience & behavior; 17. Pharmacology & toxicology; 18. Physics; 19. Plant & animal science; 20. Psychiatry & psychology[①]; 21. Social science[①]; 22. Space science.

Retrieval method: Search for "research areas" in InCites, set time period as 2020, use ESI discipline categorization model, choose "research article" and "review" for article type; and then choose "worldwide", "Chinese authors", "China's STM journals", and "Chinese authors in China's STM journals", respectively, to obtain data.

[①]There was no paper in psychiatry & psychology and social science published by China's STM journals. Hence for these two categories, the CNCI of papers published by China's STM journals and papers published by Chinese authors in China's STM journals is 0.

For 13 disciplines, the CNCI of papers published by Chinese authors is higher than the CNCI of papers published by China's SCI journals. Among them, for "social science" and "psychiatry & psychology", the difference between the two values (R) is above 1.0 ($R > 1.0$); for 4 disciplines, $0.5 < R \leq 1.0$; and for 7 disciplines, $0 < R \leq 0.5$. For the other 9 disciplines, the CNCI of papers published by China's SCI journals is higher than the CNCI of papers published by Chinese authors. Among them, for 4 disciplines, $-0.5 < R \leq 0$; for 3 disciplines, $-1.0 < R \leq -0.5$; and for "clinical medicine" and "molecular biology & genetics", $R \leq -1.0$ (table 1.15).

Tab. 1.15 – D-value of CNCI of papers in each discipline published by Chinese authors and by China's STM journals in 2020.

D-value (R)	Discipline
$R \leq -1.0$	Clinical medicine (–1.31), molecular biology & genetics (–1.18)
$-1.0 < R \leq -0.5$	Pharmacology & toxicology (–0.98), biology & biological chemistry (–0.66), plant & animal science (–0.58)
$-0.5 < R \leq 0$	Neuroscience & behavior (–0.34), multidisciplinary (–0.30), microbiology (–0.02), immunology (0.00)
$0 < R \leq 0.5$	Physics (0.12), agricultural science (0.20), chemistry (0.21), material science (0.37), geosciences (0.39), engineering (0.43), environment & ecology (0.44)
$0.5 < R \leq 1.0$	Computer science (0.58), economics & business (0.69), space science (0.75), mathematics (0.83)
$R > 1.0$	Psychiatry & psychology (1.50), social science (1.61)

Note: D-value (R) = CNCI of papers published by Chinese authors–CNCI of papers published by China's STM journals.

1.2.1.1.2.4 Number of Highly Cited Papers. In 2020, China's SCI journals published 444 highly cited papers[5], accounting for 2.09% of the world's total number of highly cited papers (21 264 papers). Chinese authors published 7920 highly cited papers, accounting for 37.25% of the world's total highly cited papers.

As shown in table 1.16, for 11 disciplines, the highly cited papers published by China's SCI journals account for 1.00%. They are: "plant & animal science" (6.71%), "chemistry" (4.68%), "physics" (4.46%), "pharmacology & toxicology" (3.74%), "geosciences" (3.73%), "material science" (3.68%), "molecular biology & genetics" (3.06%), "agricultural science" (1.74%), "immunology" (1.22%), "clinical medicine" (1.19%), and "neuroscience & behavior" (1.16%). In 2020, among all papers published by China's SCI journals, the discipline of "chemistry" has the highest number of highly cited papers—99 papers. The discipline of "plant & animal science" comes second—66 papers. Among all these highly cited papers, papers published by Chinese authors take a high percentage. Among the 17 disciplines that have highly cited papers, 16 disciplines have more than 50.00% of papers from Chinese authors. For 6 disciplines—"biology & biochemistry", "environment &

[5]The world's Top 1% papers in each discipline, ranked by times cited in 2020 (using ESI categorization for disciplines).

TAB. 1.16 – Number of highly cited papers in each discipline published worldwide, by China's STM journals, and by Chinese authors in 2020.

Serial no.	Discipline	No. of highly cited papers worldwide (A)	No. of highly cited papers published by China's STM journals (B)	% (B/A × 100%)	No. of highly cited papers published by Chinese authors (C)	% (C/A × 100%)	Ratio of highly cited papers published by Chinese authors to those by China's STM journals (C/B)	No. of highly cited papers published by Chinese authors in China's STM journals (D)	% (D/B × 100%)
1	Agricultural science	631	11	1.74	224	35.50	20.36	5	45.45
2	Biology & biochemistry	962	8	0.83	227	23.60	28.38	8	100.00
3	Chemistry	2116	99	4.68	1095	51.75	11.06	91	91.92
4	Clinical medicine	3939	47	1.19	788	20.01	16.77	44	93.62
5	Computer science	590	5	0.85	416	70.51	83.20	4	80.00
6	Economics & business	407	0	0.00	103	25.31	–	0	–
7	Engineering	2318	18	0.78	1458	62.90	81.00	14	77.78
8	Environment & ecology	1006	6	0.60	417	41.45	69.50	6	100.00
9	Geosciences	616	23	3.73	280	45.45	12.17	16	69.57
10	Immunology	328	4	1.22	143	43.60	35.75	4	100.00
11	Material science	1467	54	3.68	936	63.80	17.33	54	100.00
12	Mathematics	553	3	0.54	328	59.31	109.33	3	100.00
13	Microbiology	289	2	0.69	132	45.67	66.00	2	100.00

Tab. 1.16 – (continued).

14	Molecular biology & genetics	556	17	3.06	156	28.06	9.18	11	64.71
15	Multidisciplinary	26	0	0.00	8	30.77	–	0	–
16	Neuroscience & behavior	606	7	1.16	83	13.70	11.86	4	57.14
17	Pharmacology & toxicology	589	22	3.74	175	29.71	7.95	19	86.36
18	Physics	1166	52	4.46	399	34.22	7.67	41	78.85
19	Plant & animal science	983	66	6.71	276	28.08	4.18	47	71.21
20	Psychiatry & psychology	643	0	0.00	74	11.51	–	0	–
21	Social science	1302	0	0.00	176	13.52	–	0	–
22	Space science	171	0	0.00	26	15.20	–	0	–
	Total	21 264	444	2.09	7920	37.25	17.84	373	84.01

Note: Retrieval method—search for "research areas" in InCites, within time period 2020; using discipline categorizations of ESI; choose "research article" and "review" for article type; and then choose "worldwide", "Chinese authors", "China's STM journals", and "Chinese authors in China's STM journals", respectively, to obtain data.

ecology", "immunology", "material science", "mathematics", "microbiology", papers from Chinese authors account for 100.00%. The only discipline with the percentage of papers from Chinese authors lower than 50.00% is "agricultural science" (45.45%). There are 5 disciplines of which the percentage of highly cited papers from Chinese authors against the world's total is above 50.00%: "computer science" (70.51%), "material science" (63.80%), "engineering" (62.90%), "mathematics" (59.31%), and "chemistry" (51.75%). In all disciplines, the percentage of highly cited papers published by Chinese authors against the world's total is far higher than the percentage of highly-cited papers published by China's SCI journals against the world's total.

1.2.1.1.2.5 Number of Papers in Q1 Journals. In 2020, 11 322 papers published by China's SCI journals were Q1 journal papers in *Journal Citation Report* (JCR hereafter), accounting for 1.26% of all Q1 papers published worldwide (900 591 papers) in the same period. 253 121 papers published by Chinese authors were Q1 journal papers, accounting for 28.11% of the world's total. The above 2 percentages are both lower than the equivalent percentages of highly cited papers.

As shown in table 1.17, for 10 disciplines, the percentage of Q1 papers published by China's SCI journals is above 1.00%: "physics" (3.53%), "material science" (2.84%), "geosciences" (2.53%), "immunology" (2.40%), "agricultural science" (2.39%), "plant & animal science" (2.27%), "pharmacology & toxicology" (1.52%), "chemistry" (1.49%), "engineering" (1.43%), and "molecular biology & genetics" (1.16%). For the remaining 12 disciplines, the percentage is all lower than 1.00%.

In terms of contribution to Q1 journal papers by China's SCI journals, papers by Chinese authors account for the higher percentage, over 50% for 18 disciplines. The remaining 4 disciplines have no Q1 journals. For 3 disciplines—"microbiology", "multidisciplinary", and "space science", the papers in Q1 journals are all from Chinese authors.

In terms of percentage of Q1 journal papers published by Chinese authors, there are 9 disciplines with the percentage higher than 30.00% against the world's total of Q1 journal papers: "material science" (47.92%), "engineering" (42.74%), "computer science" (41.79%), "chemistry" (36.07%), "geosciences" (34.59%), "agricultural science" (31.45%), "environment & ecology" (30.87%), "molecular biology & genetics" (30.62%), and "physics" (30.48%). There is a big gap between the percentage of Q1 journal papers published by Chinese authors and the percentage of Q1 journal papers published by China's SCI journals, especially in "microbiology" and "space science".

1.2.1.1.3 International Cooperation of Papers Published by China's SCI Journals
In 2020, the percentage of international cooperation papers published by China's SCI journals against the total number of papers published by China's SCI journals is 18.52%, 9.47 percentage point lower than the percentage of international cooperation papers against the world's total papers (27.99%). For the same period, the percentage of international cooperation papers published by Chinese authors against the total papers published worldwide is 26.19%, 1.80 percentage point lower than the world's average (table 1.18).

Among the papers published by China's SCI journals, there are 5 disciplines for which the percentage of international cooperation papers is higher than the equivalent percentage of the world's total cooperation papers for each discipline: "multidisciplinary", "immunology", "molecular biology & genetics", "agricultural science", and "plant & animal

Tab. 1.17 – Number of papers in each discipline in Q1 journals published worldwide, by China's STM journals, and by Chinese authors in 2020.

Serial no.	Discipline	No. of papers in Q1 journals worldwide (A)	No. of papers in Q1 journals by China's STM journals (B)	% (B/A × 100%)	No. of papers in Q1 journals by Chinese authors (C)	% (C/A × 100%)	Ratio of Q1 journal papers published by Chinese authors to those by China's STM journals (C/B)	No. of papers published by Chinese authors in China's Q1 journals (D)	% (D/B × 100%)
1	Agricultural science	30 722	735	2.39	9662	31.45	13.15	588	80.00
2	Biology & biochemistry	44 149	311	0.70	12 151	27.52	39.07	274	88.10
3	Chemistry	103 443	1541	1.49	37 307	36.07	24.21	1459	94.68
4	Clinical medicine	125 896	164	0.13	14 805	11.76	90.27	89	54.27
5	Computer science	25 342	237	0.94	10 591	41.79	44.69	196	82.70
6	Economics & business	14 485	0	0.00	1888	13.03	–	0	–
7	Engineering	98 137	1406	1.43	41 948	42.74	29.83	999	71.05
8	Environment & ecology	49 653	367	0.74	15 328	30.87	41.77	277	75.48
9	Geosciences	32 807	829	2.53	11 349	34.59	13.69	565	68.15
10	Immunology	13 682	329	2.40	2172	15.87	6.60	186	56.53
11	Material science	82 329	2340	2.84	39 452	47.92	16.86	2005	85.68
12	Mathematics	20 386	0	0.00	6040	29.63	–	0	–
13	Microbiology	11 491	2	0.02	2689	23.40	1344.50	2	100.00

Tab. 1.17 – (continued).

Serial no.	Discipline	No. of papers in Q1 journals worldwide (A)	No. of papers in Q1 journals by China's STM journals (B)	% (B/A × 100%)	No. of papers in Q1 journals by Chinese authors (C)	% (C/A × 100%)	Ratio of Q1 journal papers published by Chinese authors to those by China's STM journals (C/B)	No. of papers published by Chinese authors in China's Q1 journals (D)	% (D/B × 100%)
14	Molecular biology & genetics	24 019	279	1.16	7355	30.62	26.36	249	89.25
15	Multidisciplinary	1232	7	0.57	204	16.56	29.14	7	100.00
16	Neuroscience & behavior	25 093	49	0.20	2858	11.39	58.33	29	59.18
17	Pharmacology & toxicology	23 128	351	1.52	6760	29.23	19.26	316	90.03
18	Physics	39 177	1384	3.53	11 942	30.48	8.63	1035	74.78
19	Plant & animal science	43 491	988	2.27	10 801	24.84	10.93	637	64.47
20	Psychiatry & psychology	22 245	0	0.00	1521	6.84	–	0	–
21	Social science	56 925	0	0.00	4298	7.55	–	0	–
22	Space science	12 759	3	0.02	2000	15.68	666.67	3	100.00
	Total	900 591	11 322	1.26	253 121	28.11	22.36	8916	78.75

Note: Retrieval method—search for "research areas" in InCites, within time period 2020; using discipline categorizations of ESI; choose "research article" and "review" for article type; and then choose "worldwide", "Chinese authors", "China's STM journals", and "Chinese authors in China's STM journals", respectively, to obtain data.

TAB. 1.18 – Percentage of international cooperation SCI papers in each discipline published worldwide, by China's STM journals, and by Chinese authors in 2020.

Serial no.	Discipline	% of int'l cooperation papers published worldwide (*A*)	% of int'l cooperation papers published by China's STM journals (*B*)	D-value (%) (*B* – *A*)	% of int'l cooperation papers published by Chinese authors (*C*)	D-value (%) (*C* – *A*)	D-value (%) (*C* – *B*)	% of int'l cooperation papers published by Chinese authors in China's STM journals (*D*)	D-value (%) (*D* – *B*)
1	Agricultural science	26.66	27.91	1.25	29.16	2.50	1.25	23.80	–4.11
2	Biology & biochemistry	28.12	15.25	–12.87	21.97	–6.15	6.72	14.45	–0.80
3	Chemistry	24.70	10.09	–14.61	20.35	–4.35	10.26	9.00	–1.09
4	Clinical medicine	22.93	14.05	–8.88	17.46	–5.47	3.41	12.46	–1.59
5	Computer science	32.47	23.74	–8.73	36.51	4.04	12.77	23.77	0.03
6	Economics & business	37.22	8.33	–28.89	50.95	13.73	42.62	6.67	–1.66
7	Engineering	26.81	20.17	–6.64	27.08	0.27	6.91	18.45	–1.72
8	Environment & ecology	33.66	21.78	–11.88	31.46	–2.20	9.68	18.42	–3.36
9	Geosciences	39.29	20.89	–18.40	38.68	–0.61	17.79	18.36	–2.53
10	Immunology	32.08	39.51	7.43	25.00	–7.08	–14.51	31.72	–7.79
11	Material science	27.03	15.93	–11.10	25.23	–1.80	9.30	14.87	–1.06
12	Mathematics	31.23	18.60	–12.63	27.52	–3.71	8.92	18.26	–0.34
13	Microbiology	32.75	22.12	–10.63	26.96	–5.79	4.84	20.43	–1.69
14	Molecular biology & genetics	29.29	34.57	5.28	20.73	–8.56	–13.84	35.86	1.29
15	Multidisciplinary	32.19	57.14	24.95	35.28	3.09	–21.86	57.14	0.00

Tab. 1.18 – (continued).

Serial no.	Discipline	% of int'l cooperation papers published worldwide (A)	% of int'l cooperation papers published by China's STM journals (B)	D-value (%) ($B-A$)	% of int'l cooperation papers published by Chinese authors (C)	D-value (%) ($C-A$)	D-value (%) ($C-B$)	% of int'l cooperation papers published by Chinese authors in China's STM journals (D)	D-value (%) ($D-B$)
16	Neuroscience & behavior	29.50	25.20	–4.30	27.22	–2.28	2.02	25.38	0.18
17	Pharmacology & toxicology	24.31	18.55	–5.76	14.64	–9.67	–3.91	17.34	–1.21
18	Physics	32.01	17.89	–14.12	28.35	–3.66	10.46	15.31	–2.58
19	Plant & animal science	33.30	33.40	0.10	31.24	–2.06	–2.16	31.98	–1.42
20	Psychiatry & psychology	28.27	0.00	–28.27	40.56	12.29	40.56	0.00	0.00
21	Social science	22.49	0.00	–22.49	44.08	21.59	44.08	0.00	0.00
22	Space science	58.56	18.40	–40.16	61.95	3.39	43.55	15.66	–2.74
	Total	27.99	18.52	–9.47	26.19	–1.80	7.67	16.34	–2.18

Note: Retrieval method—search for "research areas" in InCites, within time period 2020; using discipline categorizations of ESI; choose "research article" and "review" for article type; and then choose "worldwide", "Chinese authors", "China's STM journals", and "Chinese authors in China's STM journals", respectively, to obtain data.

science". They are 24.95, 7.43, 5.28, 1.25, and 0.10 percentage points higher, respectively, than the percentage of the world's papers in each discipline. In 2020, for the 5 disciplines —"multidisciplinary", "immunology" "molecular biology & genetics", "pharmacology & toxicology", "plant & animal science", the percentage of international cooperation papers published by China's SCI journals is higher than the percentage of international cooperation papers published by Chinese authors. The gap in percentage is 21.86, 14.51, 13.83, 3.90, and 2.16 respectively.

For overall disciplines, the percentage of international cooperation papers published by Chinese authors in China's SCI journals, is not much different from the percentage of international papers published by China's SCI journals.

1.2.1.2 Papers Published by China's SCI Journals—Distribution by Publishing Institution

1.2.1.2.1 Distribution by Worldwide Publishing Institutions

In 2020, 4697 institutions from 122 countries/regions published 70 464 papers[6] in China's SCI journals. Ranked by the number of publishing institutions, the Top 10 countries are: China[7], USA, India, Spain, France, Russia, Japan, Italy, Germany and Korea. In terms of the number of papers published in China's SCI journals by different countries, China is the No. 1 output country, with USA being the second. China has a total of 1038 institutions publishing 25 278 papers, accounting for 82.23%. USA has 632 institutions publishing 2596 papers, accounting for 8.44%. Six countries—India, France, Japan, Italy, Germany, Korea —each contribute over 1.00% in terms of the number of papers. On the other hand, for Australia (66 institutions publishing 685 papers), UK (126 institutions publishing 623 papers), Canada (78 institutions publishing 437 papers), and Iran (59 institutions publishing 424 papers), though the number of publishing institutions is not large, the number of papers published by each country accounts for more than 1.00% as well.

Among the Top 10 countries with the highest number of publishing institutions, China (83.78%) and USA (13.29%) are also ranked Top 2 in terms of the percentage of highly cited papers published in China's SCI journals. Following China and USA, 6 countries have a percentage of highly cited papers published in China's SCI journals above 2%: Germany (3.83%), France (2.93%), Japan (2.93%), Italy (2.93%), India (2.03%), and Spain (2.03%) (table 1.19). In addition, 5 other countries have a relatively high percentage of highly cited papers published in China's SCI journals: Australia (7.43%), Singapore (3.15%), UK (2.93%), Canada (2.93%), and Saudi Arabia (2.25%).

In terms of the number of papers, among the Top 100[8] institutions that published in China's SCI journals, 93 institutions are from China. University of California System published 265 papers, ranking 32nd; Centre National de la Recherche Scientifique (CNRS)

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[6]The number of papers published by institutions has overlap in counting, which means the same paper can be counted under multiple institutions.

[7]The data on Chinese institutions in this book do not include the data on Hong Kong, Macao, and Taiwan regions.

[8]There are two institutions both ranked 100th with the same number of papers, hence there are 101 institutions in total.

TAB. 1.19 – Facts of papers published in China's SCI journals by institutions from TOP 10 countries in 2020.

Serial no.	Country	No. of institution	No. of SCI papers	% of SCI papers against papers published by China's STM journals	No. of highly cited papers	% of highly cited papers against total highly cited papers published by China's STM journals
1	China	1038	25 278	82.23	372	83.78
2	USA	632	2596	8.44	59	13.29
3	India	292	447	1.45	9	2.03
4	Spain	170	304	0.99	9	2.03
5	France	153	351	1.14	13	2.93
6	Russia	153	208	0.68	3	0.68
7	Japan	151	435	1.42	13	2.93
8	Italy	145	324	1.05	13	2.93
9	Germany	141	570	1.85	17	3.83
10	Korea	128	385	1.25	5	1.13

Note: Retrieval method—search for "organizations" in InCites, within time period 2020; using discipline categorizations of ESI; choose "research article" and "review" for article type; and then choose "worldwide", "Chinese authors", "China's STM journals", and "Chinese authors in China's STM journals", respectively, to obtain data.
For the data of each country, use the above procedures to retrieve, and then use the baseline value for each country.
The number of papers published by China's STM journals is 30 742, and the number of highly cited papers published by China's STM journals is 444.

from France published 188 papers, ranking 52nd; United States Department of Energy published 136 papers, ranking 75th, Nanyang Technological University published 127 papers, ranking 81st, National University of Singapore published 122 papers, ranking 86th, University of Texas System published 121 papers, ranking 88th, Russian Academy of Sciences published 118 papers, ranking 89th, and Helmholtz Association of German Research Centers published 107 papers, ranking 100th.

In terms of the number of highly cited papers, among the Top 20 institutions that published highly cited papers in China's SCI journals, 18 are from China. The other 2 institutions are Helmholtz Association of German Research Centers and National University of Singapore, both publishing 11 papers and ranked 16th.

1.2.1.2.2 Distribution by Chinese Publishing Institution

Based on the statistical data from InCites (table 1.20), in 2020, 1038 Chinese institutions published 25 278 papers in China's SCI journals. During the same period, 1217 Chinese institutions published 532 471 international papers.

Influenced by factors such as other papers published in the same journal and the journal influence, the "citation impact" (2.88) and "impact relative to world" (IRW) (1.21) of

TAB. 1.20 – SCI papers published by Chinese institutions and those published in China's SCI journals.

Indicator*	SCI papers published by Chinese institutions	Papers published by Chinese institutions in China's SCI journals
No. of institutions	1217	1038
No. of WoS papers	532 471	25 278
% of world papers	25.03	1.19
% of cited papers	60.88	53.19
Total times cited	1 633 126	72 713
Citation impact	3.07	2.88
IRW**	1.29	1.21
CNCI	1.26	1.11
% of papers ranked top 1% by times cited	1.53	1.43
% of papers ranked top 10% by times cited	10.96	8.74
% of international cooperation papers	26.25	16.43
% of lateral cooperation papers	1.72	2.06
% of highly cited papers	1.46	1.47
% of hot papers	0.15	0.22
% of OA articles	35.27	37.16
% of DOAJ Gold papers	25.26	15.98

Note: Retrieval method—search for "organizations" in InCites, within time period 2020; using discipline categorizations of ESI; choose "research article" and "review" for article type; and then choose "worldwide", "Chinese authors", "China's STM journals", and "Chinese authors in China's STM journals", respectively, to obtain data.

*Baseline value was used.

**Impact Relative to World (IRW) is a ratio calculated this way: the citation impact of a group of literature compared with the citation impact of the world's total papers. The world's average is always 1. When the IRW is above 1, it means the times cited per paper of papers in this group is higher than the world's average. When the IRW is below 1, then it means the times cited per paper of this group is lower than the world's average.

papers published by Chinese institutions in China's SCI journals are both lower than their equivalent of the total papers published by Chinese institutions: 3.07 and 1.29, respectively. The CNCI of papers published by Chinese institutions (1.26) and the CNCI of papers published by Chinese institutions in China's SCI journals (1.11) are both above the disciplinary baseline (1.00). The 2 indicators—"percentage of papers ranked Top 1% by times cited (1.43%)" & "the percentage of papers ranked Top 10% by times cited (8.74%)"—of papers published by Chinese institutions in China's SCI journals are both lower than their equivalent of all SCI papers published by Chinese institutions, which are 1.53% and 10.96%, respectively.

The percentage of international cooperation papers published by Chinese institutions is 26.25%, higher than the percentage of international cooperation papers published by Chinese institutions in China's SCI journals (16.43%). On the aspect of lateral cooperation[9], the percentage of lateral cooperation papers published by Chinese institutions in China's SCI journals (2.06%) is higher than that of overall papers published by Chinese institutions (1.72%).

The "percentage of highly cited papers" of papers published by Chinese institutions and by Chinese institutions in China's SCI journals in 2020, is 1.46% and 1.47% respectively, very close to each other. The equivalent percentages of hot papers are relatively low, 0.15% and 0.22%, respectively.

When looking at the information about open access documents, the percentage of OA articles published by Chinese institutions in China's SCI journals (37.16%) is higher than the percentage of OA articles published by Chinese institutions (35.27%). However, the percentage of DOAJ Gold papers published by Chinese institutions in China's SCI journals (15.98%) is lower than the percentage of DOAJ Gold papers published by Chinese institutions (25.26%).

1.2.1.2.3 Papers Published by China's Top 50 Institutions in China's SCI Journals

The performance of papers published worldwide by Chinese institutions is quite different from that of papers published by Chinese institutions in China's SCI journals. In this part, study and analysis is done on the Top 50 research institutions ranked by the number of papers published in China's SCI journals. The papers published by these institutions in China's SCI journals account for almost 50.00% of all papers published by Chinese institutions.

1.2.1.2.3.1 Number of Papers Published. In 2020, the Top 10 institutions with the highest number of papers published in China's SCI journals are: Chinese Academy of Sciences (5217 papers), University of Chinese Academy of Sciences (2364 papers), Tsinghua University (909 papers), Peking University (803 papers), Zhejiang University (794 papers), University of Science & Technology of China (736 papers), Shanghai Jiaotong University (652 papers), Central South University (536 papers), Fudan University (522 papers) and Sun Yat-sen University (487 papers) (table 1.21).

Among the Top 50 institutions, 10 institutions have the highest percentage of papers published in China's SCI journals against the institution's total number of SCI papers. They are: China National Petroleum Corporation (12.58%), University of Chinese Academy of Sciences (9.86%), National University of Defense Technology (8.77%), Chinese Academy of Sciences (8.62%), Beijing University of Technology (8.62%), Ocean University of China (8.29%), University of Science & Technology of China (8.29%), Northeastern University (7.52%), China University of Petroleum (7.21%), and Tsinghua University (7.21%).

The 10 institutions with the lowest percentage of papers published in China's SCI journals are: Shandong University (3.04%), Xi'an Jiaotong University (3.13%), Tongji University (3.41%), Southeast University (3.66%), University of Electronic Science &

[9] Lateral cooperation includes one or multiple authors whose institution type is "enterprise".

Technology of China (3.82%), South China University of Technology (3.85%), Capital Medical University (3.86%), Sun Yat-sen University (3.86%), Sichuan University (3.92%), and Shanghai Jiaotong University (4.06%).

1.2.1.2.3.2 Citation Impact. In 2020, the Top 10 institutions with the highest citation impact of papers published in China's SCI journals are: Wuhan University (12.12), Chinese Academy of Medical Sciences & Peking Union Medical College (CAMS & PUMC) (10.99), Huazhong University of Science and Technology (9.27), Sichuan University (7.28), Shenzhen University (5.87), Hunan University (5.85), Zhengzhou University (5.79), Sun Yat-sen University (5.68), Wuhan University of Technology (4.96), and Capital Medical University (4.90) (table 1.21).

The citation impact of papers published by 19 institutions in China's SCI journals is higher than the citation impact of the institution's overall SCI papers. The Top 10 institutions with the biggest D-value are: Sichuan University (4.14), Wuhan University (3.65), CAMS & PUMC (2.47), Shenzhen University (2.13), Sun Yat-sen University (1.54), Zhengzhou University (1.25), Shanghai University (1.21), Tongji University (1.14), Suzhou University (1.12), and Hunan University (1.10). For all the remaining 31 institutions, the citation impact of the papers they publish in China's SCI journals is all lower than the citation impact of their overall SCI papers. The D-value is –2.98 ~ –0.06. The 10 institutions with the highest D-value are: Capital Medical University (–2.98), Tsinghua University (–2.03), Nankai University (–1.38), China University of Geosciences (–1.32), Beijing Normal University (–1.27), Ocean University of China (–1.23), Chinese Academy of Sciences (–0.96), Nanjing University (–0.91), East China Normal University (–0.90), and Dalian University of Technology (–0.83).

1.2.1.2.3.3 Number of Highly Cited Papers. In 2020, the Top 10 Chinese institutions, ranked by both the number of highly cited papers published worldwide and the number of highly cited papers published in China's SCI journals, are: Chinese Academy of Sciences (90/1039), University of Chinese Academy of Sciences (33/343), Huazhong University of Science and Technology (26/399), Tsinghua University (24/312), Peking University (24/239), Wuhan University (23/280), Zhengzhou University (19/234), Zhejiang University (18/280), Shanghai Jiaotong University (17/242), and Central South University (16/312) (table 1.21).

The upmost percentage of highly cited papers published by Chinese institutions in China's SCI journals against the total highly cited papers published by Chinese institutions worldwide is 12.50%. The Top 10 institutions are: China National Petroleum Corporation (12.50%), Chinese Academy of Agricultural Sciences (10.94%), Peking University (10.04%), China University of Petroleum (9.76%), University of Chinese Academy of Sciences (9.62%), Shenzhen University (9.01%), Chinese Academy of Sciences (8.66%), Wuhan University (8.21%), Zhengzhou University (8.12%), and Lanzhou University (8.06%).

1.2.1.2.3.4 Percentage of International Cooperation Papers. Ranked by the percentage of international cooperation papers published by Top 50 Chinese institutions in China's SCI journals, the Top 10 institutions are: Shenzhen University (28.14%),

TAB. 1.21 – Facts of papers published by TOP 50 Chinese institutions in world SCI journals and in China's SCI journals in 2020—volume and percentage of papers, citation impact, highly cited papers and international cooperation papers.

Serial no.	Institution name	No. of papers published by Chinese institution (A)	No. of papers published by Chinese institution in China's STM journals (B)	% (B/A × 100%)	No. of highly cited papers published by Chinese institution (C)	No. of highly cited papers published by Chinese institution in China's STM journals (D)	% (D/C × 100%)	Citation impact of papers by Chinese institution (E)	Citation impact of papers by Chinese institution in China's STM journals (F)	D-value ($F - E$)	% of int'l cooperation papers by Chinese institution (G)	% of int'l cooperation papers by Chinese institution in China's STM journal (H)	D-value ($H - G$)
1	Chinese Academy of Sciences	60 490	5217	8.62	1039	90	8.66	3.86	2.90	–0.96	31.91	18.48	–13.43
2	University of Chinese Academy of Sciences	23 985	2364	9.86	343	33	9.62	3.47	2.92	–0.55	27.25	17.77	–9.48
3	Tsinghua University	12 612	909	7.21	312	24	7.69	6.05	4.02	–2.03	36.49	20.02	–16.47
4	Peking University	12 568	803	6.39	239	24	10.04	3.85	4.03	0.18	35.59	23.66	–11.93
5	Zhejiang University	16 043	794	4.95	280	18	6.43	3.88	3.36	–0.52	31.15	20.15	–11.00
6	University of Science and Technology of China	8881	736	8.29	156	8	5.13	3.82	3.41	–0.41	31.35	16.17	–15.18
7	Shanghai Jiaotong University	16 066	652	4.06	242	17	7.02	3.84	4.89	1.05	30.80	21.63	–9.17
8	Central South University	10 978	536	4.88	312	16	5.13	3.82	3.66	–0.16	25.21	19.22	–5.99
9	Fudan University	10 867	522	4.80	199	8	4.02	4.14	4.63	0.49	29.52	23.56	–5.96

Tab. 1.21 – (continued).

10	Sun Yat-sen University	12 614	487	3.86	211	15	7.11	4.14	5.68	1.54	30.17	22.79	–7.38
11	Huazhong University of Science and Technology	11 333	468	4.13	399	26	6.52	8.96	9.27	0.31	27.38	19.87	–7.51
12	Tianjin University	7732	436	5.64	136	7	5.15	3.44	2.70	–0.74	30.54	19.04	–11.50
13	Jilin University	8520	422	4.95	91	6	6.59	2.75	2.08	–0.67	21.36	19.67	–1.69
14	Nanjing University	7450	422	5.66	140	9	6.43	3.40	2.49	–0.91	31.17	18.01	–13.16
15	Sichuan University	10 752	422	3.92	167	12	7.19	3.14	7.28	4.14	23.34	21.33	–2.01
16	Harbin Institute of Technology	8549	399	4.67	111	2	1.80	3.04	2.36	–0.68	25.97	14.04	–11.93
17	Wuhan University	8903	396	4.45	280	23	8.21	8.47	12.12	3.65	28.57	21.21	–7.36
18	Zhengzhou University	7923	389	4.91	234	19	8.12	4.54	5.79	1.25	23.67	19.02	–4.65
19	Beihang University	5416	365	6.74	64	2	3.13	2.71	2.15	–0.56	32.94	21.10	–11.84
20	University of Science and Technology Beijing	4128	356	8.62	57	4	7.02	2.86	2.39	–0.47	26.70	15.17	–11.53
21	Beijing Institute of Technology	5113	356	6.96	112	8	7.14	3.34	3.17	–0.17	31.47	17.42	–14.05
22	Northwestern Polytechnical University	5472	356	6.51	119	5	4.20	3.56	3.23	–0.33	28.82	14.61	–14.21

Tab. 1.21 – (continued).

Serial no.	Institution name	No. of papers published by Chinese institution (A)	No. of papers published by Chinese institution in China's STM journals (B)	% (B/A × 100%)	No. of highly cited papers published by Chinese institution (C)	No. of highly cited papers published by Chinese institution in China's STM journals (D)	% (D/C × 100%)	Citation impact of papers by Chinese institution (E)	Citation impact of papers by Chinese institution in China's STM journals (F)	D-value ($F - E$)	% of int'l cooperation papers by Chinese institution (G)	% of int'l cooperation papers by Chinese institution in China's STM journal (H)	D-value ($H - G$)
23	Northeastern University	4254	320	7.52	72	2	2.78	3.00	2.33	–0.67	22.52	12.81	–9.71
24	Xi'an Jiaotong University	9993	313	3.13	154	7	4.55	3.20	4.11	0.91	28.58	18.85	–9.73
25	China University of Geosciences	5042	308	6.11	89	3	3.37	2.91	1.59	–1.32	39.17	21.10	–18.07
26	China University of Petroleum	4216	304	7.21	41	4	9.76	2.68	2.27	–0.41	27.59	15.13	–12.46
27	Chinese Academy of Agricultural Sciences	5077	300	5.91	64	7	10.94	2.48	2.69	0.21	30.81	25.33	–5.48
28	Chinese Academy of Medical Sciences & Peking Union Medical College	6914	299	4.32	139	11	7.91	8.52	10.99	2.47	21.45	13.04	–8.41
29	Dalian University of Technology	5611	287	5.11	84	4	4.76	2.86	2.03	–0.83	28.43	17.07	–11.36

Tab. 1.21 – (continued).

30	Shandong University	9157	278	3.04	109	1	0.92	2.89	2.62	–0.27	25.72	19.42	–6.30
31	Southeast University	7438	272	3.66	120	4	3.33	3.05	2.45	–0.60	30.33	22.43	–7.90
32	Xiamen University	5082	264	5.19	79	3	3.80	3.29	3.23	–0.06	34.14	22.73	–11.41
33	Shenzhen University	5707	263	4.61	111	10	9.01	3.74	5.87	2.13	35.20	28.14	–7.06
34	Tongji University	7646	261	3.41	124	8	6.45	3.01	4.15	1.14	31.06	23.75	–7.31
35	Suzhou University	5872	258	4.39	112	7	6.25	3.55	4.67	1.12	26.29	17.05	–9.24
36	Nankai University	4258	257	6.04	113	5	4.42	4.48	3.10	–1.38	27.48	14.79	–12.69
37	South China University of Technology	6598	254	3.85	129	6	4.65	3.65	3.67	0.02	25.48	15.75	–9.73
38	Shanghai University	3673	250	6.81	66	5	7.58	3.27	4.48	1.21	31.64	15.20	–16.44
39	Capital Medical University	6218	240	3.86	107	5	4.67	7.88	4.90	–2.98	23.79	18.75	–5.04
40	Chongqing University	5725	238	4.16	145	5	3.45	3.86	3.18	–0.68	26.71	21.43	–5.28
41	Ocean University of China	2799	232	8.29	33	2	6.06	2.56	1.33	–1.23	33.01	19.40	–13.61
42	Hunan University	4357	220	5.05	172	13	7.56	4.75	5.85	1.10	31.37	21.82	–9.55
43	Beijing Normal University	4212	220	5.22	56	3	5.36	3.00	1.73	–1.27	37.63	27.73	–9.90

Tab. 1.21 – (continued).

Serial no.	Institution name	No. of papers published by Chinese institution (A)	No. of papers published by Chinese institution in China's STM journals (B)	% (B/A × 100%)	No. of highly cited papers published by Chinese institution (C)	No. of highly cited papers published by Chinese institution in China's STM journals (D)	% (D/C × 100%)	Citation impact of papers by Chinese institution (E)	Citation impact of papers by Chinese institution in China's STM journals (F)	D-value ($F - E$)	% of int'l cooperation papers by Chinese institution (G)	% of int'l cooperation papers by Chinese institution in China's STM journal (H)	D-value ($H - G$)
44	National University of Defense Technology	2429	213	8.77	13	1	7.69	1.71	1.49	–0.22	14.78	6.57	–8.21
45	China National Petroleum Corporation	1653	208	12.58	8	1	12.50	1.68	1.19	–0.49	18.33	11.54	–6.79
46	University of Electronic Science and Technology of China	5421	207	3.82	185	10	5.41	3.93	4.76	0.83	34.86	24.64	–10.22
47	Wuhan University of Technology	3201	189	5.90	74	5	6.76	3.93	4.96	1.03	34.08	25.93	–8.15
48	East China Normal University	3223	188	5.83	61	2	3.28	3.01	2.11	–0.90	35.18	15.43	–19.75
49	China University of Mining and Technology	4498	186	4.14	70	4	5.71	2.69	2.14	–0.55	23.77	19.89	–3.88
50	Lanzhou University	3873	182	4.70	62	5	8.06	3.24	3.03	–0.21	26.16	16.48	–9.68

Note: Retrieval method—search for "organizations" in InCites, within time period 2020, using discipline categorizations of ESI, choose "research article" and "review" for article type, then obtain data for Chinese institutions (TOP 50 institutions ranked by the number of papers published) and China's STM journals.
The database was last updated on July 1st, 2021; the data of WoS were up to May 31st, 2021; and the retrieval date was July 9th, 2021.

Beijing Normal University (27.73%), Wuhan University of Technology (25.93%), Chinese Academy of Agricultural Sciences (25.33%), University of Electronic Science and Technology of China (24.64%), Tongji University (23.75%), Peking University (23.66%), Fudan University (23.56%), Sun Yat-sen University (22.79%), and Xiamen University (22.73%) (table 1.21).

The "percentage of international cooperation papers" of papers published by each of the Top 50 institutions in China's SCI journals, is all lower than the "percentage of international cooperation papers" of all SCI papers published by each institution, with the D-value between –19.75% ~ –1.69%. The 10 institutions with the biggest D-value are: East China Normal University (–19.75%), Chinese University of Geosciences (–18.07%), Tsinghua University (–16.47%), Shanghai University (–16.44%), University of Science & Technology of China (–15.18%), Northwestern Polytechnical University (–14.21%), Beijing Institute of Technology (–14.05%), Ocean University of China (–13.61%), Chinese Academy of Sciences (–13.43%), and Nanjing University (–13.16%).

1.2.1.3 International Comparisons of Academic Influence of Papers Published by China's SCI Journals

In this section, analysis and comparisons are done on the data of papers published by 16 major scientific paper output countries in their own country's journals. Lateral comparisons are done on each country's papers, in terms of the key impact indices—total times cited, citation impact, percentage of cited papers, and CNCI. The results can objectively demonstrate the international competitiveness of China's SCI journals in different aspects.

1.2.1.3.1 Comparisons of Academic Influence of Papers Published by STM Journals in Major Scientific Paper Output Countries

In 2020, 17 countries in the world published over 40 000 papers each (table 1.22). Among the Top 5 countries ranked by the number of papers published by authors, China ranks 1st by the number of papers published by authors, 5th by the number of papers published by journals, 1st by citation impact, and 3rd by CNCI; USA ranks 2nd by the number of papers published by authors, 1st both by the number of journals and by the number of papers published by journals, 4th both by citation impact and CNCI; UK ranks 2nd by CNCI, by the number of journals, and by the number of papers published by journals, 3rd by the number of papers published by authors and by citation impact; Germany ranks 4th by the number of journals, by the number of papers published by authors, and by the number of papers published by journals, 5th by citation impact and CNCI; India ranks 5th by the number of papers published by authors, 13th by the number of papers published by journals, 16th both by citation impact and by CNCI. Among the other countries, the following countries have a big gap between the number of papers published by authors and that by journals: Canada ranks 8th by the number of papers published by authors, 13th by the number of journals, 14th by the number of papers published by journals, 8th by citation impact and by CNCI; Netherlands ranks 14th by the number of papers published by authors, 3rd by the number of journals and by the number of papers published by journals, 1st by citation impact and by CNCI; Russia ranks 16th by the number of papers published by authors, 9th by the number of journals, 8th by the number of papers published by journals, and 17th by citation impact and by CNCI.

The Top 5 countries ranked by the number of the country's own SCI journals are: USA (4397 journals), UK (3003 journals), Netherlands (970 journals), Germany (774 journals), and Japan (247 journals). China has 213 SCI journals with CN code, ranking 6th. In terms of ratio of domestic SCI journal paper volume to the domestic author paper volume, 3 countries have their domestic journal paper volume higher than the domestic author paper volume. They are: Netherlands (4.13), UK (3.85), and USA (1.45). For the following 8 countries: China (0.06), Spain (0.08), Iran (0.10), Turkey (0.11), Canada (0.12), India (0.14), Australia (0.16), and Italy (0.18), the domestic journal paper volume is lower than 20% of the domestic author paper volume.

TAB. 1.22 – Citation impact of papers published by journals from major SCI paper output countries in 2020.

Serial no.	Country	No. of journal	No. of papers published by authors from this country (A)	No of papers published by journals from this country (B)	Ratio (B/A)	Total times cited (C)	Citation impact	% of cited papers	CNCI
1	China	213	549 845	30 742	0.06	86 574	2.82	54.97	1.10
2	USA	4397①	489 830	711 430	1.45	1 831 053	2.57	58.48	1.09
3	UK	3003②	137 720	530 701	3.85	1 435 538	2.70	61.49	1.13
4	Germany	774	135 562	121 676	0.90	263 809	2.17	56.71	0.87
5	India	105	99 428	13 539	0.14	9373	0.69	27.91	0.31
6	Italy	123	97 770	17 437	0.18	32 538	1.87	50.22	0.86
7	Japan	247	96 273	25 109	0.26	27 904	1.11	43.98	0.47
8	Canada	122	88 656	10 295	0.12	17 012	1.65	49.88	0.76
9	France	189	88 379	19 071	0.22	35 733	1.87	52.91	0.80
10	Australia	160	87 618	13 788	0.16	22 727	1.65	49.64	0.74
11	Spain	123	80 507	6119	0.08	5991	0.98	37.28	0.53
12	Korea	139	75 649	14 776	0.20	23 036	1.56	47.55	0.64
13	Brazil	119	64 813	14 220	0.22	12 096	0.85	34.14	0.39
14	Netherlands	970	51 736	213 640	4.13	603 525	2.82	65.95	1.22
15	Iran	40	51 597	5201	0.10	4409	0.85	36.09	0.39
16	Russia	150	46 341	18 025	0.39	6080	0.34	21.50	0.15
17	Turkey	56	42 594	4876	0.11	3522	0.72	29.10	0.33

Note: Retrieval method—search for "research areas" in InCites, within time period 2020, using discipline categorizations of ESI, choose "research article" and "review" for article type, then obtain data for authors and journals from each country.

The above list is ordered by the number of papers published by authors from each country.

①The USA data did not include *Journal of Modern Power Systems and Clean Energy*.

②Only data of England were used, and not including *High Power Laser Science and Engineering.*

(a) The Top 3 countries with the highest "citation impact" are: Netherlands (2.82), China (2.82), and UK (2.70).
(b) The Top 3 countries with the highest "percentage of cited papers" are: Netherlands (65.95%), UK (61.49%), and USA (58.48%). China ranks 5th (54.97%).
(c) The 4 countries with "CNCI" above 1 (meaning above disciplinary average level) are: Netherlands (1.22), UK (1.13), China (1.10), and USA (1.09).

In 2020, there were 11 countries with over 1000 highly cited papers published by their domestic authors. They are: China (7920 papers), USA (7106 papers), UK (2721 papers), Germany (1948 papers), Italy (1803 papers), Australia (1782 papers), Canada (1439 papers), France (1355 papers), Spain (1158 papers), India (1064 papers), and Netherlands (1045 papers). There were 4 countries with over 1000 highly cited papers published by domestic SCI journals: USA (8022 papers), UK (6226 papers), Netherlands (2670 papers), and Germany (1084 papers). For Netherlands, UK and USA, the number of highly cited papers published by the domestic journals is higher than the number of highly cited papers published by authors of each country (table 1.23).

TAB. 1.23 – Number of highly cited papers published by authors and journals from major SCI paper output countries in 2020.

Serial no.	Country	Highly cited papers published by authors from this country		Highly cited papers published by journals from this country	
		No. of papers	Ranking	No. of papers	Ranking
1	China	7920	1	444	5
2	USA	7106	2	8022	1
3	UK	2721	3	6226	2
4	Germany	1948	4	1084	4
5	India	1064	10	27	14
6	Italy	1803	5	166	6
7	Japan	929	12	54	11
8	Canada	1439	7	81	10
9	France	1355	8	147	7
10	Australia	1782	6	94	9
11	Spain	1158	9	30	13
12	Korea	805	14	100	8
13	Brazil	502	15	42	12
14	Netherlands	1045	11	2670	3
15	Iran	838	13	9	16
16	Russia	352	17	3	17
17	Turkey	501	16	10	15

Note: Retrieval method—search for "research areas" in InCites, within time period 2020, using discipline categorizations of ESI, choose "research article" and "review" for article type, then obtain data for authors and journals from each country.
The above list is ordered by the number of papers published by authors from each country.

1.2.1.3.2 High Impact Papers Published by China's SCI Journals in 2020

In 2020, 96 of China's SCI journals (45.07%) published highly cited papers and 36 journals (16.90%) published hot papers. There are 13 journals, all English language journals, that published more than 10 highly cited papers. In terms of the number of highly cited papers published, except *Journal of Energy Chemistry* (39 papers), *Molecular Plant* (25 papers), and *Science Bulletin* (22 papers), all the remaining journals publish fewer than 20 highly cited papers (table 1.24).

TAB. 1.24 – China's SCI journals that published over 10 highly cited papers in 2020.

Serial no.	Journal name (ENG)	Journal name (CHI)	Language	No. of highly cited papers
1	*Journal of Energy Chemistry*	能源化学 (英文)	ENG	39
2	*Molecular Plant*	分子植物 (英文)	ENG	25
3	*Science Bulletin*	科学通报 (英文版)	ENG	22
4	*Chinese Chemical Letters*	中国化学快报 (英文版)	ENG	17
5	*Journal of Integrative Plant Biology*	植物学报 (英文版)	ENG	15
6	*Light: Science & Applications*	光: 科学与应用 (英文)	ENG	15
7	*Chinese Journal of Catalysis*	催化学报 (英文)	ENG	14
8	*National Science Review*	国家科学评论 (英文)	ENG	14
9	*Geoscience Frontiers*	地学前缘 (英文版)	ENG	13
10	*Journal of Materials Science & Technology*	材料科学技术 (英文版)	ENG	13
11	*Chinese Medical Journal*	中华医学杂志 (英文版)	ENG	11
12	*Nano-Micro Letters*	纳微快报 (英文)	ENG	11
13	*Science China-Physics Mechanics & Astronomy*	中国科学: 物理学力学天文学 (英文版)	ENG	10

1.2.1.3.3 International Cooperation of Papers Published by China's SCI Journals

1.2.1.3.3.1 Cooperation with 16 Major Scientific Output Countries. In 2020, the 213 SCI journals in China all published papers generated from international cooperations with other major scientific output countries. In terms of the number of international cooperation papers, 201 China's SCI journals published papers cooperation with USA, then UK, Australia, Germany, Canada, and Japan. In terms of citations, the percentage of cited international cooperation papers against all the international cooperation papers published by each of the above countries is all higher than the average percentage of cited international cooperation papers published by China's SCI journals (54.97%). Turkey (78.21%), Italy (74.89%), Germany (73.75%), Netherlands (73.64%), and Spain (73.31%) are the Top 5 countries in terms of percentage of cited papers. In terms of CNCI, the CNCI of international cooperation papers is all above 1, with Canada (3.86), Turkey (2.46), Netherlands (2.31), and India (2.23) all above 2 (table 1.25).

1.2.1.3.3.2 Number and Citation Performance of International Cooperation Papers Published by China's SCI Journals. In 2020, the 213 SCI journals in China published 5692 international cooperation papers. The number of papers per journal ranges from 1 to 182. The Top 10 journals with the highest number of international cooperation papers are:

TAB. 1.25 – Facts of international cooperation between China's SCI journals and 16 major paper output countries in 2020.

Serial no.	Country	No. of int'l cooperation journals	No. of int'l cooperation papers	Total times cited	% of cited papers	CNCI
1	USA	201	2025	9141	69.19	1.75
2	UK	163	583	2255	70.15	1.51
3	Australia	154	579	3105	72.71	1.94
4	Germany	146	480	1937	73.75	1.71
5	Canada	139	365	3559	67.40	3.86
6	Japan	133	335	1240	65.67	1.47
7	France	115	289	1057	65.40	1.58
8	Spain	96	236	901	73.31	1.56
9	Korea	87	168	732	71.43	1.72
10	Italy	84	227	886	74.89	1.83
11	India	82	151	760	71.52	2.23
12	Russia	78	147	523	68.03	1.64
13	Iran	74	172	687	71.51	1.73
14	Netherlands	69	110	913	73.64	2.31
15	Brazil	56	98	379	69.39	1.93
16	Turkey	14	78	405	78.21	2.46

Note: Retrieval method—search for "research areas" in InCites, within time period 2020, using discipline categorizations of ESI, choose "research article" and "review" for article type, then obtain data for authors and journals from each country.
The above list is ordered by the number of papers published by authors from each country.

Nano Research (182 papers), *Journal of Materials Science & Technology* (132 papers), *Journal of Energy Chemistry* (99 papers), *Light: Science & Applications* (95 papers), *Journal of Forestry Research* (91 papers), *Chinese Physics B* (88 papers), *Earth Science Frontiers* (86 papers), *Nano-Micro Letters* (79 papers), *Horticulture Research* (79 papers), and *Chinese Chemical Letters* (77 papers).

The Top 10 journals with the highest percentage of international cooperation papers are: *Fungal Diversity* (90.91%), *Chinese Journal of Underground Space and Engineering* (57.14%), *Earth Science Frontiers* (56.95%), *Light: Science & Applications* (52.20%), *Computational Visual Media* (51.52%), *Current Zoology* (51.47%), *Molecular Plant* (51.35%), *Journal of Systematics and Evolution* (51.33%), *National Science Review* (46.90%), and *Infectious Diseases of Poverty* (46.67%).

The Top 10 journals with the highest "citation impact" (times cited per paper) of international cooperation papers are: *Military Medical Research* (468.29)[10], *Cell Research*

[10]This journal has 7 international cooperation papers, with 3278 times cited.

(20.03), *Journal of Pharmaceutical Analysis* (16.24), *Journal of Energy Chemistry* (14.51), *Signal Transduction and Targeted Therapy* (14.46), *Molecular Plant* (14.04), *Virologica Sinica* (13.41), *Stroke and Vascular Neurology* (13.00), *Chinese Journal of Immunology* (11.88), and *Chinese Journal of Integrative Medicine* (11.64).

There are 85 journals with international cooperation papers whose CNCI is above 1. That means the papers' citation performance is higher than the disciplinary average level of worldwide papers. The Top 10 journals with the highest CNCI are: *Military Medical Research* (178.28), *Molecular Plant* (10.21), *Journal of Pharmaceutical Analysis* (7.84), *Fungal Diversity* (7.15), *Stroke and Vascular Neurology* (5.76), *Cell Research* (5.75), *Journal of Energy Chemistry* (5.07), *National Science Review* (4.09), *Bulletin of Botany* (3.93), and *Chinese Journal of Catalysis* (3.63).

1.2.1.3.4 Rankings by Number of Papers and Impact of China's SCI Journals

In 2020, 30 742 papers were published by the 213 SCI journals in China. The number of papers per journal ranges from 18 to 922. For the ranking lists of China's SCI journals: Top 10 by number of papers, Top 10 by times cited, Top 10 by citation impact, Top 10 by percentage of cited papers, Top 10 by CNCI, and Top 10 by journal impact factor, please see tables 1.26–1.31.

TAB. 1.26 – Top 10 China's SCI journals ranked by number of papers published in 2020.

Serial no.	Journal name (ENG)	Journal name (CHI)	Language	No. of papers
1	*Chinese Physics B*	中国物理B (英文)	ENG	922
2	*Acta Physica Sinica*	物理学报	CHI	794
3	*Spectroscopy and Spectral Analysis*	光谱学与光谱分析	CHI	657
4	*Nano Research*	纳米研究 (英文版)	ENG	640
5	*Chinese Chemical Letters*	中国化学快报 (英文版)	ENG	628
6	*Rare Metal Materials and Engineering*	稀有金属材料与工程	CHI	615
7	*Journal of Materials Science & Technology*	材料科学技术 (英文版)	ENG	571
8	*Chinese Journal of Organic Chemistry*	有机化学	CHI	416
9	*Journal of Energy Chemistry*	能源化学 (英文)	ENG	398
10	*Journal of Forestry Research*	林业研究 (英文版)	ENG	383

Tab. 1.27 – Top 10 China's SCI journals ranked by times cited in 2020.

Serial no.	Journal name (ENG)	Journal name (CHI)	Language	Total times cited
1	*Journal of Energy Chemistry*	能源化学 (英文)	ENG	4556
2	*Journal of Materials Science & Technology*	材料科学技术 (英文版)	ENG	3571
3	*Military Medical Research*	军事医学研究 (英文)	ENG	3470
4	*Chinese Chemical Letters*	中国化学快报 (英文版)	ENG	3238
5	*Nano Research*	纳米研究 (英文版)	ENG	2595
6	*Chinese Medical Journal*	中华医学杂志 (英文版)	ENG	2162
7	*Science Bulletin*	科学通报 (英文版)	ENG	1923
8	*Nano-Micro Letters*	纳微快报 (英文)	ENG	1922
9	*National Science Review*	国家科学评论 (英文)	ENG	1874
10	*Signal Transduction and Targeted Therapy*	信号转导与靶向治疗 (英文)	ENG	1732

Tab. 1.28 – Top 10 China's SCI journals ranked by citation impact in 2020.

Serial no.	Journal name (ENG)	Journal name (CHI)	Language	Citation impact
1	*Military Medical Research*	军事医学研究 (英文)	ENG	65.47
2	*International Journal of Oral Science*	国际口腔科学杂志 (英文版)	ENG	32.89
3	*Cell Research*	细胞研究 (英文版)	ENG	15.56
4	*Journal of Pharmaceutical Analysis*	药物分析学报 (英文)	ENG	14.41
5	*Frontiers of Medicine*	高等学校学术文摘·医学前沿 (英文)	ENG	13.85
6	*National Science Review*	国家科学评论 (英文)	ENG	12.92
7	*World Journal of Pediatrics*	世界儿科杂志 (英文)	ENG	12.87
8	*Signal Transduction and Targeted Therapy*	信号转导与靶向治疗 (英文)	ENG	12.11
9	*Journal of Energy Chemistry*	能源化学 (英文)	ENG	11.45
10	*Molecular Plant*	分子植物 (英文)	ENG	11.15

TAB. 1.29 – Top 10 China's SCI journals ranked by percentage of cited papers in 2020.

Serial no.	Journal name (ENG)	Journal name (CHI)	Language	% of cited papers
1	*Fungal Diversity*	真菌多样性 (英文)	英文	100.00
2	*Nano-Micro Letters*	纳微快报 (英文)	英文	97.24
3	*Electrochemical Energy Reviews*	电化学能源评论 (英文)	英文	96.67
4	*Molecular Plant*	分子植物 (英文)	英文	96.40
5	*Journal of Energy Chemistry*	能源化学 (英文)	英文	96.23
6	*National Science Review*	国家科学评论 (英文)	英文	95.86
7	*Signal Transduction and Targeted Therapy*	信号转导与靶向治疗 (英文)	英文	95.80
8	*Light: Science & Applications*	光: 科学与应用 (英文)	英文	94.51
9	*Asian Journal of Pharmaceutical Sciences*	亚洲药物制剂科学 (英文)	英文	93.22
10	*Cell Research*	细胞研究 (英文版)	英文	92.47

TAB. 1.30 – Top 10 China's SCI journals ranked by CNCI of papers published in 2020.

Serial no.	Journal name (ENG)	Journal name (CHI)	Language	CNCI
1	*Military Medical Research*	军事医学研究 (英文)	ENG	24.92
2	*International Journal of Oral Science*	国际口腔科学杂志 (英文版)	ENG	12.07
3	*Molecular Plant*	分子植物 (英文)	ENG	7.92
4	*Fungal Diversity*	真菌多样性 (英文)	ENG	7.13
5	*Frontiers of Medicine*	高等学校学术文摘·医学前沿 (英文)	ENG	5.37
6	*Journal of Pharmaceutical Analysis*	药物分析学报 (英文)	ENG	5.31
7	*National Science Review*	国家科学评论 (英文)	ENG	4.55
8	*World Journal of Pediatrics*	世界儿科杂志 (英文)	ENG	4.42
9	*Cell Research*	细胞研究 (英文版)	ENG	4.34
10	*Journal of Energy Chemistry*	能源化学 (英文)	ENG	4.09

TAB. 1.31 – Top 10 of China's SCI journals ranked by impact factor in 2020.

Serial no.	Journal name (ENG)	Journal name (CHI)	Language	Impact factor
1	*Electrochemical Energy Reviews*	电化学能源评论 (英文)	ENG	28.91
2	*Cell Research*	细胞研究 (英文版)	ENG	25.62
3	*Fungal Diversity*	真菌多样性 (英文)	ENG	20.37
4	*Signal Transduction and Targeted Therapy*	信号转导与靶向治疗 (英文)	ENG	18.19
5	*Light: Science & Applications*	光: 科学与应用 (英文)	ENG	17.78
6	*National Science Review*	国家科学评论 (英文)	ENG	17.28
7	*Nano-Micro Letters*	纳微快报 (英文版)	ENG	16.42
8	*Energy & Environmental Materials*	能源与环境材料 (英文)	ENG	15.12
9	*Protein & Cell*	蛋白质与细胞 (英文)	ENG	14.87
10	*Bone Research*	骨研究 (英文)	ENG	13.57

1.2.2 Analysis of Papers Published by China's STM Journals—Based on CNKI Data

In this section, analysis is done based on the 4399 journals (among the total of 4963 China's STM journals) included in CNKI (China National Knowledge Infrastructure, produced by CAJ-CD Electronic Publishing Housing Co. Ltd., www.cnki.net) ("China's STM journals" referred to hereafter are the 4399 journals mentioned here). The number of papers published by these journals in 2019, distribution by discipline, distribution by institution, funded papers, international cooperations, as well as the domestic and international academic influence of papers are analyzed.

1.2.2.1 Distribution by Discipline of Papers Published by China's STM Journals

In 2019, there were 1.298 million citable papers published by 4399 China's STM journals. The number of papers per journal was 294.

Annual Report for Chinese Academic Journal Impact Factors (*Natural Science*) (referred to as *Impact Factor Annual Report*) *2020 Edition* has 65 discipline categories, among which 60 are specialized disciplines, 4 are comprehensive disciplines, and 1 is cross-disciplinary. Among the 1.298 million papers, around 150 000 papers are in social science or social science cross-disciplinary, and 1.146 million papers are in 60 specialized disciplines in science & technology fields. Some papers cover two or more disciplines. Hence, considering the overlap in disciplines, the total number of papers in science & technology is around 1.29 million. The number of papers and the percentage of papers in each discipline are shown in table 1.32. Among the 60 disciplines, 35 publish over 10 000 papers each. The papers by these 35 disciplines account for 91.51% of all papers. There are 5 disciplines with the percentage of above 5%. They are: "automation technology, computer technology" (87 673 papers, 6.79%), "civil engineering" (85 376, 6.61%), "transportation

TAB. 1.32 – Number of papers published in each discipline by China's STM journals in 2019.

Serial no.	Discipline	No. of papers	% of total
1	Automation technology, Computer technology	87 673	6.79
2	Civil engineering	85 376	6.61
3	Transportation engineering	74 833	5.79
4	Internal medicine	73 000	5.65
5	Nursing	71 957	5.57
6	Traditional Chinese medicine & pharmacology	62 439	4.83
7	Electrical engineering	52 436	4.06
8	Surgery	51 612	4.00
9	Oncology	50 160	3.88
10	Environmental science & technology	44 739	3.46
11	Obstetrics, gynecology, & pediatrics	38 685	3.00
12	Radio electronics, Telecommunications	38 291	2.96
13	Chemical engineering	36 706	2.84
14	Clinical medicine (general)	31 840	2.47
15	Animal husbandry, Veterinary science	28 766	2.23
16	Preventive medicine & hygiene	27 244	2.11
17	Mining engineering technology	25 413	1.97
18	Metal science & metalwork	25 194	1.95
19	Neurology & psychiatry	24 935	1.93
20	Agronomy	22 234	1.72
21	Chemistry	21 729	1.68
22	Food science & technology	21 398	1.66
23	Geology	19 473	1.51
24	Oil & gas industry	19 284	1.49
25	Horticulture	17 688	1.37
26	Mechanical engineering	17 510	1.36
27	Water conservancy engineering	17 155	1.33
28	Aeronautical and space science & technology	13 774	1.07
29	Forestry	12 727	0.99
30	Pharmacology	12 464	0.97
31	Biology	11 428	0.88
32	Plant protection	11 416	0.88
33	Material science	11 175	0.87
34	Otorhinolaryngology & ophthalmology	10 747	0.83
35	Mathematics	10 322	0.80
36	Agricultural basic science	8849	0.69
37	Light industry (excl textile & food)	8838	0.68
38	Agricultural engineering	7092	0.55
39	Atmospheric science	6686	0.52
40	Surveying and mapping science & technology	6638	0.51
41	Military medicine & special medicine	6370	0.49
42	Stomatology	6301	0.49

TAB. 1.32 – (continued).

Serial no.	Discipline	No. of papers	% of total
43	Basic medicine	6143	0.48
44	Engineering & technology science basic disciplines	5748	0.45
45	Physics	5700	0.44
46	Metallurgical engineering technology	5457	0.42
47	Aquaculture	5316	0.41
48	Energy & power engineering	5195	0.40
49	Geophysics	4151	0.32
50	Dermatology & venereology	3994	0.31
51	Textile science & technology	3508	0.27
52	Marine science	3228	0.25
53	Weapon industry & military technology	2786	0.22
54	Mechanics	2118	0.16
55	Nuclear science & technology	1770	0.14
56	Medicine & health administration	1284	0.10
57	Astronomy	859	0.07
58	Safety science & technology	784	0.06
59	Natural geography	481	0.04
60	System science	324	0.03
Total		1 291 443	100.00

Note: Ordered by the number of papers.
Data source is CNKI.
There is overlap in the numbers since a paper can cover 2 or more than 2 disciplines.

engineering" (74 833 papers, 5.79%) "internal medicine" (73 000 papers, 5.65%), and "nursing" (71 957 papers, 5.57%).

1.2.2.2 Distribution by Region of Papers Published by China's STM Journals

Statistics on all the regions of publishing institutions in China show (table 1.33) that the region with the highest number of papers published in 2019 is Beijing—125 424 papers, accounting for 9.71%. Aside from Beijing, the 11 regions with high volume of papers are: Jiangsu (107 230 papers, 8.30%), Guangdong (90 647 papers, 7.02%), Henan (77 345 papers, 5.99%), Shandong (71 366 papers, 5.53%), Shaanxi (58 720 papers, 4.55%), Hubei (57 312 papers, 4.44%), Shanghai (56 130 papers, 4.35%), Liaoning (55 069 papers, 4.26%), Sichuan (54 946 papers, 4.25%), Zhejiang (51 212 papers, 3.97%), and Hebei (40 953 papers, 3.17%).

1.2.2.3 Distribution by Publishing Institution of Papers Published in China's STM Journals

In 2019, among the publishing institutions of papers published by China's STM journals, higher education institutions (excluding colleges/vocational schools, the same hereafter)

TAB. 1.33 – Number of domestic papers published by China's STM journals in 2019.

Serial no.	Region	No. of papers	%	Serial no.	Region	No. of papers	%
1	Beijing	125 424	9.71	17	Heilongjiang	32 637	2.53
2	Jiangsu	107 230	8.30	18	Tianjin	29 945	2.32
3	Guangdong	90 647	7.02	19	Jiangxi	29 786	2.31
4	Henan	77 345	5.99	20	Gansu	28 032	2.17
5	Shandong	71 366	5.53	21	Guangxi	27 577	2.14
6	Shaanxi	58 720	4.55	22	Jilin	27 051	2.09
7	Hubei	57 312	4.44	23	Chongqing	23 780	1.84
8	Shanghai	56 130	4.35	24	Yunnan	22 864	1.77
9	Liaoning	55 069	4.26	25	Guizhou	22 131	1.71
10	Sichuan	54 946	4.25	26	Xinjiang	19 324	1.50
11	Zhejiang	51 212	3.97	27	Inner Mongolia	15 273	1.18
12	Hebei	40 953	3.17	28	Qinghai	7104	0.55
13	Hunan	37 410	2.90	29	Ningxia	6791	0.53
14	Shanxi	37 151	2.88	30	Hainan	6447	0.50
15	Anhui	36 429	2.82	31	Tibet	1917	0.15
16	Fujian	33 367	2.58		Total	1 291 370	100.00

Note: Ordered by the number of papers published in each discipline.
Data source is CNKI.
There is overlap in the numbers since a paper's publishing institution can be counted into different regions.
The data here did not include the data of papers published in Hong Kong, Macao, and Taiwan of China.

account for 36.66%, medical institutions account for 28.43%, enterprises and research institutions account for 13.57% and 9.95%, respectively, public organizations, and other institutions such as colleges/vocational schools, middle/high schools, elementary school, kindergartens, etc. account for 11.39% (figure 1.2).

Table 1.34 lists the composition of different publishing institutions of China's STM journal papers in each discipline:

(A) For 9 disciplines, the percentage of papers published by higher education institutions is higher than 75%. They are: "mathematics" (94.41%), "mechanics" (92.35%), "physics" (90.63%), "system science" (90.22%), "material science" (88.26%), "biology" (83.18%), "astronomy" (80.94%), "engineering & science and technology basic subjects" (76.54%), and "natural geography" (76.37%).

(B) Medical institutions are the primary contributor of papers in clinical medicine fields. The only disciplines in which medical institutions publish less than 70% of the total papers are: "pharmacy", "medicine and health administration", and "basic medicine". The disciplines with the highest percentage of papers published by medical institutions are: "surgery" (97.77%), "obstetrics, gynecology & pediatrics" (97.56%), "nursing"

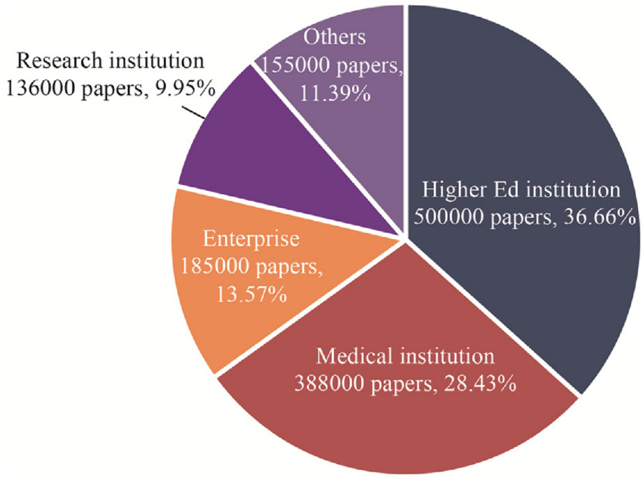

FIG. 1.2 – Distribution by publishing institution of China's STM journal papers in 2019.

(95.59%), "otorhinolaryngology & ophthalmology" (95.31%), "oncology" (95.20%), "dermatology & venereology" (94.90%), "clinical medicine comprehensive" (94.86%), "internal medicine" (94.66%), "stomatology" (93.05%), "neurology & psychiatry" (92.27%), and "military medicine & special medicine" (90.13%).

(C) The Top 10 disciplines with the highest percentage of papers published by enterprises are: "oil & natural gas industry" (74.45%), "mining engineering & technology" (69.00%), "metallurgical engineering technology" (65.71%), "electrical engineering" (50.84%), "transportation engineering" (48.70%), "metal science & metalwork" (36.17%), "civil engineering" (33.66%), "energy & power engineering" (31.28%), "chemical engineering" (30.97%), and "geology" (27.15%).

(D) The Top 10 disciplines with the highest percentage of papers published by research institutions are: "nuclear science & technology" (58.15%), "astronomy" (56.00%), "agronomy" (42.84%), "aquaculture" (40.84%), "horticulture" (38.13%), "marine science" (37.63%), "plant protection" (37.02%), "natural geography" (36.54%), "aeronautical and astronautical science & technology" (35.21%), and "geophysics" (34.39%).

1.2.2.4 Analysis of Funded Papers Published by China's STM Journals

Papers generated from the results of a research project supported by a fund are called funded papers. Research projects supported by funds are done based on sufficient argumentation and investigation. Especially for research projects funded by national-level funds, the object of a study is normally about the nation's tasks of urgent needs, or hot topics, key tasks, and difficult tasks of basic research. In 2019, there were 498 843 funded papers published by China's STM journals, accounting for 38.44% of the total papers. The Top 10 funds that supported the highest number of papers are listed in table 1.35. It shows that apart from

Tab. 1.34 – Distribution by institution type of papers in each discipline published by China's STM journals in 2019.

Serial no.	Discipline	No. of papers in this discipline	Higher Ed Inst		Medical Inst		Enterprise		Research Inst		Others	
			No. of papers	%	No. of papers	%	No. of papers	%	No. of papers	%	No. of papers	%
1	Automation technology, Computer technology	83 396	61 186	73.37	2729	3.27	11 437	13.71	7116	8.53	9866	11.83
2	Civil engineering	68 221	34 703	50.87	361	0.53	22 965	33.66	10 598	15.53	7251	10.63
3	Transportation engineering	65 145	26 705	40.99	33	0.05	31 723	48.70	8122	12.47	7616	11.69
4	Internal medicine	71 688	8936	12.47	67 857	94.66	214	0.30	1071	1.49	967	1.35
5	Nursing	70 918	5113	7.21	67 789	95.59	26	0.04	117	0.16	1138	1.60
6	Traditional Chinese medicine & pharmacology	61 269	27 610	45.06	44 021	71.85	1222	1.99	3694	6.03	2113	3.45
7	Electrical engineering	47 618	22 378	46.99	66	0.14	24 208	50.84	6628	13.92	4651	9.77
8	Surgery	50 930	4180	8.21	49 793	97.77	67	0.13	266	0.52	359	0.70
9	Oncology	49 818	6842	13.73	47 429	95.20	101	0.20	574	1.15	431	0.87
10	Environmental science & technology	38 026	22 688	59.66	409	1.08	6631	17.44	8690	22.85	8064	21.21
11	Obstetrics, gynecology, & pediatrics	38 140	2331	6.11	37 209	97.56	53	0.14	287	0.75	495	1.30
12	Radio electronics, Telecommunications	35 403	20 724	58.54	241	0.68	9270	26.18	4614	13.03	5155	14.56
13	Chemical engineering	32 372	20 147	62.24	317	0.98	10 027	30.97	4903	15.15	2027	6.26
14	Clinical medicine (general)	31 450	3296	10.48	29 834	94.86	147	0.47	514	1.63	452	1.44
15	Animal husbandry, Veterinary medicine	22 085	10 833	49.05	1415	6.41	1608	7.28	4678	21.18	8737	39.56
16	Preventive medicine & hygiene	26 307	7112	27.03	20 427	77.65	364	1.38	1432	5.44	1603	6.09

Tab. 1.34 – (continued).

17	Mining engineering & technology	22 351	6586	29.47	7	0.03	15 422	69.00	1947	8.71	1723	7.71
18	Metal science & metalwork	23 291	14 475	62.15	39	0.17	8425	36.17	3134	13.46	1610	6.91
19	Neurology & psychiatry	24 618	4154	16.87	22 714	92.27	41	0.17	393	1.60	327	1.33
20	Agronomy	19 496	8971	46.01	101	0.52	1466	7.52	8352	42.84	5977	30.66
21	Chemistry	20 283	14 557	71.77	1168	5.76	1993	9.83	3780	18.64	2853	14.07
22	Food science & technology	19 392	13 739	70.85	556	2.87	1978	10.20	4076	21.02	2883	14.87
23	Geology	18 635	7969	42.76	2	0.01	5059	27.15	5718	30.68	6748	36.21
24	Oil & gas industry	18 205	5387	29.59	4	0.02	13 554	74.45	2319	12.74	608	3.34
25	Horticulture	14 677	6708	45.70	27	0.18	593	4.04	5596	38.13	4773	32.52
26	Mechanical engineering	15 804	9913	62.72	242	1.53	3528	22.32	2269	14.36	1727	10.93
27	Water conservancy engineering	14 128	3899	27.60	3	0.02	3806	26.94	4151	29.38	4764	33.72
28	Aeronautical and space science & technology	13 265	6724	50.69	7	0.05	2944	22.19	4670	35.21	1757	13.25
29	Forestry	10 294	4305	41.82	91	0.88	347	3.37	3122	30.33	4964	48.22
30	Pharmacology	12 048	3982	33.05	7885	65.45	525	4.36	1104	9.16	872	7.24
31	Biology	11 204	9319	83.18	508	4.53	225	2.01	3249	29.00	1450	12.94
32	Plant protection	9611	4260	44.32	159	1.65	397	4.13	3558	37.02	3842	39.98
33	Material science	10 882	9604	88.26	132	1.21	1013	9.31	1671	15.36	487	4.48
34	Otorhinolaryngology & ophthalmology	10 482	1171	11.17	9990	95.31	25	0.24	132	1.26	102	0.97
35	Mathematics	10 249	9676	94.41	97	0.95	211	2.06	448	4.37	525	5.12
36	Agricultural basic science	8082	4934	61.05	9	0.11	567	7.02	2747	33.99	2469	30.55
37	Light industry (excl textile & food)	8052	5693	70.70	53	0.66	1578	19.60	639	7.94	906	11.25

Tab. 1.34 – (continued).

Serial no.	Discipline	No. of papers in this discipline	Higher Ed Inst		Medical Inst		Enterprise		Research Inst		Others	
			No. of papers	%	No. of papers	%	No. of papers	%	No. of papers	%	No. of papers	%
38	Agricultural engineering	5722	2916	50.96	5	0.09	437	7.64	1221	21.34	1999	34.94
39	Atmospheric science	6432	2469	38.39	5	0.08	132	2.05	1595	24.80	4401	68.42
40	Surveying and mapping science & technology	5867	2910	49.60	3	0.05	725	12.36	1847	31.48	1752	29.86
41	Military medicine & special medicine	6232	812	13.03	5617	90.13	58	0.93	116	1.86	156	2.50
42	Stomatology	6127	989	16.14	5701	93.05	18	0.29	39	0.64	90	1.47
43	Basic Medicine	6064	3802	62.70	2760	45.51	142	2.34	839	13.84	237	3.91
44	Engineering & technology science basic disciplines	5357	4100	76.54	23	0.43	776	14.49	660	12.32	395	7.37
45	Physics	5605	5080	90.63	43	0.77	219	3.91	1114	19.88	282	5.03
46	Metallurgic engineering & technology	4943	1782	36.05	3	0.06	3248	65.71	508	10.28	142	2.87
47	Aquaculture	4758	2795	58.74	33	0.69	370	7.78	1943	40.84	1214	25.51
48	Energy & power engineering	4783	3212	67.15	6	0.13	1496	31.28	835	17.46	247	5.16
49	Geophysics	4019	1765	43.92	0	0.00	182	4.53	1382	34.39	2115	52.63
50	Dermatology & venereology	3925	449	11.44	3725	94.90	9	0.23	108	2.75	61	1.55
51	Textile science & technology	3090	2194	71.00	2	0.06	611	19.77	218	7.06	438	14.17
52	Marine science	3120	2114	67.76	6	0.19	385	12.34	1174	37.63	664	21.28
53	Weapon industry & military technology	2699	1604	59.43	0	0.00	507	18.78	799	29.60	463	17.15
54	Mechanics	2092	1932	92.35	11	0.53	130	6.21	297	14.20	70	3.35

Tab. 1.34 – (continued).

55	Nuclear science & technology	1706	908	53.22	24	1.41	256	15.01	992	58.15	108	6.33
56	Health & medicine administration	1270	642	50.55	645	50.79	3	0.24	37	2.91	132	10.39
57	Astronomy	834	675	80.94	0	0.00	19	2.28	467	56.00	84	10.07
58	Safety science & technology	663	368	55.51	4	0.60	172	25.94	123	18.55	80	12.07
59	Natural geography	457	349	76.37	0	0.00	13	2.84	167	36.54	100	21.88
60	System science	317	286	90.22	3	0.95	25	7.89	31	9.78	20	6.31
	Total	1 193 917	484 963	40.62	432 343	36.21	193 693	16.22	142 891	11.97	127 542	10.68

Note: Ordered by the number of papers published in each discipline.
The numbers in this list is based on the institution type mentioned in the papers in each discipline.
Data source is CNKI.
"%" is the percentage of papers published by this type of institution against the total number of papers in this discipline.
There is overlap in counting the institutions since a paper can be counted towards multiple institutions.

TAB. 1.35 – Facts of Top 10 funds of China's STM journal papers in 2019.

Serial no.	Fund name	No. of papers
1	National Natural Science Foundation of China	166 501
2	National Key Research & Development Project	51 572
3	China Postdoctoral Science Foundation	5910
4	National Social Science Fund of China	4978
5	Henan Science and Technology Research Plan	4787
6	Jiangsu Natural Science Foundation	4281
7	Shandong Natural Science Foundation	3850
8	Guangdong Natural Science Foundation	3302
9	Shaanxi Natural Science Foundation	3159
10	Zhejiang Natural Science Foundation	3153

Note: Ordered by the number of funded papers.
Data source is CNKI.

national-level funds such as National Natural Science Foundation of China and National Key Research & Development Project, some provincial-level funds in Henan, Jiangsu, Shandong, etc. have also provided great support to the publishing of academic papers.

For the number and the percentage of funded papers in each discipline published by China's STM journals in 2019, please see table 1.36. There are 9 disciplines with the percentage of funded papers higher than 70%. They are primarily in the basic research fields: "biology" (85.82%), "astronomy" (80.21%), "physics" (79.74%), "mechanics" (78.94%), "mathematics" (78.16%), "natural geography" (77.75%), "material science" (77.33%), "marine science" (76.21%), and "basic medicine" (71.71%).

1.2.2.5 Papers Published in China's STM Journals by Overseas[11] Authors and Papers Published in Cooperation with Overseas Authors

"Papers by overseas authors" refer to papers published in China's STM journals, with the 1st author being from overseas. "Overseas cooperation papers" refer to papers with Chinese authors as the 1st author, but published in China's STM journals in cooperation with authors from other countries/regions. In 2019, there were 7649 "papers by overseas authors" published in China's STM journals, and 7178 "overseas cooperation papers" published.

There are 16 disciplines with the percentage of the above 2 types of papers higher than 1% (table 1.37). There are 8 disciplines with the percentage of "papers by overseas authors" higher than 2%. They are: "astronomy" (10.24%), "physics" (5.89%), "biology" (5.00%), "mechanics" (4.77%), "material science" (4.31%), "basic medicine" (3.17%), "mathematics" (2.94%), and "marine science" (2.45%). There are 8 disciplines with the percentage of "overseas cooperation papers" higher than 2%. They are: "astronomy" (9.90%), "physics" (4.04%), "natural geography" (3.53%), "marine science" (3.47%), "mechanics" (3.35%), "biology" (3.35%), "material science" (3.03%), "geophysics" (2.29%). Ordered by the sum of "papers by overseas authors" and "overseas cooperation papers", the disciplines with the

[11] The word "overseas" here refers to all countries and regions outside the Chinese mainland.

TAB. 1.36 – Number and percentage of funded papers of Top 20 disciplines among all papers published by China's STM journals in 2019.

Serial no.	Discipline	No. of paper (A)	No. of funded paper (B)	% (B/A × 100%)
1	Biology	11 428	9807	85.82
2	Astronomy	859	689	80.21
3	Physics	5700	4545	79.74
4	Mechanics	2118	1672	78.94
5	Mathematics	10 322	8068	78.16
6	Natural geography	481	374	77.75
7	Material science	11 175	8642	77.33
8	Marine science	3228	2460	76.21
9	Basic medicine	6143	4405	71.71
10	Chemistry	21 729	14 881	68.48
11	Geophysics	4151	2826	68.08
12	Food science and technology	21 398	14 374	67.17
13	Aquaculture	5316	3562	67.01
14	Agricultural basic science	8849	5771	65.22
15	System science	324	203	62.65
16	Agronomy	22 234	13 852	62.30
17	Atmospheric science	6686	3995	59.75
18	Nuclear science and technology	1770	1015	57.34
19	Traditional Chinese medicine and pharmacology	62 439	35 633	57.07
20	Medicine and health administration	1284	730	56.85

Note: Ordered by the percentage of funded papers in each discipline.
The list includes all funded papers, not limited by the level or size of a fund.
Data source is CNKI.

highest number of "overseas papers" and the corresponding numbers are: "biology" (954 papers), "material science" (821 papers), "chemistry" (570 papers), "physics" (566 papers), and "mathematics" (501 papers).

Among the "papers by overseas authors" and "overseas cooperation papers" published by China's STM journals in 2019, for papers published by authors from Hong Kong, Macao, and Taiwan regions of China and papers published in cooperation with Hong Kong, Macao, and Taiwan regions of China, please see table 1.38; for papers published by authors from other countries and papers published in cooperation with other countries, please see tables 1.39 and 1.40.

1.2.2.6 Academic Influence of Papers Published by China's STM Journals

1.2.2.6.1 Analysis of Domestic Cites to Papers Published by China's STM Journals

The number of references of the documents published by the four databases—CNKI's Chinese Academic Journal (CD Edition), Chinese Doctoral Dissertations Full-text Database, Chinese Master's Theses Full-text Database, China Proceedings of Conference

Tab. 1.37 – Papers by overseas authors and from overseas cooperations published in China's STM journals in 2019.

Serial no.	Discipline	No. of paper in this discipline (A)	Papers by overseas author		Papers from overseas cooperation		Total no. of overseas papers
			No. of paper (B)	% (B/A × 100%)	No. of paper (C)	% (C/A × 100%)	
1	Biology	11 428	571	5.00	383	3.35	954
2	Material science	11 175	482	4.31	339	3.03	821
3	Chemistry	21 729	289	1.33	281	1.29	570
4	Physics	5700	336	5.89	230	4.04	566
5	Mathematics	10 322	303	2.94	198	1.92	501
6	Geology	19 473	212	1.09	248	1.27	460
7	Basic medicine	6143	195	3.17	121	1.97	316
8	Marine science	3228	79	2.45	112	3.47	191
9	Astronomy	859	88	10.24	85	9.90	173
10	Mechanics	2118	101	4.77	71	3.35	172
11	Geophysics	4151	76	1.83	95	2.29	171
12	Atmospheric science	6686	53	0.79	108	1.62	161
13	Energy and power engineering	5195	68	1.31	55	1.06	123
14	Nuclear science and technology	1770	25	1.41	20	1.13	45
15	Natural geography	481	8	1.66	17	3.53	25
16	System science	324	6	1.85	6	1.85	12

Note: Ordered by the total number of overseas papers.
Data source is CNKI.

Full-text Database—in 2019 is 62.38 million, covering disciplines in natural science, engineering technology, and humanity & social science. Statistics show that the number of references to China's STM journal papers in 2019 by journal papers, doctoral dissertations, master's theses, and conference papers is 14.10 million, accounting for 22.61% of the total references (table 1.41). Among all the times cited of China's STM journal papers, the times cited by journals take up the highest percentage (31.47%), the times cited by conference papers are the second highest (22.33%), then master's theses (17.84%), and doctoral dissertation (9.91%).

1.2.2.6.2 Analysis of International Cites to China's STM Journal Papers

According to the data reported in *CNKI China Academic Journal International Citation Annual Report* 2013–2020 editions, the total international times cited of China's STM journals kept increasing during the years (figure 1.3). The increase started to accelerate in 2016 and the total times cited reached 986 000 in 2019, 1.62 times of the number in 2012 (376 000). The numbers manifest the fast growth of the international impact of China's STM journals.

Tab. 1.38 – Number of papers published in China's STM journals by authors from Hong Kong, Macao, and Taiwan regions in 2019.

Serial no.	Region	No. of paper by overseas authors	No. of overseas cooperation papers	Total no. of overseas papers
1	Hong Kong	478	620	1098
2	Macao	177	184	361
3	Taiwan	112	160	272

Tab. 1.39 – Number of papers published by overseas authors in China's STM journals in 2019 (Top 20 countries).

Serial no.	Country	No. of paper by overseas authors	Serial no.	Country	No. of paper by overseas authors
1	USA	1772	11	France	186
2	Iran	431	12	Russia	142
3	UK	416	13	Singapore	136
4	Australia	360	14	Spain	115
5	Korea	358	15	Brazil	106
6	India	344	16	Malaysia	98
7	Germany	307	17	Pakistan	96
8	Japan	304	18	Netherlands	82
9	Canada	264	19	Turkey	81
10	Italy	187	20	Egypt	78

Note: Ordered by the number of papers published by overseas authors.
Data source is CNKI.

Tab. 1.40 – Number of overseas cooperation papers published in China's STM journals in 2019 (Top 20 countries).

Serial no.	Country	No. of cooperation papers	Serial no.	Country	No. of cooperation papers
1	USA	2565	11	Netherlands	94
2	UK	663	12	Russia	84
3	Australia	606	13	Italy	70
4	Japan	472	14	Denmark	66
5	Canada	432	15	Pakistan	61
6	Germany	296	16	New Zealand	53
7	Singapore	204	17	Saudi Arabia	51
8	Korea	188	18	Switzerland	49
9	France	151	19	Belgium	46
10	Sweden	106	20	Finland	38

Note: Ordered by the number of overseas cooperation papers.
Data source is CNKI.

TAB. 1.41 – Cites by four types of domestic literature to the papers published by China's STM journals in 2019.

Literature type	No. of reference (A)	Cites to China's STM journals (B)	% ($B/A \times 100\%$)
Journal paper	25 336 794	7 972 898	31.47
Doctoral dissertation	6 543 626	648 248	9.91
Master's thesis	29 599 000	5 279 812	17.84
Conference paper	902 132	201 482	22.33
Total	62 381 552	14 102 440	22.61

Note: This list counts each single item of reference. For example, if a document cites another document multiple times, then it is counted as multiple references.
For journal papers, the data are based on the publication time of the paper version. For graduate theses and conference papers, the data are based on publication time on CNKI website. Hence, the papers in 2019 refer to papers published or papers put online during Jan 1st, 2019 to Dec 31st, 2019. Data source is CNKI.

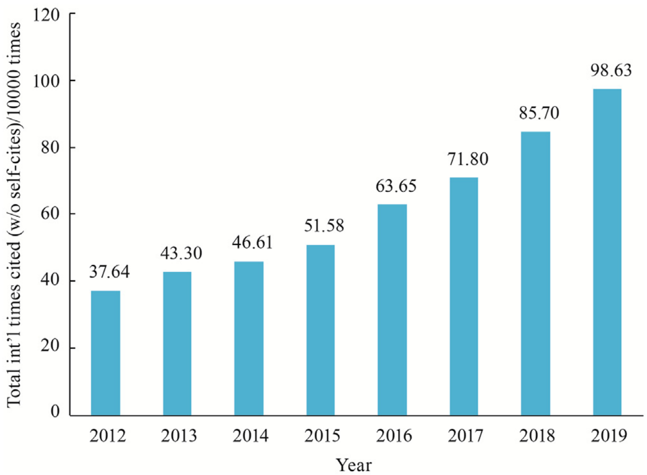

FIG. 1.3 – Change of international times cited of papers published by China's STM journals during 2012–2019.

Table 1.42 lists the total international times cited (without self-cites) of China's STM journals in each discipline, as reported in *China Academic Journal International Citation Annual Report 2019*. The 4040 STM journals included in this report had a total of 986 000 times cited, with an average of 244 times cited per journal. Statistics show that the 3 disciplines with the highest number of total international times cited (without self-cites) are: industrial technology general introduction (279 629 times, 28.35%), mathematical

TAB. 1.42 – International times cited (w/o self-cites) of papers in each discipline published by China's STM journals in 2019.

	Discipline	No. of journal	Int'l total times cited (w/o self-cites)	% of int'l times cited (w/o self-cites)	Times cited (w/o self-cites) per journal
Basic science (1275)	N Natural science general intro	353	53 277	5.40	151
	O Mathematical & physical science and chemistry	167	161 451	16.37	967
	P Astronomy, Geosciences	220	123 619	12.53	562
	Q Biological science	94	93 559	9.49	995
	S Agriculture, forestry, comprehensive agricultural science	441	60 162	6.10	136
Technical science (1787)	T Industrial technology general introduction	1516	279 619	28.35	184
	U Transportation	148	11 552	1.17	78
	V Aeronautics, Spaceship	55	10 248	1.04	186
	X Environmental science, Safety science	68	32 310	3.28	475
Medicine & health (978)	R Medicine and health, Comprehensive medicine and health	978	160 522	16.27	164
	Total	4040	986 319	100.00	244

Note: The disciplines are categorized based on the CN code.
The percentage of international total times cited (w/o self-cites) refers to the percentage of the total international times cited (w/o self-cites) to journals in the discipline against the total international times cited (w/o self-cites) to all China's STM journals.
Data source is CNKI.

science and chemistry (161 451 times, 16.37%), and medicine, health and comprehensive medicine & health (160 522 times, 16.27%). The Top 3 disciplines of average times cited per journal are: biological science (995 times cited per journal), mathematical science & chemistry (967 times cited per journal), and astronomy & geosciences (562 times cited per journal).

1.3 Analysis of China's STM Journal Influence

Based on the data from 3 publications: *Annual Report for Chinese Academic Journal Impact Factors* (*Natural Science*) (*Impact Factor Annual Report* hereafter), *Annual Report for International Citation of Chinese Academic Journals* (*Natural Science*) (*International Citation Annual Report* hereafter), and *World Journal Clout Index* (*WJCI*) *of Scientific and Technological Periodicals* (*WJCI*[12] *Report* hereafter), this section analyzes the overall performance of China's STM journals in terms of domestic and international influence.

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[12] *The World Journal Clout Index* (*WJCI*) *Report of Scientific and Technological Periodicals* (*WJCI Report* hereafter) is a journal evaluation report jointly developed by Institute of Scientific and Technical Information of China (ISTIC), CAJ-CD Electronic Publishing Housing Co. Ltd, Tsinghua University Library, Wanfang Data, Society of China University Journals (CUJS). This report is the research result of the project "Research on the Comprehensive Evaluation Method of World Science & Technology Journal Impact" commissioned by China Association for Science and Technology (CAST) and it was selected to be part of the Innovation China Initiative.

(A) Selection of source journals. The *WJCI Report* determines the proportion of source journals in each country/region from four dimensions: R&D input, output of research papers, number of researchers, and the scale and level of journals. It aims to present, in a fair and scientific manner, the realistic situation of the science and technology development and STM journal development in different countries. *WJCI Report 2020 Edition* selected 14 287 high-level journals (Q1) representative of the region, discipline and industry as source journals from about 60 000 sci-tech academic journals being published worldwide.

(B) The evaluation index. The evaluation index released in the *WJCI Report*, which integrates the World Academic Journal Clout Index (WAJCI) based on citation data and Web Impact (WI) based on web usage data is the WJCI index. It comprehensively reflects the quality, quantity, history, academic influence on the basic research and applied research, and the social impact of journals. WJCI has been widely acknowledged by experts and scholars worldwide.

(C) The disciplinary classification system. On the basis of thorough research on the journal classification systems of eight citation databases (WoS, Scopus Medline, EI, JST, KCI, CABA, RSCI), our research group creates a novel journal classification system with 279 disciplinary categories. This novel system comprehensively covers all sci-tech fields and reflects the development of emerging and cross-disciplinary disciplines, following the general outline of the *Classification and Code of Disciplines of the People's Republic of China*, with reference to the *Chinese Library Classification* and *Disciplinary Classification for Degree Granting and Talent Training*, etc. It calculates the WJCI and ranks journals within each disciplinary category.

(D) The basic data system. The project has also established the World Citation Database, based on CNKI-Scholar and under the support of CrossRef and Digital Science, for calculating indexes and obtained the web usage data on CNKI, Wanfang and Altmetrics. The statistical source of the evaluation indexes is the 144 million citation items of 26 653 international journals in the year of 2019.

Impact Factor Annual Report is a yearly journal published in CD form. It records and publishes data, within the statistical year, on academic papers published in China's STM journals, and on cites by domestic journals, conference papers, and graduate theses. It publishes dozens of quantitative evaluation indices and is an authoritative reference for evaluating China's STM journal academic influence. *Impact Factor Annual Report 2020 Edition* included 3943 STM journals in China, among which 3692 journals participated in the annual inspection—3441 Chinese language journals and 251 English language journals.

International Citation Annual Report records the information of cites to 3083 STM journals in China, by over 21 000 academic journals, books and conference papers worldwide. It publishes multiple evaluation indices every year, and reveals on a broad scale the international academic influence of China's journals. The comprehensive evaluation index of *International Citation Annual Report* is Clout Index (CI). Each year, according to the ranking by CI, it selects the Top 5% journals as "The Highest International Impact Academic Journal of China" (175 journals), and the Top 5%–10% journals as "The Excellent International Impact Academic Journal of China" (175 journals). The above two types of journals are referred to as "Journals with Top International Impact" (350 journals) (TOP Journals hereafter). *International Citation Annual Report 2020 Edition* included 2796 Chinese language journals and 287 English language journals that participated in the annual inspection.

WJCI Report calculates the WJCI score of world STM journals by discipline and ranks them, which provides comparisons for analysis on world STM journals. It divides STM journals into 4 sections—Q1 to Q4 sections according to the number of journals. *WJCI Report 2020 Edition* included 1376 China's STM journals that participated in the 2020 annual inspection, among which 1122 were Chinese language journals and 254 were English language journals.

1.3.1 Analysis of China's Chinese Language STM Journal Impact

According to *Impact Factor Annual Report 2020 Edition*, the 3441 Chinese language STM journals covered 65 disciplines, among which 389 are cross-disciplinary journals. The 3 disciplines with the highest number of journals are: "natural science and engineering technology" (224 journals), "medicine and health comprehensive" (183 journals), and "chemical engineering" (169 journals). Table 1.43 lists the distribution information of Chinese language STM journals by discipline.

1.3.1.1 Citable Documents

Citable documents generally refer to journal articles that have academic research results, and can be cited by other academic papers during the process of research. It is different from non-original papers, such as narrative and lyrics, introductory, general science, secondary literature, fiction, directory and index. The citable document of a journal is an important index for the journal's capacity of scientific research information. The times

TAB. 1.43 – Distribution by discipline of Chinese language STM journals included in *Impact Factor Annual Report 2020 Edition*.

Serial no.	Discipline	No. of journal	%
1	Natural science & engineering technology in general	224	5.83
2	Medicine & health in general	183	4.77
3	Chemical engineering	169	4.40
4	Civil engineering	155	4.04
5	Transportation engineering	143	3.72
6	Radio electronics, Telecommunications	138	3.59
7	Automation technology, Computer technology	124	3.23
8	Engineering technology in general	121	3.15
9	Traditional Chinese medicine & pharmacology	117	3.05
10	Electrical engineering	115	3.00
11	Clinical medicine in general	110	2.87
12	Geology	95	2.47
13	Agricultural science in general	94	2.45
14	Internal medicine	93	2.42
15	Oil & gas industry	88	2.29
16	Mechanical engineering	83	2.16
17	Metal science & metalwork	79	2.06
18	Surgery	78	2.03
19	Metallurgical engineering technology	78	2.03
20	Preventive medicine & hygiene	75	1.95
21	Water conservancy engineering	73	1.90
22	Mining engineering technology	73	1.90
23	Biology	67	1.75
24	Animal husbandry, Veterinary science	66	1.72
25	Forestry	65	1.69
26	Environmental science & technology	63	1.64
27	Pharmacology	58	1.51
28	Basic medicine	56	1.46
29	Aeronautical and space science & technology	52	1.35
30	Food science & technology	51	1.33
31	Energy & power engineering	50	1.30
32	Engineering & technology science basic disciplines	48	1.25
33	Agronomy	47	1.22
34	Chemistry	40	1.04
35	Textile science & technology	33	0.86
36	Physics	33	0.86
37	Oncology	33	0.86
38	Obstetrics, gynecology & pediatrics	31	0.81
39	Atmospheric science	30	0.78
40	Light industry (excl textile and food)	29	0.76
41	Neurology & psychiatry	28	0.73

Tab. 1.43 – (continued).

Serial no.	Discipline	No. of journal	%
42	Mathematics	27	0.70
43	Medicine & health administration	27	0.70
44	Geophysics	27	0.70
45	Surveying and mapping science & technology	26	0.68
46	Aquaculture	24	0.63
47	Weapon industry & military technology	24	0.63
48	Otorhinolaryngology & ophthalmology	23	0.60
49	Nursing	23	0.60
50	Material science	22	0.57
51	Horticulture	22	0.57
52	Agricultural basic science	21	0.55
53	Marine science	21	0.55
54	Plant protection	20	0.52
55	Agricultural engineering	19	0.49
56	Stomatology	18	0.47
57	Safety science & technology	17	0.44
58	Military medicine & special medicine	16	0.42
59	Mechanics	15	0.39
60	Nuclear science & technology	15	0.39
61	Resource science	13	0.34
62	Natural geography	13	0.34
63	Dermatology & venereology	7	0.18
64	System science	6	0.16
65	Astronomy	5	0.13
	Total	3839	100.00

Note: Ordered by the number of journals in the discipline.
Data source is *Impact Factor Annual Report 2020 Edition*.
There are journals that were counted towards two or more disciplines.

cited, impact factor and other data reflect the journal's academic influence. The analysis below, based on *Impact Factor Annual Report*, is on the evolution of the number of citable documents, times cited, and impact factor in the past 5 years, in order to reflect the change in the information published by the journals and the journals' influence.

According to *Impact Factor Annual Report* 2016–2020 editions (statistical years were 2015–2019), the citable documents per journal of Chinese STM journals reduced from 295.44 papers in 2015 to 286.19 papers in 2019, with a decrease of 3.13% (table 1.44). Yet the size of citable documents is still larger than that of international journals on the average. According to *Journal Citation Reports 2019* (*JCR*) published by Web of Science (WoS), the number of annual citable documents (articles + reviews) per journal of world STM journals was 179.

TAB. 1.44 – Number of citable documents of Chinese language STM journals during 2015–2019.

Statistical year	No. of citable document	No. of journal	No. of citable document per journal
2015	978 792	3313	295.44
2016	970 789	3355	289.36
2017	965 679	3391	284.78
2018	986 516	3410	289.30
2019	984 779	3441	286.19

Note: Ordered by the statistical year.
Data source is *Impact Factor Annual Report* 2016–2020 editions.

1.3.1.2 Total Times Cited

The statistical source of *Impact Factor Annual Report* is composed of the selected source journal papers, graduate theses, and conference papers. The comprehensive total times cited (total times cited hereafter) refers to a journal's total times cited within the statistical years, calculated as the total cites to all the citable documents since the journal's first publication, by the statistical source. It reflects a journal's total influence in a variety of scientific and talent cultivation activities. The total times cited of Chinese language STM journals during 2015–2019 was 8 004 400 per year. Looking at the trend, 2015 had 7 708 100 domestic total cites of, 2017 reached the peak of 8 436 100 cites, and then the number decreased to 7 675 200 in 2019, with a decrease rate of 9.02% from the highest point.

International Citation Annual Report records times cited by more than 2 100 000 world academic journals, books and academic conference papers. The yearly average times cited of China's Chinese language STM journals by world academic documents during 2015–2019 was 442 900. Looking at the trend, the total international times cited (without self-cites) were 309 600 in 2015 and reached 620 300 in 2019, which kept a high increase rate of 18.97% a year on average. This shows that the international impact kept increasing.

In general, the total times cited of Chinese STM journals during 2015–2019 were showing a trend of increase followed by a decrease. It increased from 7 948 400 in 2015 to 8 772 200 in 2017, then decreased to 8 200 400 in 2019. In terms of percentage, the average percentage of domestic times cited of Chinese language STM journals against the total times cited was 95.68% during 2015–2019, with 96.98% in 2015 and 93.60% in 2019. This shows that the impact of Chinese STM journals is mostly within China (table 1.45).

1.3.1.3 Internet Dissemination Indices

The internet dissemination indices, which include total download, web immediacy download, and web immediacy download ratio, reflect the full-text download of journals. *Impact Factor Annual Report* publishes download information based on all the download logs in the main server and overseas sever of CNKI, and the mirror servers in China. The data cleaning, following the principle that the download by the same user each day, using the same IP address, under the same log-in and downloading the same article is only counted for one time, can avoid the discrepancy caused by the various types of multi-thread

TAB. 1.45 – Domestic and international cites to Chinese language STM journals during 2015–2019.

Statistical year	No. of journal	Comprehensive domestic cites (A)	International cites (B)	Total ($A + B$) (overlap removed)	Increase rate (%)
2015	3313	7 708 133	309 631	7 948 357	–
2016	3355	8 236 901	379 773	8 548 060	7.54
2017	3391	8 436 149	421 527	8 772 233	2.62
2018	3410	7 965 429	483 222	8 358 906	–4.71
2019	3441	7 675 175	620 322	8 200 389	–1.90

Note: Ordered by statistical year.
Data source is *Impact Factor Annual Report* 2016–2020 editions and *International Citation Annual Report* 2016–2020 editions.
Due to the fact that some Chinese language journals are included in SCI Database and CNKI's *Impact Factor Annual Report* at the same time, the overlap in statistical data is removed when adding up the domestic and international total cites in order to ensure accuracy.
The increase rate is a year-on-year rate after overlap is removed from the total ($A + B$).

download software thus can reflect the realistic usage. The "total download" refers to total full-text download times, within the statistical year, of all the papers of a journal published in CNKI; the "web immediacy download" refers to the total full-text download times, within the same year of publication, of the papers of a journal in CNKI; and the "web immediacy download ratio" refers to the ratio of the total full-text download times of the papers of a journal published by CNKI in the year of the publication to the total number of papers of that journal that were published and put online in the same year. It represents the download times per paper.

According to *Impact Factor Annual Report* 2016–2020 editions (statistical years 2015–2019), the total download of Chinese language STM journals increased from 233 million times in 2015 to 382 million times in 2019. It showed an increasing trend, with an annual increase rate of 13.15%. The immediacy download times increased from 22 856 900 in 2015 to 62 218 100 in 2019. It showed an increase trend and the increase rate from 2015 to 2019 was 172.21%. The percentage of immediacy download increased from 9.82% in 2015 to 16.30% in 2019. It showed an overall increasing trend, and the increase rate from 2015 to 2019 was 65.99%. The average immediacy download ratio per journal increased by 155.30% from 2015 to 2019. The annual increase rate was 26.40% (table 1.46).

1.3.1.4 Impact Factor and Immediacy Index

The average comprehensive impact factor is calculated as the following: a journal's total cites by the comprehensive statistical source, within the statistical years, to the citable documents published by the journal in the past 2 years, divided by the total number of citable documents published by the journal in the past 2 years. A comprehensive immediacy index per journal is calculated as the following: a journal's total cites by the comprehensive statistical source within the statistical year, to the citable documents published in the statistical year, divided by the number of citable documents published by this journal in the same year.

TAB. 1.46 – Download times of Chinese language STM journals reported by *Impact Factor Annual Report* 2015–2019 editions.

Statistical year	Total download times (A)	Immediacy download times (B)	% of Immediacy download times (B/A)	Increase rate of immediacy download times	Avg. Immediacy download ratio
2015	232 857 439	22 856 899	9.82	–	25.57
2016	271 828 764	26 331 640	9.69	15.20	29.80
2017	272 863 685	29 386 539	10.77	11.60	32.80
2018	306 172 698	42 700 698	13.95	45.31	41.61
2019	381 620 883	62 218 112	16.30	45.71	65.28

Note: Ordered by statistical year.
Data source is *Impact Factor Annual Report* 2016–2020 editions.
The data here only include STM journals that have immediacy download.
The increase rate is the year-on-year increase rate of immediacy download times.

Based on the data in *Impact Factor Annual Report* 2016–2020 editions (statistical year 2015–2019), the average comprehensive impact factor of a Chinese STM journal was 0.622 in 2015 and 0.842 in 2019, showing an increase with a yearly increase rate of 7.86%. The comprehensive immediacy index per journal was 0.082 in 2015 and 0.132 in 2019, showing an increase with a yearly increase rate of 12.64% (table 1.47).

Based on the data in *International Citation Annual Report* 2016–2020 editions, the average comprehensive immediacy index (without self-cites) of the Chinese TOP journals was 0.228 in 2015 and 0.475 in 2019, with a yearly increase rate of 20.14%. The immediacy index per journal was 0.035 in 2015 and 0.090 in 2019, with a yearly increase of 26.63% (table 1.47).

TAB. 1.47 – Facts of impact factor and immediacy index of Chinese language STM journals during 2015–2019.

Statistical year	Domestic influence			International influence (TOP journals)		
	No. of journals	Avg. comprehensive impact factor	Avg. comprehensive immediacy index	No. of journals	Avg. impact factor (without self-cites)	Avg. immediacy index
2015	3313	0.622	0.082	183	0.228	0.035
2016	3355	0.670	0.081	179	0.269	0.046
2017	3391	0.713	0.091	161	0.332	0.066
2018	3410	0.766	0.098	149	0.411	0.101
2019	3441	0.842	0.132	135	0.475	0.090

Note: Ordered by statistical year.
Data source is *Impact Factor Annual Report* 2016–2020 editions and *International Citation Annual Report* 2016–2020 editions.

1.3.1.5 Self-Citation Rate

Self-citation rate refers to a journal's times cited by its own articles, within the statistical year, divided by the total times cited. Journals with a self-citation rate higher than 20% are called highly self-cited journals. Based on the data from *Impact Factor Annual Report* 2016–2020 editions, the average self-citation rate of a Chinese language STM journal was kept at around 10.00%. In 2019, journals with a self-citation rate lower than 20% account for 89.40% of all journals. Journals with a self-citation rate higher than 20% account for 10.60% of all journals. The percentage of journals with a self-citation rate lower than 20% increased to some extent. Based on the distribution of journals by self-citation rate, the higher the self-citation rate, the fewer the journals are (table 1.48).

1.3.1.6 Distribution by Discipline

Based on the data of 3441 Chinese language STM journals included in *International Citation Annual Report 2020 Edition*, the discipline with the highest number of journals is "natural science & engineering technology" (224 journals), the discipline with the highest number of citable documents is "medicine and health comprehensive" (103 013 papers), the discipline with the highest immediacy download ratio per journal is "natural geography" (241.23 times), the discipline with the highest total cites is "traditional Chinese medicine and pharmacology" (499 200 cites), the discipline with the highest total cites per journal is "natural geography" (8014.15 cites), the discipline with the highest impact factor per journal is "natural geography" (3.380), the discipline with the highest immediacy index per journal is "natural geography" (0.418), the discipline with the longest citation half-life per journal is "marine science" (8.55 years), and the discipline with the shortest citation half-life is "nursing" (3.56 years). Statistics show that for 4 indices—immediacy download ratio, times cited per journal, average impact factor, average immediacy index, "natural geography" is the journal with the highest score (table 1.49).

According to *International Citation Annual Report 2020 Edition*, there were 135 Chinese language STM journals selected as TOP Journals, distributed in 41 disciplines, and the discipline with the most journals selected is "geology" (23 journals). The discipline with the highest total international times cited (without self-cites) is "geology" (42 864 cites). The discipline with the highest total international times cited (without self-cites) per journal is "agricultural engineering" (3104 cites). The discipline with the highest average impact factor per journal is "oncology" (3.137). The discipline with the highest immediacy index per journal is "chemistry" (0.285) (table 1.50).

There were 1122 Chinese language STM journals included in *WJCI Report 2020 Edition*. 85 of them were Q1 journals, accounting for 7.58% of all Chinese language STM journals included (table 1.51).

1.3.2 Analysis of China's English STM Journal Impact

1.3.2.1 Current Situation of China's English STM Journals

By the end of 2020, there were 375 English language STM journals in China. *Chinese Medical Journal*, established in 1887, was the oldest English STM journal in China. Since

TAB. 1.48 – Distribution of self-citations of Chinese language STM journals during 2015–2019.

Statistical year	No. of journal	% of self-citation											
		0～		10～		20～		30～		40～		50～	
		No. of journal	%	No. of journal	%	No. of journal	%	No. of journal	%	No. of journal	%	No. of journal	%
2015	3313	2035	61.42	861	25.99	287	8.66	90	2.72	28	0.85	12	0.36
2016	3355	2084	62.12	863	25.72	277	8.26	92	2.74	31	0.92	8	0.24
2017	3391	2137	63.02	878	25.89	273	8.05	75	2.21	19	0.56	9	0.27
2018	3410	2165	63.49	872	25.57	253	7.42	89	2.61	19	0.56	12	0.35
2019	3441	2156	62.66	920	26.74	256	7.44	84	2.44	19	0.55	6	0.17

Note: Ordered by statistical year.
Data source is *Impact Factor Annual Report* 2016–2020 editions.
The percentage here refers to the percentage of the journals within each range of self-citation rate against the total number of journals.

Tab. 1.49 – Distribution by discipline of domestic influence of Chinese language STM journals in 2019.

Serial no.	Discipline	No. of journal	No. of citable document	Avg. immediacy download ratio	Total times cited	Times cited per journal	Avg. impact factor	Avg. immediacy index	Avg. cited half-life (yr)
1	Natural science & engineering technology in general	224	46 462	73.60	228 726	1021.10	0.579	0.095	5.81
2	Medicine & health in general	183	103 013	47.93	349 233	1908.38	0.595	0.076	3.71
3	Chemical engineering	169	42 670	55.53	226 526	1340.39	0.531	0.078	6.51
4	Civil engineering	155	47 534	72.35	417 772	2695.30	0.737	0.107	5.46
5	Transportation engineering	143	32 061	53.98	186 048	1301.03	0.588	0.091	5.55
6	Radio electronics, Telecommunications	138	42 775	61.12	242 727	1758.89	0.777	0.107	4.78
7	Automation technology, Computer technology	124	55 482	84.44	407 876	3289.32	1.098	0.176	4.51
8	Engineering technology in general	121	27 991	76.21	249 766	2064.18	0.796	0.131	6.23
9	Traditional Chinese medicine & pharmacology	117	54 644	86.45	499 185	4266.54	1.038	0.159	4.62
10	Electrical engineering	115	28 786	60.52	353 437	3073.37	1.044	0.162	4.84
11	Clinical medicine in general	110	65 420	55.51	262 745	2388.59	0.799	0.103	3.67
12	Geology	95	12 067	61.35	318 241	3349.91	1.441	0.268	8.41
13	Agricultural science in general	94	36 290	81.43	303 930	3233.30	0.911	0.143	6.65
14	Internal medicine	93	23 244	55.32	191 928	2063.74	1.022	0.147	4.09
15	Oil & gas industry	88	19 029	49.52	176 569	2006.47	0.982	0.156	6.65
16	Mechanical engineering	83	31 773	50.98	190 951	2300.61	0.648	0.087	5.54

Tab. 1.49 – (continued).

Serial no.	Discipline	No. of journal	No. of citable document	Avg. immediacy download ratio	Total times cited	Times cited per journal	Avg. impact factor	Avg. immediacy index	Avg. cited half-life (yr)
17	Metal science & metalwork	79	16 886	50.18	159 931	2024.44	0.712	0.107	6.64
18	Surgery	78	19 319	43.40	134 717	1727.14	0.932	0.124	3.83
19	Metallurgical engineering technology	78	17 355	40.40	80 927	1037.53	0.548	0.086	6.97
20	Preventive medicine & hygiene	75	26 333	54.72	178 553	2380.71	1.035	0.156	3.95
21	Water conservancy engineering	73	17 333	46.62	111 796	1531.45	0.628	0.119	5.52
22	Mining engineering technology	73	19 708	43.27	157 270	2154.38	0.744	0.131	5.80
23	Biology	67	11 789	93.32	239 986	3581.88	1.179	0.201	7.63
24	Animal husbandry, Veterinary science	66	15 784	54.89	113 627	1721.62	0.662	0.120	5.87
25	Forestry	65	8921	64.02	104 234	1603.60	0.806	0.153	6.82
26	Environmental science & technology	63	16 022	103.32	251 965	3999.44	1.275	0.201	5.56
27	Pharmacology	58	26 258	81.30	145 297	2505.12	0.904	0.131	4.54
28	Basic medicine	56	12 123	65.48	79 966	1427.96	0.755	0.099	4.32
29	Aeronautical and space science & technology	52	6539	50.69	78 212	1504.08	0.652	0.094	6.49
30	Food science & technology	51	19 558	88.88	205 306	4025.61	1.038	0.180	5.85
31	Energy & power engineering	50	11 623	58.78	57 940	1158.80	0.612	0.089	5.45

Tab. 1.49 – (continued).

32	Engineering & technology science basic disciplines	48	9588	60.69	79 181	1649.60	0.704	0.097	5.78
33	Agronomy	47	9339	66.64	98 151	2088.32	1.064	0.204	6.91
34	Chemistry	40	7164	81.03	97 449	2436.23	1.018	0.172	6.15
35	Textile science & technology	33	5361	57.88	30 713	930.70	0.521	0.090	5.28
36	Physics	33	7487	57.70	89 330	2706.97	0.928	0.151	5.88
37	Oncology	33	8025	70.50	54 684	1657.09	1.110	0.208	3.87
38	Obstetrics, gynecology, & pediatrics	31	9008	70.24	82 530	2662.26	1.113	0.151	4.01
39	Atmospheric science	30	2650	51.67	63 288	2109.60	1.412	0.208	7.17
40	Light industry (excl textile & food)	29	7102	45.21	27 230	938.97	0.641	0.143	5.92
41	Neurology & psychiatry	28	5588	57.30	41 764	1491.57	0.819	0.108	4.17
42	Mathematics	27	2829	57.85	21 100	781.48	0.467	0.085	7.98
43	Medicine & health administration	27	13 054	79.84	58 653	2172.33	1.073	0.147	3.64
44	Geophysics	27	3194	51.30	85 558	3168.81	1.121	0.171	8.36
45	Surveying and mapping science & technology	26	5136	88.35	65 840	2532.31	1.201	0.188	4.89
46	Aquaculture	24	3274	68.58	36 919	1538.29	0.868	0.129	7.21
47	Weapon industry & military technology	24	3864	53.92	33 241	1385.04	0.657	0.103	6.40
48	Otorhinolaryngology and ophthalmology	23	3913	43.56	27 729	1205.61	0.707	0.106	4.28
49	Nursing	23	15 167	99.80	93 965	4085.43	0.965	0.105	3.56
50	Material science	22	5349	78.59	78 772	3580.55	0.902	0.128	6.95
51	Horticulture	22	4433	65.73	52 287	2376.68	0.897	0.154	6.56
52	Agricultural basic science	21	3855	105.57	137 907	6567.00	2.022	0.295	6.90

Tab. 1.49 – (continued).

Serial no.	Discipline	No. of journal	No. of citable document	Avg. immediacy download ratio	Total times cited	Times cited per journal	Avg. impact factor	Avg. immediacy index	Avg. cited half-life (yr)
53	Marine science	21	2251	77.14	36 869	1755.67	0.826	0.099	8.55
54	Plant protection	20	2810	62.15	35 407	1770.35	0.842	0.274	6.78
55	Agricultural engineering	19	13 086	86.74	100 397	5284.05	0.953	0.174	5.12
56	Stomatology	18	2206	47.38	14 653	814.06	0.724	0.086	4.31
57	Safety science & technology	17	2935	61.59	36 764	2162.59	0.897	0.107	5.79
58	Military medicine & special medicine	16	3212	49.45	24 663	1541.44	0.966	0.139	4.19
59	Mechanics	15	1929	68.80	36 907	2460.47	1.126	0.211	6.89
60	Nuclear science & technology	15	1710	29.73	11 830	788.67	0.440	0.072	7.07
61	Resource science	13	2171	148.62	50 229	3863.77	1.499	0.284	5.66
62	Natural geography	13	1720	241.23	104 184	8014.15	3.380	0.418	7.69
63	Dermatology & venereology	7	1935	54.67	11 013	1573.29	0.610	0.071	4.57
64	System science	6	747	136.50	28 617	4769.50	1.481	0.120	6.35
65	Astronomy	5	333	42.60	2661	532.20	0.590	0.162	6.98
	Total	3839	1 087 217	–	8 555 872	–	–	–	–

Note: Ordered by the number of journals in this discipline.
Data source is *Impact Factor Annual Report 2020 Edition*.
There are journals that belong to 2 or more disciplines.

TAB. 1.50 – Evaluation indices of international influence of TOP Chinese language STM journals in each discipline in 2019.

Serial no.	Discipline	No. of journal	Int'l total times cited (w/o self-cite)	Int'l total times cited per journal (w/o self-cite)	Avg. impact factor	Avg. immediacy index
1	Geology	23	42 864	1863.65	0.502	0.096
2	Chemistry	11	16 780	1525.45	0.814	0.285
3	Automation technology, Computer technology	10	11 396	1139.60	0.400	0.067
4	Biology	9	14 523	1613.67	0.421	0.151
5	Radio electronics, Telecommunications	7	7665	1095.00	0.227	0.031
6	Civil engineering	6	15 685	2614.17	0.356	0.044
7	Electrical engineering	6	12 974	2162.33	0.297	0.036
8	Oil & gas industry	6	10 163	1693.83	0.699	0.099
9	Environmental science & technology	6	8613	1435.50	0.242	0.039
10	Geophysics	6	8066	1344.33	0.308	0.061
11	Mining engineering technology	5	8867	1773.40	0.577	0.062
12	Natural geography	5	7294	1458.80	0.511	0.074
13	Physics	4	8974	2243.50	0.291	0.068
14	Material science	4	5915	1478.75	0.366	0.067
15	Chemical engineering	4	4909	1227.25	0.624	0.059
16	Traditional Chinese medicine & pharmacology	3	6562	2187.33	0.247	0.038
17	Metal science & metalwork	3	5702	1900.67	0.429	0.083
18	Mechanical engineering	3	4715	1571.67	0.219	0.022
19	Agricultural basic science	3	4206	1402.00	0.229	0.053
20	Medicine & health comprehensive	3	3313	1104.33	0.868	0.220
21	Surveying and mapping science & technology	3	2425	808.33	0.404	0.078
22	Agricultural engineering	2	6208	3104.00	0.360	0.033

Tab. 1.50 – (continued).

Serial no.	Discipline	No. of journal	Int'l total times cited (w/o self-cite)	Int'l total times cited per journal (w/o self-cite)	Avg. impact factor	Avg. immediacy index
23	Metallurgical engineering technology	2	3199	1599.50	0.468	0.102
24	Oncology	2	3142	1571.00	3.137	0.117
25	Resource science	2	2713	1356.50	0.359	0.044
26	Atmospheric science	2	2545	1272.50	0.521	0.057
27	Preventive medicine & hygiene	2	2359	1179.50	0.342	0.045
28	Water conservancy engineering	2	2157	1078.50	0.276	0.051
29	Marine science	2	1615	807.50	0.239	0.035
30	Natural science & engineering technology in general	1	2180	2180.00	0.472	0.088
31	Agricultural science in general	1	2053	2053.00	0.238	0.020
32	Pharmacology	1	1677	1677.00	0.200	0.036
33	Engineering & technology science basic disciplines	1	1458	1458.00	0.133	0.011
34	System science	1	1393	1393.00	0.171	0.033
35	Agronomy	1	1360	1360.00	0.201	0.032
36	Mechanics	1	1271	1271.00	0.184	0.047
37	Engineering technology in general	1	1251	1251.00	0.145	0.014
38	Plant science	1	1026	1026.00	0.230	0.007
39	Aeronautical and astronautical science & technology	1	1023	1023.00	0.180	0.034
40	Forestry	1	1021	1021.00	0.214	0.049
41	Obstetrics, gynecology, and pediatrics	1	786	786.00	0.246	0.047
	Total	158	252 048	–	–	–

Note: Ordered by the number of journals in the discipline.
Data sources is *International Citation Annual Report 2020 Edition.*
There are journals that belong to 2 or more disciplines.

TAB. 1.51 – Chinese Language STM Q1 Journals and WJCI scores in *WJCI Report 2020*.

Serial no.	Discipline	Journal name (ENG)	Journal name (CHI)	WJCI	Int'l ranking
1	Ship & vessel engineering	*Journal of Engineering for Thermal Energy and Power*	热能动力工程	1.549	6/24
2	Earth science in general	*Journal of Earth Science*	地球科学	2.363	26/124
3	Earth science in general	*Scientia Sinica* (*Terrae*)	中国科学: 地球科学	2.145	31/124
4	Geology	*Geology in China*	中国地质	3.927	12/127
5	Geology	*Acta Geologica Sinica*	地质学报	3.406	17/127
6	Geology	*Geological Review*	地质论评	3.149	19/127
7	Geology	*Earth Science Frontiers*	地学前缘	2.661	26/127
8	Geology	*Geology and Exploration*	地质与勘探	2.383	30/127
9	Geology	*Quaternary Sciences*	第四纪研究	2.321	31/127
10	Electric power	*Automation of Electric Power Systems*	电力系统自动化	4.386	4/30
11	Electrical engineering	*Proceedings of the CSEE*	中国电机工程学报	5.137	16/191
12	Electrical engineering	*Power System Technology*	电网技术	3.775	31/191
13	Electrical engineering	*Transactions of China Electrotechnical Society*	电工技术学报	3.361	35/191
14	Electrical engineering	*Power System Protection and Control*	电力系统保护与控制	2.781	43/191
15	Electronic technology	*Laser & Optoelectronics Progress*	激光与光电子学进展	3.690	13/115
16	Engineering mechanics	*Chinese Journal of Rock Mechanics and Engineering*	岩石力学与工程学报	4.901	4/29
17	Engineering mechanics	*Rock & Soil Mechanics*	岩土力学	4.296	6/29
18	Genera engineering technology	*Blasting*	爆破	2.094	10/40
19	Engineering & technology basic science	*Journal of Vibration and Shock*	振动与冲击	2.831	10/59
20	Engineering in general	*Acta Armamentarii*	兵工学报	3.087	23/159
21	Engineering in general	*Journal of Xi'an Jiaotong University*	西安交通大学学报	2.929	24/159
22	Engineering in general	*Journal of Zhejiang University* (*Engineering Science*)	浙江大学学报 (工学版)	2.768	27/159
23	Engineering in general	*Journal of Harbin Institute of Technology*	哈尔滨工业大学学报	2.738	28/159
24	Engineering in general	*Chinese Journal of Engineering*	工程科学学报	2.606	32/159
25	Engineering in general	*Journal of Southwest Jiaotong University*	西南交通大学学报	2.268	36/159

Tab. 1.51 – (continued).

Serial no.	Discipline	Journal name (ENG)	Journal name (CHI)	WJCI	Int'l ranking
26	Aeronautical and astronautical science & technology	*Acta Aeronautica ET Astronautica Sinica*	航空学报	2.699	15/84
27	Aeronautical and astronautical science & technology	*Systems Engineering and Electronics*	系统工程与电子技术	2.069	19/84
28	Aeronautical and astronautical science & technology	*Journal of Astronautics*	宇航学报	2.041	20/84
29	Nursing	*Chinese Journal of Nursing*	中华护理杂志	2.197	36/209
30	Environmental science & technology in general	*Chinese Journal of Applied Ecology*	应用生态学报	2.336	49/227
31	Environmental science & technology in general	*Environmental Science*	环境科学	2.282	52/227
32	Mechanical engineering	*Journal of Mechanical Engineering*	机械工程学报	3.478	17/150
33	Computer science & technology in general	*Chinese Journal of Computers*	计算机学报	7.646	22/172
34	Computer science & technology in general	*Computer Engineering and Applications*	计算机工程与应用	6.494	24/172
35	Computer science & technology in general	*Computer Science*	计算机科学	6.007	25/172
36	Computer science & technology in general	*Application Research of Computers*	计算机应用研究	5.581	26/172
37	Computer science & technology in general	*Journal of Computer Applications*	计算机应用	5.464	28/172
38	Computer science & technology in general	*Computer Engineering*	计算机工程	4.205	36/172
39	Computer software	*Journal of Software*	软件学报	2.152	20/99
40	Computer system structure	*Computer Integrated Manufacturing Systems*	计算机集成制造系统	3.469	3/28
41	Computer system structure	*Journal of Chinese Computer Systems*	小型微型计算机系统	2.657	5/28
42	Computer system structure	*Computer simulation*	计算机仿真	2.593	6/28
43	Computer hardware & architecture	*Acta Automatica Sinica*	自动化学报	3.192	8/56
44	Science & technology in general	*Chinese Science Bulletin*	科学通报	3.892	43/246
45	Science & technology in general	*Bulletin of Chinese Academy of Sciences*	中国科学院院刊	3.528	48/246

Tab. 1.51 – (continued).

Serial no.	Discipline	Journal name (ENG)	Journal name (CHI)	WJCI	Int'l ranking
46	Control science & technology	*Control and Decision*	控制与决策	1.833	17/69
47	Mining engineering technology	*Journal of China Coal Society*	煤炭学报	5.430	4/58
48	Mining engineering technology	*Mineral Deposits*	矿床地质	3.370	9/58
49	Mining engineering technology	*Journal of China University of Mining & Technology*	中国矿业大学学报	3.065	13/58
50	Agricultural engineering	*Transactions of the Chinese Society of Agricultural Engineering*	农业工程学报	4.910	3/22
51	Agricultural science in general	*Scientia Agricultura Sinica*	中国农业科学	8.090	4/134
52	Agricultural science in general	*Journal of Agro-Environment Science*	农业环境科学学报	5.202	9/134
53	Agricultural science in general	*Chinese Journal of Eco-Agriculture*	中国生态农业学报 (中英文)	4.930	10/134
54	Agricultural science in general	*Chinese Agricultural Science Bulletin*	中国农学通报	3.988	15/134
55	Agricultural science in general	*Chinese Journal of Agrometeorology*	中国农业气象	3.339	20/134
56	Agricultural science in general	*Agricultural Research in the Arid Areas*	干旱地区农业研究	2.631	29/134
57	Agricultural science in general	*Journal of China Agricultural University*	中国农业大学学报	2.514	33/134
58	Agricultural biology	*Transactions of the Chinese Society for Agricultural Machinery*	农业机械学报	4.558	4/28
59	Agronomy	*Journal of Plant Nutrition and Fertilizers*	植物营养与肥料学报	2.623	23/134
60	Agronomy	*Acta Agronomica Sinica*	作物学报	2.527	26/134
61	Agronomy	*Ecology and Environmental Sciences*	生态环境学报	2.034	33/134
62	Regional planning, Urban–rural planning	*Urban Planning Forum*	城市规划学刊	2.924	9/39
63	Ecology	*Acta Eclogica Sinica*	生态学报	3.137	34/143
64	Oil & gas industry	*Acta Petrolei Sinica*	石油学报	2.967	4/58
65	Oil & gas industry	*Petroleum Exploration and Development*	石油勘探与开发	2.958	5/58

Tab. 1.51 – (continued).

Serial no.	Discipline	Journal name (ENG)	Journal name (CHI)	WJCI	Int'l ranking
66	Oil & gas industry	*Natural Gas Industry*	天然气工业	2.415	8/58
67	Oil & gas industry	*China Petroleum Exploration*	中国石油勘探	1.913	9/58
68	Oil & gas industry	*Oil & Gas Geology*	石油与天然气地质	1.893	10/58
69	Oil & gas industry	*Petroleum Geology & Experiment*	石油实验地质	1.743	12/58
70	Oil & gas industry	*Petroleum Geology and Recovery Efficiency*	油气地质与采收率	1.585	14/58
71	Water conservancy engineering	*Journal of Hydraulic Engineering*	水利学报	2.855	4/53
72	Water conservancy engineering	*Advances in Water Science*	水科学进展	2.448	7/53
73	Water conservancy engineering	*Journal of Irrigation and Drainage*	灌溉排水学报	1.929	12/53
74	Special medicine	*Military Medical Research*	军事医学研究	3.118	3/17
75	Civil engineering	*Chinese Journal of Geotechnical Engineering*	岩土工程学报	2.316	30/147
76	Soil science	*Acta Pedologica Sinica*	土壤学报	1.897	13/55
77	System science	*Systems Engineering—Theory & Practice*	系统工程理论与实践	2.499	2/27
78	Petrology	*Acta Petrologica Sinica*	岩石学报	3.073	7/41
79	Medicine in general	*National Medical Journal of China*	中华医学杂志	3.133	71/349
80	Chinese traditional medicine & pharmacology, Integrative & complementary medicine	*China Journal of Chinese Materia Medica*	中国中药杂志	2.482	4/29
81	Chinese traditional medicine & pharmacology, Integrative & complementary medicine	*Chinese Traditional and Herbal Drugs*	中草药	1.907	7/29
82	Natural geography	*Acta Geographica Sinica*	地理学报	4.304	12/209
83	Natural geography	*Geographical Research*	地理研究	2.878	33/209
84	Natural geography	*Progress in Geography*	地理科学进展	2.829	36/209
85	Natural geography	*Scientia Geographica Sinica*	地理科学	2.411	49/209

Note: Ordered by the discipline name and the WJCI score within each discipline.
Data source is *WJCI Report 2020 Edition*.
A journal can belong to multiple disciplines and the discipline with the best ranking was chosen.

2014, there has been around 20 new English STM journals established each year. Please see figure 1.4 for the numbers of English journals established each year. There were 19 new English STM journals established in 2020 (table 1.52).

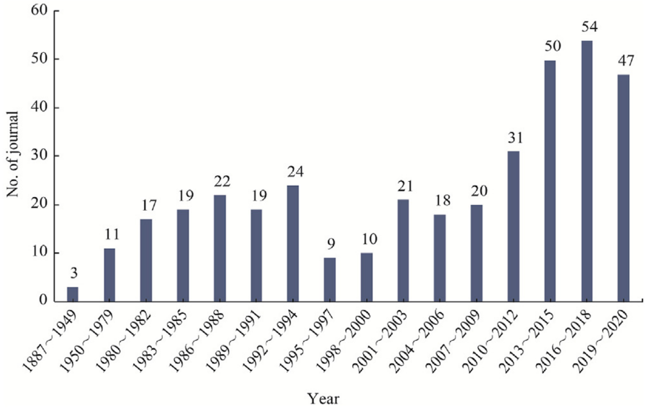

FIG. 1.4 – Year of establishment of China's English STM journals.

TAB. 1.52 – List of China's English STM Journals established in 2020.

Serial no.	Journal name (ENG)	Journal name (CHI)	Hosting organization
1	*Bio-Design and Manufacturing*	生物设计与制造 (英文)	Zhejiang University
2	*Carbon Energy*	碳能源 (英文)	Wenzhou University
3	*Cardiology Discovery*	心血管病探索 (英文)	Chinese Medical Association
4	*Chinese Medicine and Culture*	中医药文化 (英文)	Shanghai University of Traditional Chinese Medicine, China Association of Chinese Medicine
5	*Complex System Modeling and Simulation*	复杂系统建模与仿真 (英文)	Tsinghua University
6	*eLight*	光: 快讯 (英文)	Changchun Institute of Optics, Fine Mechanics and Physics, CAS
7	*Food Quality and Safety*	食品品质与安全研究 (英文)	Zhejiang University
8	*Frigid Zone Medicine*	寒地医学 (英文)	Heilongjiang Health Development Research Center
9	*Gastroenterology Report*	胃肠病学报道 (英文)	Sun Yat-sen University
10	*Genes & Diseases*	基因与疾病 (英文)	ChongQing Medical University

Tab. 1.52 – (continued).

Serial no.	Journal name (ENG)	Journal name (CHI)	Hosting organization
11	*Green Chemical Engineering*	绿色化学工程 (英文)	Institute of Process Engineering, CAS
12	*High Voltage*	高电压 (英文)	China Electric Design and Research Institute Co., Ltd.
13	*Infectious Diseases & Immunity*	感染性疾病与免疫 (英文)	Chinese Medical Association
14	*Intelligent Medicine*	智慧医学 (英文)	Chinese Medical Association
15	*Journal of Remote Sensing*	国际遥感学报 (英文)	Aerospace Information Research Institute, CAS
16	*Journal of the National Cancer Center*	癌症科学进展 (英文)	National Cancer Center
17	*Ultrafast Science*	超快科学 (英文)	Xi'an Institute of Optics and Precision Mechanics, CAS
18	*World Journal of Chinese Medicine*	中医学报 (英文)	Henan University of Chinese Medicine, China Association of Chinese Medicine
19	*World Journal of Pediatrics*	世界儿科杂志 (英文)	Zhejiang University, The Children's Hospital of Zhejiang University School of Medicine, Zhejiang University Press Co. Ltd.

Note: Ordered by the English name of journals.

1.3.2.2 Citable Documents of China's English STM Journals

According to the statistics of *Impact Factor Annual Report* 2016–2020 editions, the number of citable documents per journal of China's English STM journals decreased from 121.10 in 2015 to 103.19 in 2019, with a total decrease rate of 14.79%, average yearly decrease rate being 3.92% (table 1.53). The size of citable documents is smaller than the average number of papers per journal of international journals reported by JCR (179 papers), also lower than the average number of papers per journal of Chinese language journals (286 papers).

1.3.2.3 Total Times Cited

According to *Impact Factor Annual Report* and *International Citation Annual Report* (table 1.54), the average comprehensive total times cited per year of China's English STM journals during 2015–2019 was 232 700, and the average international total times cited was 301 700. The comprehensive total times cited by international and domestic documents increased from 2015 to 2019, with an average yearly increase rate of 13.90%. Data showed that the international times cited of China's English STM journals had exceeded the

TAB. 1.53 – Numbers of citable documents of China's English STM journals during 2015–2019.

Statistical year	No. of citable document	No. of journal	No. of citable document per journal
2015	24 220	200	121.10
2016	24 448	216	113.19
2017	24 384	220	110.84
2018	25 328	237	106.87
2019	25 901	251	103.19

Note: Ordered by statistical year.
Data source is *Impact Factor Annual Report* 2016–2020 editions.

TAB. 1.54 – Domestic and international cites of China's English STM journals during 2015–2019.

Statistical year	Domestic comprehensive times cited (A)	International times cited (B)	Total ($A + B$) (overlap removed)	Increase rate %
2015	210 709	196 851	371 739	–
2016	239 864	245 578	448 528	20.66
2017	238 797	281 302	481 299	7.31
2018	234 314	351 814	542 511	12.72
2019	239 993	432 837	625 629	15.32

Note: Ordered by statistical year.
Data source is *Impact Factor Annual Report* 2016–2020 editions and *International Citation Annual Report* 2016–2020 editions.
The increase rate is a year-on-year rate after overlap is removed from the total ($A + B$).

domestic times cited since 2016, and the percentage of international cites reached 69.18% in 2019. One thing to pay attention to is that: the domestic times cited of China's English STM journals started to decrease since 2016 and the international times cited were increasing by 21.77% per year on average during the 5 years. The domestic and international dissemination and usage of China's English journals were showing a big difference. Hence, we should pay more attention to the domestic impact of China's English STM journals, enhance their domestic dissemination and usage, and bring into full play their functions in supporting China's scientific research development and economic construction.

1.3.2.4 Internet Dissemination Indices

According to statistics of *Impact Factor Annual Report* 2016–2020 editions (table 1.55), the total download times of China's English STM journals and immediacy download times were showing an overall increasing trend. The total download times increased by 13.41% from 2015 to 2019, with an average yearly increase rate of 3.20%. The immediacy download times increased by 77.38% from 2015 to 2019, with an average yearly increase rate of

TAB. 1.55 – Download times of China's English STM journals during 2015–2019 as reported by *Impact Factor Annual Report*.

Statistical year	Total download times (A)	Immediacy download times (B)	Percentage of immediacy download times (B/A)/%	Increase rate of immediacy download times (%)
2015	1 870 378	167 140	8.94	–
2016	2 371 655	213 006	8.98	27.44
2017	1 910 127	177 361	9.29	–16.73
2018	1 973 220	218 797	11.09	23.36
2019	2 121 172	296 466	13.98	35.50

Note: Ordered by statistical year.
Data source is *Impact Factor Annual Report* 2016–2020 editions.

15.40%. The percentage of immediacy download increased from 8.94% in 2015 to 13.98% in 2019, with an average yearly increase rate of 11.83%.

1.3.2.5 Impact Factor and Immediacy Index

According to *Impact Factor Annual Report* 2016–2020 editions (table 1.56), the average comprehensive impact factor of China's English STM journals was 0.683 in 2015 and 0.837 in 2019, with an average yearly increase rate of 5.21%. The average comprehensive immediacy index was 0.164 in 2015 and 0.170 in 2019, with an average yearly increase rate of 0.90%.

According to the data in *International Citation Annual Report* 2016–2020 editions (table 1.56), the average impact factor (without self-cites) of China's TOP English STM journals during the 5-year period was showing a big increase, reaching 2.934 in 2019 (an increase of 98.92% from 2015), with an average yearly increase rate of 18.76%. The average

TAB. 1.56 – Impact factor and immediacy index of China's English STM journals during 2015–2019.

Statistical year	Domestic influence			International influence (TOP journals)		
	No. of journal	Avg. comprehensive impact factor	Avg. comprehensive immediacy index	No. of journal	Avg. impact factor (w/o self-cite)	Avg. Immediacy index
2015	200	0.683	0.164	163	1.475	0.352
2016	216	0.750	0.140	170	1.781	0.392
2017	220	0.780	0.167	187	2.048	0.530
2018	237	0.778	0.167	198	2.449	0.701
2019	251	0.837	0.170	212	2.934	0.789

Note: Ordered by statistical year.
Data source is *Impact Factor Annual Report* 2016–2020 editions and *International Citation Annual Report* 2016–2020 editions.

immediacy index during the 5-year period was largely increasing to 0.789 in 2019, with an increase of 124.15% from 2015, an average yearly increase rate of 22.36%.

1.3.2.6 Self-Citation Rate of Journals

According to the data in *Impact Factor Annual Report* 2016–2019 editions (table 1.57), the average self-citation rate of China's English STM journals in the past 5 years was around 18.00%. In 2019, journals with a self-citation rate lower than or equal to 10% account for 31.08% of the total journals, and journals with a self-citation rate higher than 20% account for 38.25% of the total journals. Looking at the changes in data, the number of journals with self-citation rate lower than or equal to 20% was decreasing each year, from 69.50% in 2015 to 61.76% in 2019. In terms of distribution of journals in each self-citation rate section, the higher the self-citation rate, the fewer the journals.

1.3.2.7 Distribution by Discipline of China's English STM Journals

According to the statistics of the 251 English STM journals included in *Impact Factor Annual Report* (table 1.58), these journals cover 56 disciplines, with "biology" (24 journals) having the highest number of journals, "physics" (2523 papers) having the highest number of citable documents, "natural geography" (41.80 times) having the highest immediacy download ratio per journal, "biology" having the highest number of comprehensive total times cited (30 900 times), "material science" having the highest average times cited per journal (2578.70 cites), "oncology" having the highest impact factor per journal (2.113), "astronomy" having the highest immediacy index per journal (2 journals, average immediacy index was 0.525), and "surveying and mapping science & technology" having the longest citation half-life (9.50 years).

According to the statistics in *International Citation Annual Report 2020 Edition* (table 1.59), 212 China's English STM journals were selected as TOP Journals, and they cover 55 disciplines. "biology" (23 journals) has the highest number of English TOP journals, and also the highest number of international total times cited (without self-cites) (68 957 times). "material science" has the highest international total times cited (without self-cites) per journal, and the average international total times cited (without self-cites) per journal of the 9 English journals selected in this discipline is 5690.11. "nature science and engineering technology in general" has the highest impact factor per journal with 3 English journals selected in this discipline, the average impact factor being 10.432. "nature science and engineering technology in general" also has the highest immediacy index per journal, with 3 English journals selected in this discipline, the average immediacy index being 2.433.

WJCI 2020 Edition included 254 English language STM journals in China, among which 88 were in Q1 section (table 1.60).

1.3.2.8 China's English STM Journals Included in International Databases

With the rapid development of China's science and technology, the English STM journals of China have gained increasingly prominent position and roles in international academic exchange, hence have received greater attention and recognition from the international

TAB. 1.57 – Distribution of self-citation rate of China's English STM journals during 2015–2019.

Statistical year	No. of journal	Self-citation rate (%) 0 ∼		10 ∼		20 ∼		30 ∼		40 ∼		50 ∼	
		No. of journal	%	No. of journal	%	No. of journal	%	No. of journal	%	No. of journal	%	No. of journal	%
2015	200	68	34.00	71	35.50	28	14.00	17	8.50	9	4.50	7	3.50
2016	216	78	36.11	63	29.17	36	16.67	19	8.80	12	5.56	8	3.70
2017	220	88	40.00	51	23.18	40	18.18	25	11.36	11	5.00	5	2.27
2018	237	82	34.60	75	31.65	37	15.61	27	11.39	8	3.38	8	3.38
2019	251	78	31.08	77	30.68	50	19.92	24	9.56	16	6.37	6	2.39

Note: Ordered by statistical year.

Data source is *Impact Factor Annual Report* 2016–2020 editions.

TAB. 1.58 – Distribution by discipline of domestic influence of China's English STM journals in 2019.

Serial no.	Discipline	No. of journal	No. of citable document	Immediacy download ratio	Total times cited	Total times cited per journal	Avg. impact factor	Avg. immediacy index	Avg. cited half-life (yr)
1	Biology	24	2027	11.38	30 902	1287.58	0.974	0.268	6.82
2	Mathematics	18	1101	6.92	4349	241.61	0.208	0.064	8.56
3	Radio electronics Telecommunications	15	1697	10.50	11 505	767.00	0.674	0.110	3.81
4	Engineering technology in general	14	1427	19.67	14 041	1002.93	0.578	0.107	6.16
5	Physics	13	2523	8.11	17 333	1333.31	0.768	0.186	4.20
6	Automation technology, Computer technology	11	1185	14.25	8570	779.09	0.962	0.127	3.94
7	Chemistry	11	2246	25.89	20 250	1840.91	1.605	0.341	3.37
8	Material science	10	1969	20.38	25 787	2578.70	1.358	0.221	4.46
9	Metal science & metalwork	9	1533	13.63	20 812	2312.44	1.303	0.190	4.64
10	Civil engineering	8	693	21.00	3142	392.75	0.647	0.096	3.88
11	Traditional Chinese medicine & pharmacology	8	573	12.50	6096	762.00	0.756	0.151	4.80
12	Geophysics	7	527	10.00	7152	1021.71	0.819	0.241	4.56
13	Geology	7	601	13.00	4770	681.43	0.662	0.163	6.10
14	Marine science	6	646	8.67	3192	532.00	0.373	0.070	6.68
15	Environmental science & technology	6	615	41.00	8297	1382.83	0.919	0.201	4.35
16	Mechanics	6	625	5.67	5603	933.83	0.749	0.274	5.20
17	Atmospheric	6	435	19.20	4730	788.33	0.759	0.175	5.25

Tab. 1.58 – (continued).

Serial no.	Discipline	No. of journal	No. of citable document	Immediacy download ratio	Total times cited	Total times cited per journal	Avg. impact factor	Avg. immediacy index	Avg. cited half-life (yr)
18	Metallurgical engineering technology	6	939	15.00	14 980	2496.67	1.005	0.124	5.42
19	Natural geography	5	532	41.80	5284	1056.80	1.019	0.184	4.78
20	Natural science & engineering technology in general	5	676	20.40	10 020	2004.00	1.222	0.323	4.56
21	Pharmacology	5	464	17.20	5435	1087.00	1.160	0.242	4.28
22	Energy & power engineering	5	428	8.33	2352	470.40	1.275	0.168	3.64
23	Mechanical engineering	5	279	21.50	2685	537.00	0.658	0.069	4.50
24	Agricultural science in general	4	398	13.50	4757	1189.25	0.519	0.179	4.58
25	Internal medicine	4	238	3.33	1009	252.25	0.544	0.108	3.95
26	Chemical engineering	4	555	8.00	4029	1007.25	0.746	0.114	4.25
27	Medicine & health in general	4	799	41.00	7479	1869.75	0.964	0.178	4.88
28	Oncology	4	283	5.75	3166	791.50	2.113	0.148	4.60
29	Surgery	4	259	4.00	2057	514.25	1.174	0.176	3.75
30	Neurology & psychiatry	3	517	8.00	4382	1460.67	1.044	0.256	6.70
31	Basic medicine	3	320	5.50	3030	1010.00	0.996	0.201	5.53
32	Transportation engineering	3	126	11.33	741	247.00	0.483	0.066	5.77

Tab. 1.58 – (continued).

33	Aeronautical and astronautical science & technology	2	326	8.50	2975	1487.50	0.813	0.151	5.15
34	Otorhinolaryngology & ophthalmology	2	71	–	119	59.50	0.398	0.067	2.80
35	Engineering & technology science basic disciplines	2	191	13.00	1506	753.00	1.921	0.329	3.55
36	Stomatology	2	61	3.00	406	203.00	0.860	0.050	3.90
37	Mining engineering technology	2	168	11.00	2915	1457.50	1.573	0.252	5.20
38	Forestry	2	259	7.00	1211	605.50	0.587	0.093	6.25
39	Agronomy	2	123	14.50	820	410.00	0.877	0.218	5.05
40	Oil & gas industry	2	167	8.50	825	412.50	0.642	0.103	4.85
41	Animal husbandry, Veterinary science	2	153	9.00	856	428.00	1.151	0.131	3.00
42	Water conservancy technology	2	93	2.50	736	368.00	0.709	0.036	5.50
43	Astronomy	2	352	7.00	2267	1133.50	0.828	0.525	4.25
44	System science	1	41	–	381	381.00	1.017	0.049	5.80
45	Weapon industry & military technology	1	110	5.00	355	355.00	0.832	0.118	3.20
46	Preventive medicine & hygiene	1	213	31.00	767	767.00	0.433	0.131	3.10
47	Horticulture	1	32	16.00	144	144.00	1.270	0.375	2.20
48	Agricultural basic science	1	73	9.00	2116	2116.00	1.339	0.123	8.70
49	Dermatology & venereology	1	54	–	492	492.00	0.320	–	6.90

Tab. 1.58 – (continued).

Serial no.	Discipline	No. of journal	No. of citable document	Immediacy download ratio	Total times cited	Total times cited per journal	Avg. impact factor	Avg. immediacy index	Avg. cited half-life (yr)
50	Light industry (excl textile and food)	1	31	6.00	155	155.00	0.732	0.097	6.70
51	Clinical medicine in general	1	62	–	74	74.00	1.526	0.097	2.00
52	Surveying and mapping science & technology	1	28	–	184	184.00	0.295	–	9.50
53	Textile science & technology	1	85	15.00	281	281.00	0.201	–	5.80
54	Obstetrics, gynecology & and pediatrics	1	84	–	434	434.00	0.677	0.333	4.00
55	Nuclear science & technology	1	185	7.00	745	745.00	0.954	0.184	2.70
56	Nursing	1	66	–	127	127.00	0.309	0.045	3.30
	Total	278	30 264	–	288 828	–	–	–	–

Note: Ordered by the number of journals in the discipline.
Data source is *Impact Factor Annual Report 2020 Edition*.
There are journals that belong to 2 or more disciplines.

TAB. 1.59 – Evaluation indices of China's TOP English journals in each discipline in 2019.

Serial no.	Discipline	No. of journal	Int'l total times cited (w/o self cites)	Int'l total times cited (w/o self cites) per journal	Avg. impact factor	Avg. immediacy index
1	Biology	23	68 957	2998.13	4.638	1.492
2	Physics	12	37 442	3120.17	3.056	0.970
3	Chemistry	11	38 606	3509.64	4.193	1.595
4	Radio electronics, Telecommunications	11	13 460	1223.64	2.135	0.484
5	Automation technology, Computer technology	11	10 782	980.18	1.793	0.399
6	Mathematics	10	8797	879.70	0.857	0.396
7	Material science	9	51 211	5690.11	3.143	0.940
8	Metal science & metalwork	8	32 392	4049.00	2.031	0.573
9	Environmental science & technology	7	17 802	2543.14	2.443	0.548
10	Engineering technology in general	7	17 386	2483.71	1.905	0.487
11	Metallurgical engineering technology	6	23 184	3864.00	2.470	0.493
12	Chemical engineering	6	12 845	2140.83	4.206	1.152
13	Mechanics	6	11 011	1835.17	1.922	0.879
14	Geology	6	10 354	1725.67	1.858	0.590
15	Geophysics	6	10 292	1715.33	1.899	0.818
16	Civil engineering	6	5971	995.17	1.715	0.449
17	Internal medicine	5	4503	900.60	2.821	0.359
18	Energy & power engineering	5	4177	835.40	3.051	0.704
19	Pharmacology	4	16 224	4056.00	4.386	1.450
20	Medicine & health in general	4	10 719	2679.75	1.696	0.355
21	Neurology & psychiatry	4	8389	2097.25	3.171	0.775
22	Natural geography	4	7466	1866.50	1.846	0.459
23	Atmospheric science	4	6962	1740.50	2.512	0.575
24	Surgery	4	6638	1659.50	4.021	0.634
25	Marine science	4	5474	1368.50	0.825	0.228
26	Traditional Chinese medicine & pharmacology	4	4273	1068.25	1.365	0.301

Tab. 1.59 – (continued).

Serial no.	Discipline	No. of journal	Int'l total times cited (w/o self cites)	Int'l total times cited (w/o self cites) per journal	Avg. impact factor	Avg. immediacy index
27	Natural science & engineering technology in general	3	9418	3139.33	10.432	2.433
28	Basic medicine	3	7554	2518.00	4.478	1.198
29	Oncology	3	4551	1517.00	3.728	0.441
30	Mechanical engineering	3	3229	1076.33	3.038	0.917
31	Transportation engineering	3	1453	484.33	1.417	0.442
32	Engineering & technology science basic disciplines	2	4754	2377.00	6.656	1.755
33	Astronomy	2	4562	2281.00	2.325	1.506
34	Animal husbandry & veterinary science	2	3162	1581.00	4.153	0.723
35	Forestry	2	2152	1076.00	1.939	0.443
36	Agronomy	2	2145	1072.50	3.187	0.712
37	Water conservancy engineering	2	1873	936.50	2.029	0.358
38	Oil & gas industry	2	1675	837.50	2.438	0.383
39	Clinical medicine in general	2	1671	835.50	7.248	0.485
40	Stomatology	2	1487	743.50	2.239	0.418
41	Horticulture	2	1428	714.00	3.107	0.750
42	Agricultural basic science	1	3578	3578.00	3.670	0.565
43	Agricultural science in general	1	3377	3377.00	1.817	0.604
44	Aeronautical and astronautical science & technology	1	3084	3084.00	1.814	0.656
45	Mining engineering technology	1	2541	2541.00	3.513	1.000
46	Military medicine & special medicine	1	1607	1607.00	5.227	1.635
47	Obstetrics, gynecology, & pediatrics	1	966	966.00	1.392	0.622
48	Weapon industry & military technology	1	830	830.00	2.349	0.518

Tab. 1.59 – (continued).

Serial no.	Discipline	No. of journal	Int'l total times cited (w/o self cites)	Int'l total times cited (w/o self cites) per journal	Avg. impact factor	Avg. immediacy index
49	Nuclear science & technology	1	786	786.00	1.122	0.199
50	Surveying and mapping science & technology	1	666	666.00	4.410	0.429
51	Preventive medicine & hygiene	1	549	549.00	1.496	0.737
52	System science	1	535	535.00	1.013	0.659
53	Otorhinolaryngology & ophthalmology	1	476	476.00	2.207	0.359
54	Aquaculture	1	258	258.00	3.042	0.200
55	Food science & technology	1	160	160.00	2.944	0.000
	Total	236	515 844	–	–	–

Note: Ordered by the number of journals in the discipline.
Data source is *International Citation Annual Report 2020 Edition*.
Some journals can belong to 2 or more disciplines.

Tab. 1.60 – WJCI list and index of China's English STM Q1 Journals in 2020.

Serial no.	Discipline	Journal name (ENG)	Journal name (CHI)	WJCI	Int'l ranking
1	Material science in general	*Journal of Materials Science & Technology*	材料科学技术 (英文版)	3.016	39/193
2	Surveying and mapping science & technology	*Geo-spatial Information Science*	地球空间信息科学学报 (英文版)	2.558	19/79
3	Ship & vessel engineering	*Journal of Marine Science and Application*	船舶与海洋工程学报 (英文版)	1.716	5/24
4	Earth science in general	*Science China Earth Sciences*	中国科学: 地球科学 (英文版)	3.627	15/124
5	Geology	*Geoscience Frontiers*	地学前缘 (英文版)	3.795	13/127
6	Geology	*Petroleum*	油气 (英文)	2.809	24/127

TAB. 1.60 – (continued).

Serial no.	Discipline	Journal name (ENG)	Journal name (CHI)	WJCI	Int'l ranking
7	Geology	*Acta Geologica Sinica (English Edition)*	地质学报(英文版)	2.447	28/127
8	Electronic technology	*High Power Laser Science and Engineering*	高功率激光科学与工程(英文)	2.061	28/115
9	Animal science	*Current Zoology*	动物学报	2.462	21/149
10	Zoology	*Integrative Zoology*	整合动物学(英文)	2.221	27/149
11	Zoology	*Zoological Research*	动物学研究	1.982	37/149
12	Simulation science & technology	*npj Computational Materials*	计算材料学(英文)	4.092	6/113
13	Simulation science & technology	*International Journal of Automation and Computing*	国际自动化与计算杂志	2.068	18/113
14	Molecular biology	*Protein & Cell*	蛋白质与细胞	2.623	40/170
15	General engineering technology	*Journal of Control and Decision*	控制与决策学报 (英文)	5.532	4/40
16	Engineering in general	*Engineering*	工程 (英文)	9.446	4/159
17	Engineering in general	*Journal of Zhejiang University-Science A (Applied Physics & Engineering)*	浙江大学学报 (英文版) A辑	4.616	13/159
18	Engineering in general	*Defence Technology*	防务技术(英文)	4.220	15/159
19	Orthopedics	*Bone Research*	骨研究 (英文)	4.161	15/133
20	Optics	*Light: Science & Applications*	光: 科学与应用 (英文)	5.458	5/88
21	Optics	*Photonics Research*	光子学研究(英文)	2.450	18/88
22	Aeronautical and astronautical science & technology	*Chinese Journal of Aeronautics*	中国航空学报 (英文版)	4.357	9/84
23	Aeronautical and astronautical science & technology	*Astrodynamics*	航天动力学(英文)	2.603	16/84

TAB. 1.60 – (continued).

Serial no.	Discipline	Journal name (ENG)	Journal name (CHI)	WJCI	Int'l ranking
24	Nuclear physics	*Chinese Physics C*	中国物理C	4.492	2/29
25	Chemical engineering in general	*Frontiers of Chemical Science and Engineering*	高等学校学术文摘·化学科学与工程前沿 (英文)	2.633	34/138
26	Chemistry in general	*Science China Chemistry*	中国科学: 化学 (英文版)	3.997	27/182
27	Chemistry in general	*Chinese Chemical Letters*	中国化学快报 (英文版)	3.157	36/182
28	Environmental science & technology in general	*Journal of Environmental Sciences*	环境科学学报 (英文版)	3.343	31/227
29	Environmental ecology	*Ecosystem Health and Sustainability*	生态系统健康与可持续性 (英文)	1.593	5/22
30	Mechanical engineering	*Friction*	摩擦 (英文)	3.444	18/150
31	Computer science& technology in general	*Journal of Computer Science & Technology*	计算机科学技术学报 (英文版)	3.655	38/172
32	Computer hardware & architecture	*Microsystems & Nanoengineering*	微系统与纳米工程 (英文版)	3.040	9/56
33	Architectural science	*Building Simulation*	建筑模拟 (英文)	1.834	12/57
34	Metal science	*Journal of Rare Earths*	稀土学报 (英文版)	2.836	9/73
35	Metal science	*Acta Metallurgica Sinica (English Letters)*	金属学报 (英文版)	2.199	13/73
36	Science & technology in general	*National Science Review*	国家科学评论 (英文)	32.692	5/246
37	Science & technology in general	*Science Bulletin*	科学通报 (英文版)	18.742	8/246

TAB. 1.60 – (continued).

Serial no.	Discipline	Journal name (ENG)	Journal name (CHI)	WJCI	Int'l ranking
38	Science & technology in general	*Research*	研究 (英文)	10.325	16/246
39	Science & technology in general	*Science China Technological Sciences*	中国科学: 技术科学 (英文版)	6.637	22/246
40	Science & technology in general	*Tsinghua Science and Technology*	清华大学学报自然科学版 (英文版)	3.856	44/246
41	Stomatology	*International Journal of Oral Science*	国际口腔科学杂志	2.505	39/191
42	Mining engineering technology	*International Journal of Mining Science and Technology*	矿业科学技术学报	4.466	6/58
43	Mining engineering technology	*International Journal of Coal Science and Technology*	国际煤炭科学技术学报 (英文)	3.038	14/58
44	Mechanics in general	*Science China Physics, Mechanics & Astronomy*	中国科学: 物理学力学天文学 (英文版)	3.179	5/63
45	Forestry in general	*Forest Ecosystems*	森林生态系统 (英文)	2.041	19/87
46	Forestry in general	*Journal of Forestry Research*	林业研究 (英文版)	2.026	20/87
47	Immunology	*Cellular & Molecular Immunology*	中国免疫学杂志 (英文版)	2.457	26/120
48	Nano science & nano technology	*Nano Research*	纳米研究 (英文版)	3.256	15/104
49	Energy system engineering	*Journal of Energy Chemistry*	能源化学 (英文)	3.060	14/86
50	Agricultural science in general	*Journal of Integrative Agriculture*	农业科学学报 (英文版)	7.211	5/134
51	Agronomy	*The Crop Journal*	作物学报 (英文版)	3.014	18/134
52	Agronomy	*Rice Science*	水稻科学 (英文版)	2.551	24/134

TAB. 1.60 – (continued).

Serial no.	Discipline	Journal name (ENG)	Journal name (CHI)	WJCI	Int'l ranking
53	Biology in general	*Science China Life Sciences*	中国科学: 生命科学 (英文版)	6.296	16/186
54	Mathematics in general	*Science China Mathematics*	中国科学: 数学 (英文版)	3.087	40/345
55	Mathematics in general	*Acta Mathematica Scientia*	数学物理学报 (英文版)	2.080	74/345
56	Mathematics in general	*Frontiers of Mathematics in China*	中国高等学校学术文摘·数学	1.940	82/345
57	Water conservancy engineering	*Journal of Hydrodynamics*	水动力学研究与进展B辑	2.626	6/53
58	Water conservancy engineering	*International Journal of Sediment Research*	国际泥沙研究 (英文版)	2.374	8/53
59	Ceramography	*Journal of Advanced Ceramics*	先进陶瓷 (英文)	3.513	4/22
60	Civil engineering	*Underground Space*	地下空间 (英文)	2.024	35/147
61	Soil science	*Pedosphere*	土壤圈 (英文版)	1.962	12/55
62	System science	*Journal of Systems Engineering and Electronics*	系统工程与电子技术 (英文版)	1.754	6/27
63	Cell engineering	*Cell Research*	细胞研究 (英文版)	11.208	2/46
64	Information science	*Science China Information Sciences*	中国科学: 信息科学 (英文版)	10.102	4/65
65	Sexology, Andrology	*Asian Journal of Andrology*	亚洲男性学杂志 (英文)	2.341	7/30
66	Animal husbandry	*Journal of Animal Science and Biotechnology*	畜牧与生物技术杂志 (英文版)	3.497	5/57
67	Animal husbandry	*Animal Nutrition*	动物营养 (英文)	3.167	6/57
68	Pharmacology in general	*Acta Pharmacologica Sinica*	中国药理学报	2.969	47/246

Tab. 1.60 – (continued).

Serial no.	Discipline	Journal name (ENG)	Journal name (CHI)	WJCI	Int'l ranking
69	Pharmacy in general	*Acta Pharmaceutica Sinica B*	药学学报 (英文)	4.341	14/88
70	Metallurgical engineering technology	*Transactions of Nonferrous Metals Society of China*	中国有色金属学报 (英文版)	6.383	4/76
71	Metallurgical engineering technology	*Journal of Magnesium and Alloys*	镁合金学报 (英文)	4.764	8/76
72	Metallurgical engineering technology	*Journal of Central South University*	中南大学学报 (英文版)	2.896	14/76
73	Metallurgical engineering technology	*Rare Metals*	稀有金属 (英文版)	2.807	16/76
74	Metallurgical engineering technology	*International Journal of Minerals Metallurgy and Materials*	矿物冶金与材料学报 (英文版)	2.651	17/76
75	Metallurgical engineering technology	*Journal of Iron and Steel Research (International)*	钢铁研究学报 (英文版)	2.342	19/76
76	Medical imaging science, Medical imaging technology	*Signal transduction and targeted therapy*	信号转导与靶向治疗	4.472	14/141
77	Medicine in general	*Frontiers of Medicine*	高等学校学术文摘·医学前沿 (英文)	6.725	32/349
78	Medicine in general	*Chinese Medical Journal*	中华医学杂志 (英文版)	4.993	46/349
79	Genetics	*Genomics, Proteomics & Bioinformatics*	基因组蛋白质组与生物信息学报	2.106	39/156
80	Applied chemistry	*Chinese Journal of Catalysis*	催化学报	2.776	9/50
81	Applied mathematics	*Applied Mathematics and Mechanics (English Edition)*	应用数学和力学 (英文版)	1.891	39/174
82	Applied physics	*Nano-Micro Letters*	纳微快报 (英文)	4.192	14/113

Tab. 1.60 – (continued).

Serial no.	Discipline	Journal name (ENG)	Journal name (CHI)	WJCI	Int'l ranking
83	Horticulture	*Horticulture Research*	园艺研究 (英文)	4.279	4/43
84	Mycology	*Fungal Diversity*	真菌多样性 (英文)	3.976	1/34
85	Botany	*Molecular Plant*	分子植物	9.225	8/202
86	Botany	*Journal of Integrative Plant Biology*	植物学报 (英文版)	4.374	24/202
87	Automation & control system	*IEEE/CAA Journal of Automatica Sinica*	自动化学报 (英文)	3.364	16/97
88	Natural geography	*Journal of Geographical Sciences*	地理学报 (英文版)	2.889	32/209

Note: Ordered by the name of the disciplines and the WJCI value within each discipline.
Data source is *WJCI 2020 Edition*.
For a journal that belongs to multiple disciplines, the discipline with the best ranking was chosen.

well-known databases. Here we choose two comprehensive citation databases of Web of Science (WoS), Scopus and six professional abstract databases of EI (engineering technology), PubMed (biology and medicine), Chemical Abstracts-ACS (chemistry), MathSciNet-MSN (mathematics), GeoRef (geosciences), and CAB Abstracts (agriculture) to record and analyze the inclusion of China's English STM journals.

Among the 375 English journals in China, 311 journals (82.93% of the total) were included in at least 1 of the above-mentioned databases (see details in table 1.61). In 2021, 29 more English journals were included in the above databases (table 1.62).

Tab. 1.61 – Number of China's English STM journals included in international databases.

Serial no.	Database	Discipline covered	No. of journals included
1	WoS	Comprehensive	239
2	Scopus	Comprehensive	264
3	EI	Engineering technology	86
4	PubMed	Biology & Medicine	67
5	ACS	Chemistry	167
6	CAB Abstracts	Agriculture	63
7	GeoRef	Geosciences	37
8	MSN	Mathematics	30

Note: Retrieval time was April 2021.

TAB. 1.62 – China's English STM journals newly included in overseas databases in 2020.

Serial no.	Journal name (ENG)	Journal name (CHI)	Database
1	*Advanced Photonics*	先进光子学 (英文)	EI; ACS
2	*Astrodynamics*	航天动力学 (英文)	Scopus
3	*Automotive Innovation*	汽车创新工程 (英文)	Scopus
4	*Biosafety and Health*	生物安全与健康 (英文)	Scopus
5	*Carbon Energy*	碳能源 (英文)	ACS; GeoRef
6	*CCS Chemistry*	中国化学会会刊 (英文)	ACS
7	*China Chemical Reporter*	中国化工报导 (英文版)	ACS
8	*Chinese Journal of Electrical Engineering*	中国电气工程学报 (英文)	Scopus
9	*Chinese Neurosurgical Journal*	中华神经外科杂志 (英文)	Scopus; PubMed
10	*Chinese Nursing Research (Print)*	护理前沿 (英文)	Scopus
11	*Clean Energy*	清洁能源 (英文)	Scopus
12	*Cybersecurity*	网络空间安全科学与技术 (英文)	Scopus
13	*Digital Chinese Medicine*	数字中医药 (英文)	ACS
14	*Electrochemical Energy Reviews*	电化学能源评论 (英文)	WoS; ACS
15	*Environmental Science & Ecotechnology*	环境科学与生态技术 (英文)	WoS
16	*Geography and Sustainability*	地理学与可持续性 (英文)	WoS; Scopus
17	*Global Energy Interconnection*	全球能源互联网 (英文)	Scopus
18	*Grain & Oil Science and Technology*	粮油科技 (英文)	ACS
19	*Journal of Bioresources and Bioproducts*	生物质资源与工程 (英文)	Scopus; ACS; MSN
20	*Journal of Cotton Research*	棉花研究 (英文)	WoS; ACS
21	*Journal of Traditional Chinese Medical Sciences*	中医科学杂志 (英文)	Scopus
22	*Liver Research*	肝脏研究 (英文)	Scopus; ACS
23	*Nano Materials Science*	纳米材料科学 (英文)	ACS
24	*Pediatric Investigation*	儿科学研究 (英文)	Scopus; ACS
25	*Petroleum Research*	石油研究 (英文)	Scopus; ACS
26	*Precision Clinical Medicine*	精准临床医学 (英文)	WoS; Scopus
27	*Research*	研究 (英文)	WoS; Scopus; EI; PubMed; ACS

TAB. 1.62 – (continued).

Serial no.	Journal name (ENG)	Journal name (CHI)	Database
28	*World Journal of Pediatric Surgery*	世界小儿外科杂志 (英文)	Scopus
29	*World Journal of Traditional Chinese Medicine*	世界中医药杂志 (英文)	WoS; Scopus; ACS

Note: This list includes the English language STM journals in China that were included in any of the databases—WoS, Scopus, EI, PubMed, ACS, CAB Abstracts, GeoRef, MSN during April 2020 to March 2021.

Chapter 2

Development of China's Open Science and STM Journals

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Abstract

China has the foundation for developing open science. With the global open science movement, Chinese societies combine this opportunity and their existing infrastructure and practical experience to develop open science.

There are many new ways of accessing China's STM journals, such as using open access journals, data sharing services (data journal and data repository), open infrastructure (institutional repositories, pre-print platform, registration system) and participatory research (open peer review, citizen science).

The number of open access articles published has continued to increase year after year. More and more journals are transforming into open access journals. From 2011 to 2020, China published 700 634 open access articles, accounting for 17.32% of the total number of open access articles in the world.

Four data journals have been established in China. From 2014 to 2020, Chinese researchers published 702 data papers, accounting for 8.80% of the world's total data papers.

China's social groups advocate open science. For example, Chinese researchers have participated in the international conferences and signed cooperative memoranda. China has actively promoted the openness idea and has arranged a lot of seminars to impact the other sectors of the society. Funding agencies and the research institutes have issued open access policies and data management and sharing policies; they have built their repositories and made a series of guidelines. China's publishers have increased their open access journals in the past few years, and some of them collaborated with international publishing groups for the development of open access journals.

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Open science in China has laid a stable foundation in the fields of institutional repository, journal full-text online, data infrastructure and data publishing. Open science in China has its principles based on the copyright law, data security law, network security law and personal information protection law. In addition, the push power has been established from the science and technology progress law under revision (Dec.2021) and a series of China's STM journal statements.

STM journals in China have their social responsibility in open science environment; they have to support scientific community development, to disseminate S&T ethics, to promote world S&T frontiers applied in regional problem-solutions, to enhance intellectual property rights, and to accelerate young talents' communication.

Open science on the one hand brings more users to China's STM journals and more extending spaces in open research data, open education resource, open source software and code, public participants in scientific research, and also Bibliodiversity and open peer review to itself, on the other hand, China's STM journals are reforming in order to be a part of global open science and digital inclusion.

2.1 China's Open Science Environment

2.1.1 China's Open Science Achievement

2.1.1.1 Scientific Information to Open Access

China has provided a large amount of scientific information to open access in the past few years, including open access journals and open access articles.

In the past 10 years, the number and proportion of open access articles in China have continued to increase, accounting for an increasing proportion in global open access data, year by year[1]. From 2011 to 2020, Chinese researchers published a total of 4 225 372 articles and 700 634 open access articles, accounting for 16.58% (figure 2.1). Over the past 10 years, China's open access articles have increased by 20.40% and its proportion in global open access articles has increased from 8.93% in 2011 to 19.68% in 2020, an increase of 10.75% (figure 2.2)[2].

The total number of Open Access Journals in China is increasing year by year. By the end of July 2021, DOAJ has collected 143 Chinese journals[1]. It is about 0.86% of the total number of DOAJ journals (16 635). They are mainly in English (113) and about 79.02% of the total. There are few Journals in Chinese (23) and in both Chinese and English (7)[2].

The rapid growth in the number of open access articles in China represents a phenomenon that the Chinese researchers support open access journals and the open

[1] Statistical display based on Scopus database. Retrieval time is 2021-10-01 and the method using Scopus advance search as: Publishing time (2011～2020); Filter countries by faceted navigation box in the search result interface (China), Document type (Article, Review, Letter, OA in Gold and Hybrid).

[2] Retrieval time is 2021-10-16 and the method suing Scopus advance search as same as the above path.

FIG. 2.1 – Total number of articles in China and the number and proportion of open access articles in China from 2011 to 2020.

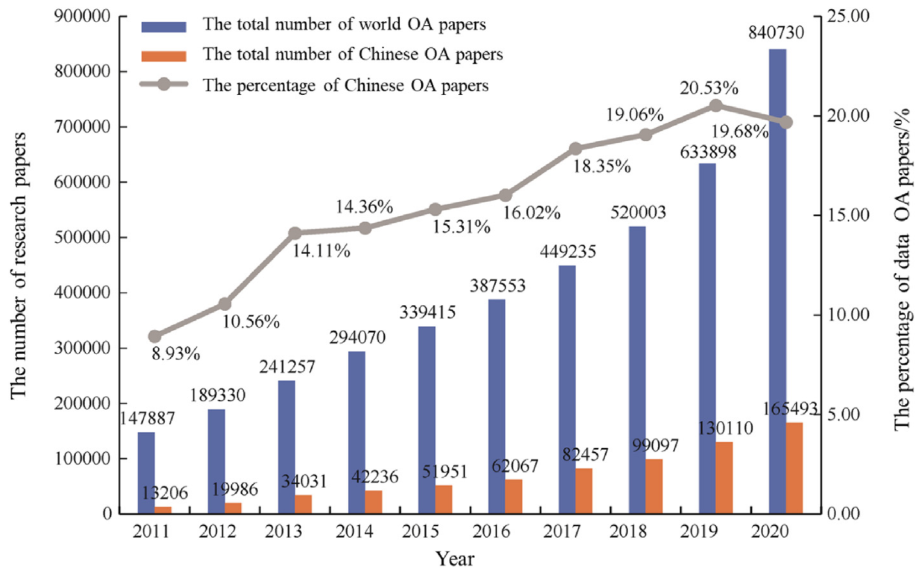

FIG. 2.2 – Number and proportion of world open access articles and Chinese open access articles from 2011 to 2020.

publishing way. The progress of open access journals in China represents those STM journals' developing direction.

2.1.1.2 Scientific Data to Open Sharing

With research funding, continuous input, scientific activities, scientific data and data sharing frequency are rapid. The need for the open research data service has given a steady build-up, especially, in data infrastructure, data journal and data paper.

The ministry of science and technology of China (MOST) and the ministry of finance of China (MOF) made optimization and adjustment on the basis of the national scientific and technological resource sharing service platform in 2019. In order to improve or establish scientific data centers, China has renewed and built 20 national scientific data centers[3] (table 2.1). For example, the National Microbiology Science Data Center built by the Institute of Microbiology, Chinese Academy of Sciences (CAS), has gathered more than 2PB data resources in the field of Microbiology, with more than 4 billion data records[4].

According to the policy of data management and sharing from MOST, the Computer Network Information Center of CAS launched an integrated scientific data center network with the construction "General Center—Discipline Center—Institute level Center" to guarantee the security system, operation system and evaluation system. Based on the above policy and the practical experience, CAS has published its policy of data management and sharing (trial proposal). At present, the construction including 1 general center, 18 discipline centers and 16 institute level centers, has been preliminarily established to provide the basis for collection and management, security sharing and analysis services[5].

TAB. 2.1 – Overview of National Science Data Center.

No.	National platform	Supporting institution	Competent authority
1	National HEP Data Center	Institute of High Energy Physics, Chinese Academy of Sciences	Chinese Academy of Sciences
2	National Genomic Data Center	Beijing Institute of Genomic, Chinese Academy of Sciences	Chinese Academy of Sciences
3	National Microbiology Data Center	Institute of Microbiology, Chinese Academy of Sciences	Chinese Academy of Sciences
4	National Space Science Data Center	National Space Science Center, Chinese Academy of Sciences	Chinese Academy of Sciences
5	National Astronomical Data Center	National Astronomical Observatories, Chinese Academy of Sciences	Chinese Academy of Sciences
6	National Earth Observation Data Center	Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences	Chinese Academy of Sciences
7	National Arctic and Antarctic Data Center	Polar Research Institute of China	Ministry of Natural Resources

TAB. 2.1 – (continued).

No.	National platform	Supporting institution	Competent authority
8	National Tibetan Plateau Data Center	Institute of Tibetan Plateau Research, Chinese Academy of Sciences	Chinese Academy of Sciences
9	National Ecosystem Science Data Center	Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences	Chinese Academy of Sciences
10	National Materials Corrosion and Protection Data Center	University of Science and Technology Beijing	Ministry of Education
11	National Cryosphere Desert Data Center	Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences	Chinese Academy of Sciences
12	National Metrology Data Center	National Institute of Metrology, China	State Administration for Market Regulation
13	National Earth System Science Data Center	Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences	Chinese Academy of Sciences
14	National Population Health Data Center	Chinese Academy of Medical Sciences	National Health Commission
15	National Basic Science Data Center	Computer Network Information Center, Chinese Academy of Sciences	Chinese Academy of Sciences
16	National Agriculture Science Data Center	Agricultural Information Institute of CAAS	Ministry of Agriculture and Rural Affairs
17	National Forestry and Grassland Data Center	Institute of Resource Information, Chinese Academy of Forestry	National Forestry and Grassland Administration
18	National Meteorological Data Center	National Meteorological Information Center	China Meteorological Administration
19	National Earthquake Data Center	China Earthquake Networks Center	China Earthquake Administration
20	National Marine Data Center	National Marine Data Information Center	Ministry of Natural Resource

On other counts, the number of data papers in China is growing rapidly. From 2014 to 2020, the total number of data papers in China reached 702, accounting for 8.80% of the total number of data papers in the world. China has published 237 data papers in 2020, accounting for 33.76% of the world publications, making it the year with the largest number of data papers published (figure 2.3).

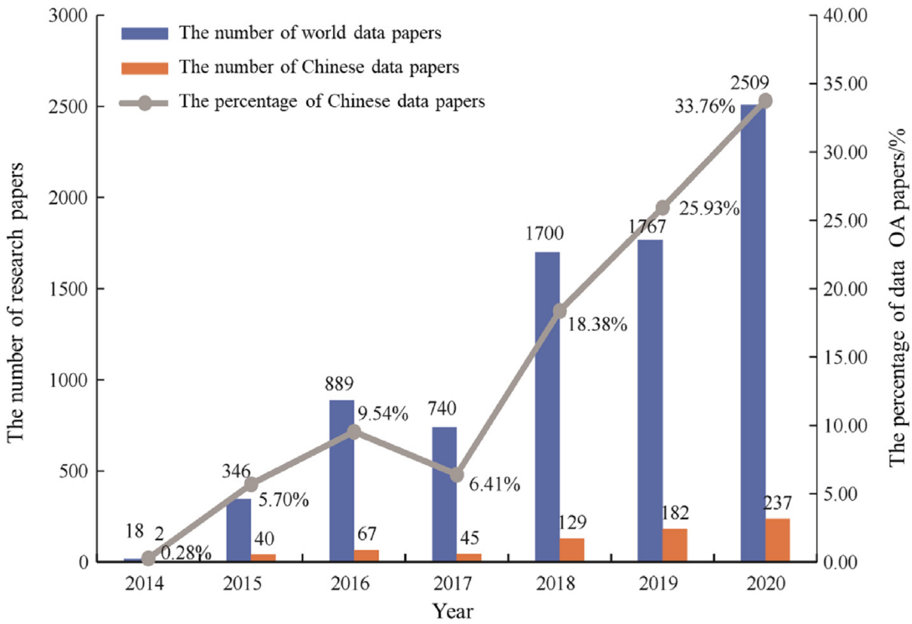

FIG. 2.3 – Number and proportion of world data papers and China data papers from 2014 to 2020.

Since 2012, China has successively established four data journals, namely *GigaScience*, *China Scientific Data*, *Journal of Global Change Data & Discovery* and *Big Earth Data* (table 2.2).

TAB. 2.2 – Overview of Chinese data journals.

Name	Foundation	Organizer	Discipline	Introduction
GigaScience	2012. July	BGI Group BioMed Central	Life Science	The journal adopts a new model combining standard full-text literature, database information and information analysis tools to provide researchers with free and open effective data, biological discoveries and other resources. We are committed to data opening and publish data sets of unpublished research results for use by other research projects.[6]

Tab. 2.2 – (continued).

Name	Foundation	Organizer	Discipline	Introduction
China Scientific Data	2015. August*	Computer Network Information Center, Chinese Academy of Sciences	Multidisciplinary	The journal has carried out preliminary practice and innovation in platform construction, content integration, communication channels and knowledge services, so as to provide reference experience for the network innovative publishing of scientific and technological journals and the development of media integration.[7]
Journal of Global Change Data & Discovery	2017. March (trial since 2014)	Institute of Geographic Sciences and Natural Resources Research, CAS The Geographical Society of China (GSC)	Earth Science	The journal publishes data papers related to scientific data (entity data), and constructs a new model of integrated publication of metadata, entity data and data papers for global change scientific research; Both Chinese and English are published in the same journal, with the same DOI, charts, page numbers, references, etc.[8]
Big Earth Data (BEDJ)	2018. February	Institute of Remote Sensing and Digital Earth, CAS	Earth Science	By publishing articles on various fields of Geoscience, the journal promotes data openness and sharing, promotes the development of sharing, processing and analysis technology of geoscience related big data, creates new theories and methods, and develops and innovates people's cognition and understanding of the earth system. The journal not only publishes research articles, review articles and newsletters related to global big data, but also publishes data papers to encourage authors to promote data sharing and utilization by storing data and algorithms in recognized public memory.[9]

Note: *China's first data journal with CN number.

The increasing number of open data in China has provided high-quality data resources for data publishing to enrich research materials for world scientists. One of the next phases is to gradually bring data publishing into China's STM journals, based on existing infrastructure and practical experience[10]. At the same time, the construction of CAS is realizing deeper data mining and wider data sharing[11].

2.1.1.3 Open Science Infrastructure

Institutional repository is a part of the open access practice, and is the main foundation of the world open access movement; it is therefore the important and indispensable part of global open science. Until July 2021, China has 54 institutional repositories included in the directory of open access repositories (OpenDOAR). They are affiliated to research institutes, universities, and individual companies (table 2.3). They store documents that are mainly journal articles, followed by dissertations and conference articles.

TAB. 2.3 – China's institutional repository in OpenDOAR.

No.	Institutional name	Amount	No.	Institutional name	Amount
1	Chinese Academy of Sciences	39	9	Lanzhou University of Finance and Economics	1
2	OAlib	1	10	Southern University of Science and Technology	1
3	Peking University	1	11	Tsinghua University	1
4	Beijing University of Science and Technology	1	12	Xiamen University	1
5	Fujian Normal University	1	13	Xi'an Jiaotong University	1
6	Guangxi University for Nationalities	1	14	Party School of the CPC Gansu Provincial Committee (Gansu Institute of Administration)	1
7	National Natural Science Foundation of China	1	15	China Europe International Business School	1
8	Science and Technology Development Center of the Ministry of Education	1	16	First Institute of Oceanography, Ministry of Natural Resources	1

Note: The sort is according to the number of institutional repositories; there are no statistical data on Hong Kong, Macao and Taiwan areas.

The open resource platform can provide users with centralized, convenient and free query, statistics, download and other services, which are conducive to promoting sharing and utilization of open resources. At present, China's open resource platform mainly focuses on integrated journal articles (table 2.4).

TAB. 2.4 – China's open resource platform (part).

Name	Organizer	Description
National Social Sciences Database	Chinese Academy of Social Sciences Library	The platform was launched on July 16, 2013. It aims to build the largest database of public welfare social science journals and the largest social science open access platform in China, to realize the open sharing of academic resources, provide strong basic conditions for academic research, promote the social dissemination of academic achievements, and promote the prosperity and development of Chinese philosophy and social sciences.[12]
Science Paper Online	Ministry of Education PRC	Using modern information technology means, Chinese scientific and technological articles online break the concept of traditional publications, eliminate the traditional procedures of evaluation, modification, editing and printing, provide a convenient and fast communication platform for scientific researchers, and provide an effective channel for timely publication of achievements and new ideas, to promote new achievements and exchange scientific research and innovation ideas in a timely manner.[13]
National Science and Technology Journal Open Platform	Institute of Scientific & Technical Information Centre	The platform is positioned as "public welfare, open sharing and authoritative high-quality products", and takes the open integration of domestic scientific and technological journals as the way to gather more than 1000 domestic academic journals (core journals account for more than 70%), with more than 5 million articles. Fully relying on the resources of China Institute of science and technology information, it has realized the full integration of article citations, multi-angle display of statistical analysis, provided instant one-stop access services for scientific and technological personnel, and comprehensively promoted the dissemination and utilization of Chinese scientific and technological articles.[14]

Tab. 2.4 – (continued).

Name	Organizer	Description
GoOA	National Science Library, CAS	The open access article one-stop discovery platform is an open access journal service platform initiated by the Chinese Academy of Sciences and implemented by the literature and information center of the Chinese Academy of Sciences. It integrates 2570 strictly selected journals, 472 open access publishing houses, 591 777 open access articles, and provides open access journals and articles' integrated discovery, free download, and open access journal submission analysis, besides feature functions such as association retrieval, knowledge map analysis and user sharing.[15]
Socolar	China Education Books Import and Export Co., Ltd.	SOCOLAR open access one-stop retrieval service platform is a nonprofit project, which aims to provide users with a public service platform for open access resource retrieval and full-text link services.[16]
CNKI Open Access Aggregator	TSINGHUA TONGFANG Co., Ltd.	On the basis of global open access resources, we are committed to breaking through the constraints of disciplines, geography, language and other factors, providing users with a large number of open access resources through resource integration, intelligent retrieval, knowledge organization system interoperability and other related technologies, so that users can understand the research situation of peers and the development trend of disciplines at the lowest cost, and perceive the development trend of the current international open access movement. At the same time, we promote academic exchanges and knowledge sharing, contribute to the sound development of open science ecosystem, and improve the visibility and accessibility of global open access resources.[17]

In order to promote openness and internationalization of publishing, China's publishing industry began to explore new publishing platforms and build different types of open publishing platforms (table 2.5).

TAB. 2.5 – China open publishing platform (part).

Name	Organizer	Description
SciEngine	Science Press Chinese Academy of Sciences	China's first self-developed R&D service platform integrating the whole process digital publishing and international dissemination, fully using the experience of advanced publishing organizations abroad, has advanced, open, seamless docking features, and has reached the international advanced level of functions and technologies.[18]
Digital Twin	Beijing University of Aeronautics and Astronautics F1000	The platform allows all research results to be published in an open access manner, combining the advantages of preprint and peer review. It provides researchers with an open and transparent publishing experience. It uses the mandatory data policy to realize the comprehensive access to the source data of research results. At the same time, digital twin technology research covering various forms is realized, including research articles, research schemes, registration reports, data descriptions, case studies, etc.[19]

Chinaxiv is the first pre-print platform in China. According to the international standard of preprint, most of the posted academic articles that have not yet been peer reviewed, almost focus on frontier, newest, official research results[20]. Until July 2021, the total number of articles has reached 15 050. Chinaxiv has also established many instances with academic groups, universities and government departments (table 2.6).

The open science infrastructure has attracted a lot of attention. For the service to scientists' entire research lifecycle, their content is constantly enriched and their technical application is upgraded. They are connecting with China's STM journals for double-win results.

2.1.1.4 Scientific Activities of Public Engagement

China's university library arranges a series of countrywide innovation competitions. Peking University Library and the Department of Information Management of Peking University hold this competition every two years, which is jointly sponsored by the Big Data Development of the National Information Center and Beijing Information Resource Management Center[21]. Both in 2017 and 2019 competitions attracted 1193 teams and 3596 students from national universities, research institutes and social public, covering more than 200 universities and 56 disciplines[22]. The event was successfully held for the third time in 2021.

TAB. 2.6 – China's pre-print platform (part).

Name	Organizer	Description
Chinese Psychology Preprint Platform	Institute of Psychology, CAS	The Institute of psychology of the Chinese Academy of Sciences and Chinaxiv jointly supported the global exchange of psychological preprints
China Bioengineering Preprint Publishing Platform	Chinese Society of Biotechnology	Chinese Society of Biotechnology and Chinaxiv jointly built to support global biological preprint exchange
Rock and Soil Mechanics Preprint Platform	Rock and Soil Mechanics, CAS	Rock and Soil Mechanics, CAS and Chinaxiv jointly built to support global mechanics preprint exchange
Chinese Phonomuse. Chinaxiv.org	Center for Chinese Linguistics PKU	Center for Chinese Linguistics PKU and Chinaxiv jointly built to support global phonomuse preprint exchange
Chinese Library and Information Science Preprint Platform	National Science Library, CAS	Chinese Library and information science scholars support the global exchange of preprinted copies of Library and information science
Guizhou Academic Preprint Platform	Department of Science and Technology in Guizhou Province	Guizhou Provincial Department of science and technology and Chinaxiv jointly built to support the academic exchange of preprinted copies in Guizhou Province

China's public library calls for citizen science activities. The open data competition for the whole society was sponsored by Shanghai Library based on the data service platform that solicits mobile application product prototypes or service ideas from citizens.[23] The competition is held once a year since 2016. It has been successfully held five times, gathering a number of data maker teams and accumulating a large number of excellent works and creativity[24].

The Ministry of Science and Technology of China (MOST) sponsored the China Innovation Challenge since 2016. The competition focuses on the industry–university–research institute collaboration in order to develop the regional high-quality economic society. It has been successfully held five times[25].

Publisher and Internet content provider built the Chinese Massive Open Online Courses, namely the China's University MOOC that was officially launched in 2014. The Higher Education Press cooperates with the NetEase company to make this open education resource platform. The Ministry of Education of China (MOE) supports the National Excellent Courses from well-known universities in China. Until August 2021, the platform has participated in 450 institutions and launched 1317 series courses[26].

2.1.2 China's Open Science Actors

2.1.2.1 Researchers

Scientist plays a role of publicity and guidance in promoting open science. Scientists are also the pioneers and practitioners. Chapter 3 includes expert interviews. Here is a brief introduction of the history of open science of Chinese researchers.

Chinese researchers publicize and support open science by publishing relevant academic articles, participating in international activities, carrying out subject research, putting forward policy suggestions, organizing meetings and forums and participating in open science practice (figure 2.4).

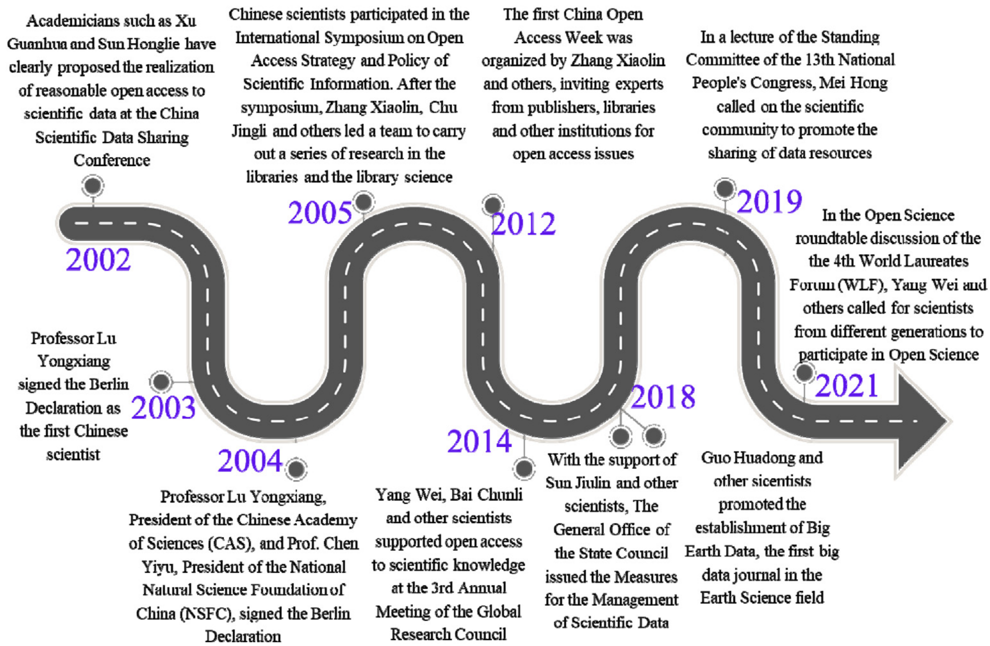

FIG. 2.4 – Representative researchers in China's open science movement (part).

2.1.2.2 Funding Agencies

Funding agency plays a role in cultivating young talents and in promoting open science. China's funding agencies support research projects related to open science (table 2.7), making rule of open access policies, establishing institutional repository, organizing open science theme seminars and participating in international conferences, so as to provide important support for China's open science development.

TAB. 2.7 – Research projects of open science supported by NSFC.

Projects	Start year	Principal investigator	Undertake institution
Research on scientific research data governance under the concept of open science	2017	Guifeng LIU	Jiangsu University
Research on open sharing mechanism and Countermeasures of scientific data under open science environment	2018	Xiaoping SHEN	South China Normal University
Research on data ethics and governance based on "open science"	2019	Miao LIAO	Changsha University of Technology
Research on key problems and platform construction of unified discovery of open science dataset	2020	Jiming WANG	Peking University
Research on data librarian service mode in open science environment	2021	Liping GU	Chinese Academy of Sciences
Research on the service mode of Library Promoting Open Science from the perspective of collaborative governance	2021	Wei YU	Nanjing University
Research on the integration of STM journal industrial chain for open science	2021	Jie XU	WuHan University
Research on collaborative innovation mode and operation mechanism between intelligence institutions and think tanks in open science environment	12021	Changwei HUANG	Harbin University of Commerce
Research on economic value and measurement of open science data	2021	Zhifang TU	Chinese Academy of Sciences

2.1.2.3 Universities and Research Institutions

Universities and research institutions have accumulated rich experience in the publicly funded research to open access. They built up institutional repositories, encouraged faculty members to submit research articles to high-quality open access journals, and some integrate open science into their development strategy.

For example, Tsinghua University launched the "open science support plan" as one of academic affairs[27]. Institute of Scientific and Technical Information of China (ISTIC) and Springer-nature company announced the establishment of ISTIC- Springer Open Science Joint Laboratory[28].

2.1.2.4 Publishers

Publishers are an important carrier as the open science enterprise in China. Although Chinese publishers have not yet a common understanding of open science, they have different explorations. The Science Press has made a striding practice of open publishing.

With Elsevier, it has established the Beijing Keai Senlan Culture Communication Co., Ltd. (as "KeAi") in 2007 in order to forward the internationalization of Chinese-English STM journals. The KeAi has created a number of high-level open access journals since 2013, has disseminated China excellent research achievements in the world[29].

2.1.3 China's Open Science Policies

In September 2020, UNESCO submitted the draft of UNESCO open science recommendation to 193 member countries[30]. The draft and its next official document in March & May 2021 have shown that one of the recommendations is the member states should reform their legal policy to support open science.

China has open access policies, data management and sharing policy, STM infrastructure policies and Public STM resource policies. In December 2021, The National People's Congress of the People's Republic of China has published the 4th law for science and technology progress. The 95th article of the law is about promoting open science and developing STM journals. This is the first country in the world that adds the article of open science in the national law after the UNSECO open science recommendation.

2.1.3.1 Open Access Policies

At the press briefing of the 2014 Beijing meeting of the Global Research Council held on May 15, 2014, the Chinese Academy of Sciences (CAS) and the National Natural Science Foundation of China (NSFC) jointly issued each of their own open access policies: the "policy statement of the CAS on the implementation of open access for articles published by publicly funded scientific research projects" and the "policy statement of the NSFC on open access to research articles of funded projects".

The two policies declare that scientific achievements and research articles funded by the public should deposit the final peer-reviewed manuscript of the article in the corresponding institutional repositories and implement open access within 12 months after publication[31].

The two policies are issued in the form of policy statements. Although the two institutions can only represent their own institutions, their scope covers almost the whole country. The content of the policy supports green open access and promotes China's open access work. In addition, the open access policy of the CAS has the following contents: ① support public funded scientific research projects to publish articles in open publishing academic journals with reliable quality control and reasonable cost; ② Establish a selection guide for open publication academic journals that can be funded for publication; ③ The experiment supports the transformation of influential academic journals of the CAS into open publication journals. The part of golden open access is experimental, so it is more appropriate to point out a development direction in the policy statement.

In May 2015, the NSFC officially operated the "Basic Research Repository of National Natural Science Foundation of China" and issued the detailed implementation guideline, including the general provisions, terminology, content (deposited content, deposited version), submission, use, interoperability, intellectual property rights and disclaimer[32].

The Suzhou Declaration On Open Access in October 2012 was jointly adopted by the Journal of Library and Information Work and other journals in the field of library and information science. This declaration has given the proposal to encourage journals to publish open access articles, encourage authors to deposit their articles on time in the institutional repository, within a 12-month or shorter embargo period, and to encourage university and research institutions to actively explore new models of open publishing and to enhance collaboration in the field of open access[33].

2.1.3.2 Data Sharing and Management Policies

In March 2018, the General Office of the State Council promulgated the "measures for scientific data management"[34], marking China's formal strengthening and standardization of scientific data management at the national level[35]. From 2018 to 2020, there are totally 22 provinces, autonomous regions and cities that have issued their implementation details for following the policy, as at the country regional level. In 2019, the research institutes issued the "Scientific Data Management and Sharing of Chinese Academy of Sciences (trial measures version)"[36] and "Scientific Data Management and Sharing of the Chinese Academy of Agricultural Sciences (CAAS)"[37] at the institutional level.

2.1.3.3 STM Infrastructure Policies

In 2004, the Ministry of Science and Technology of China (MOST), the National Development and Reform Commission (NDRC), the Ministry of Education (MOE) and the Ministry of Finance (MOF) jointly issued the outline for the construction of the national science and technology infrastructure platform, from 2004 to 2010 for the welfare of the whole society and to improve the ability of STI (scientific and technological innovation)[38].

In 2015, the State Council issued its guidance on the opening of national major scientific research infrastructure and large scientific research instruments to the society. This opinionated guidance indicated that the STM facilities and instruments should be accelerated to the society for improving the utilization efficiency of their resources[39].

In 2017, the MOST, NDRC and MOF issued measures for the administration of the national science and technology resource sharing service platform. The measures emphasize full release of the service potential and improvement in the use efficiency[40].

In October 2018, the MOST and MOF issued measures for the management of the national scientific and technological resource platform that requires to make guidelines and to open for citizen society, in order to deeply implement China's national innovation driven development strategy[41].

2.1.3.4 Public STM Resource Policies

In May 2015, the State Council issued the "Notice of the State Council on printing and distributing the action platform for promoting the development of big data"[42], which called for accelerating the opening, sharing and circulation of data resources, strengthening the application of data resources in various fields and promoting industrial transformation and upgrading.

In 2016, the Ministry of Education (MOE) issued the "Action plan for promoting the transfer and transformation of scientific and technological achievements in colleges and universities", which proposed to provide innovative and entrepreneurial social groups with opening the data, articles and other education resources, and provide information related to scientific and technological achievements, so as to strengthen the open sharing of innovation resources in colleges and universities[43].

In 2019, The "opinion on deepening reform and cultivating world-class STM journals" required China STM journals to advance digitization, professionalization, collectivization and internationalization, in order to build up an open, innovative, collaborative and world-class China STM journals system[44].

In addition to STM journals and data sharing, the continuously cultivated open research culture has also laid a good foundation for the development of open science[45].

2.1.4 China's Open Science Paths

In 2014, in his keynote speech at the International Conference on Engineering Science and Technology, President Xi pointed out that "the development of science and technology is a strategic choice for mankind to meet global challenges and achieve sustainable development"[46].

The development and evolution of open science is inseparable from various stakeholders. Chinese government departments, funding agencies, universities and research institutions, scientists and scientific community, publishers, enterprises, the public and many other social groups are participating in the development process of open science.

2.1.4.1 Researcher Keeps the Role of Open Science Promotion

The highest mission of scientists engaged in scientific research is to increase social welfare and promote the progress of human civilization. The researcher is not only a contributor to science, but also a beneficiary of science. Therefore, the researcher is the core of open science. Its recognition and recognition of open science plays a decisive role in the development of open science.

Most researchers in China begin their cognition of open science with open access. With the continuous expansion of the global open access movement, Chinese researchers' attitude towards open access has also changed greatly, and their overall cognition has gradually improved (table 2.8) from the initial ignorance to being misled by the name of open access, which is essentially "predatory journals" (journals with unreasonable APC pricing) or "bottom-up journals" (journals with lax article review process and quality control), and holding a negative attitude towards open access. Then there is the awareness of open access, but there are many concerns about copyright infringement, data security and funding. With the institutional repository and open publishing journals gradually becoming an important way of academic communication and exchange, Chinese researchers began to participate in the practice of open access more and more, upload their scientific research achievements to the institutional repository and pay APC to publish open publishing articles.

According to the statistical data in section 2.2 of this chapter (figures 2.1 and 2.2), in the past 10 years, the average annual growth rate of open publishing articles in China is 32.43%, higher than that of global open publishing articles (21.30%). Among them, the total number of articles published in China in 2020 was 165 493, accounting for 25.58% of the articles published in China in the whole year.

TAB. 2.8 – Cognitive changes of Chinese researchers on open access (%).

Awareness of OA	Survey in 2005 (64/223 samples)[47]	Survey in 2014 (287 samples)[48]	Survey in 2020 (101 samples)[49]
Very well	3.00	3.83	8.91
Better understanding	–	15.33	32.67
General understanding	45.00	34.84	30.69
I don't know much	–	27.53	18.81
Not at all	52.00	18.47	8.91

Compared with open access, Chinese researchers are more proactive in recognizing and supporting open research data, which is mainly based on the urgent needs of researchers for data sharing after entering the information age. As early as 1994, a group of scientists from the Chinese Academy of Sciences wrote reports to relevant state departments, requiring data sharing[50]. Later, after long-term brewing and pilot construction, in 2018, with the support of academician Sun Jiulin and other scientists, the General Office of the State Council issued the measures for scientific data management. In 2019, Springer-nature and the National Science Library of CAS jointly conducted a survey on data sharing among more than 2000 researchers in China. The results show that 93% of researchers have formulated data management plans, and half or more of them said that they are to ensure effective data management and good practice in research[51]. Therefore, the vast majority of Chinese researchers have long recognized the importance of open research data for scientific and technological work, and actively promoted and participated in the policy-making and practical development of open data.

There are significant differences in the needs, cognition, attitude and behavior of Chinese researchers for open science and its main contents. In 2019, Zhao Yandong and others showed in the conference report of the 8th China open access week that through preliminary interview and research on more than 30 researchers and education institutions, they learned that the respondents have low awareness of the specific connotation of open science.

In addition to being familiar with open access, open data and open source software, they are also familiar with other forms of practice, but the open evaluations are relatively unfamiliar. Among them, geoscience, astronomy and other disciplines that are highly dependent on data resources have a higher awareness of open data, and computer disciplines are also familiar with the frequent use of open source software.

2.1.4.2 Funding Agencies and Government Departments Support Infrastructure and Data Sharing

The open sharing of scientific data infrastructure is a key step to realize open science, especially the accessible, usable, evaluable and understandable data are an important foundation of open science[52]. In 2004, the General Office of the State Council forwarded the "outline for the construction of national science and technology basic conditions platform from 2004 to 2010" issued by the Ministry of Science and Technology (MOST) and other departments, requiring the construction of a national science and technology basic conditions platform with resource sharing as the core.

In 2019, the original 28 national science and technology resource sharing service platforms were optimized and adjusted to form 20 national science data centers and 30 national biological germplasm and experimental material resource libraries, in order to realize standardized management. These platforms, together with major scientific research infrastructure and large scientific research instruments, will be integrated and managed by China Science and Technology Resource Sharing Network (CSTR), forming a nationwide logical unity, with high integration.

The efficient sharing of CSTR effectively promotes the overall management and sharing services of scientific and technological resources, and realizes the platform concept of information sharing driving physical sharing[53].

The development of the open science infrastructure and open data has always been led by national government departments, and implemented by provincial, district and municipal governments and key universities and research institutions. This top-down development process is fast and effective, providing a strong boost to open science.

2.1.4.3 Universities and Research Institutions Establish the Foundation of Open Science Practice

The development of open access directly affects the process of open science. In 2003, academician Lu Yongxiang signed the Berlin Declaration on behalf of Chinese scientists; In 2004, the National Natural Science Foundation of China (NSFC) and the Chinese Academy of Sciences (CAS) signed the Berlin Declaration.

In 2004, The HKUST (Hong Kong University of Science and technology) library established its institutional repository and metadata integrated system. In 2006, Xiamen University library established the first institutional repository in Chinese version; In 2007, the National Science Library of CAS and the Institute of mechanics of CAS piloted the construction of institutional repository, and then started the large-scale construction of the whole Academy.

In 2013, CAS built the largest institutional repository cluster in China. In 2014, the NSFC and CAS issued open access policies, respectively, which provided clear policy guidance for the development of open access in China. In the same year, on behalf of China, the NSTL (National Science and Technology Literature Center) joined the International Open Publishing Support Alliance for High Energy Physics ($SCOAP^3$) to jointly support the conversion of journal articles in the field of high energy physics to open publishing with major scientific and technological countries in the world.

In 2017, the National Science Library of CAS took the lead in signing the intention letter for the OA2020 initiative to achieve large-scale open access to journal articles. Open Access movement in China is from individuals to institutions and then to the country-wide science community.

2.1.4.4 Publishers Explore Their Innovation in the Open Science Environment

As an important link in the exchange and dissemination of academic achievements, publishers are the most active actors directly affected by open science and there is a need to make changes.

In the early phase, Chinese publishers had the initial concern about a series of challenges brought by open access, such as the reduction in periodical circulation and income, copyright infringement and the loss of manuscript sources[54]. In the recent years, they gradually changed into adopting the form of "free access" according to local conditions, based on Chinese local conditions and scientific research needs, combined with the current situation of periodical development, to promote the open sharing of publications.

Free access often publishes the published article results on the journal website for free, so that the majority of readers can quickly obtain the latest scientific and technological literature in this field, further improve the influence of the journal and attract more manuscript sources[55]. However, due to the lack of clear open access policy statement and open license agreement, these journals are yet to be the open access journals because of the unstable rights.

In the circle of China STM journals, people often chat two matters: Shall we "take a boat to that ocean" or "build a boat away this harbor"? That means that the developing strategy has at least two options; one is to cooperate with the international publisher group to make itself more internationalized and commercialized in order to face the open science challenge; the other is to enhance the existing digital service to hold more legal rights in the open science environment.

There are many STM journals in China that explore the new service by digital technology. For example, publishers promote data sharing by establishing new scientific data journals, and build a STM journal service platform for whole process digital publishing and international communication[56].

2.2 China's STM Journals in Open Science Environment

In the environment of open science, publishing of China STM journals mainly focuses on open publishing, data publishing and journal evaluation. Open access plays an important role in promoting the visibility of scientific and technological achievements, improving the citation rate of scientific research achievements, and expanding their academic and social influence. In order to publish scientific research data, data journals and data publishing platforms came into being.

The open science environment has at least three influence on China STM journals, namely the open content, data-driven digital inclusion, and the new evaluation direction. Especially, the open content has more and more diversity; on the one hand is the new behavior change of authors, readers and the public and on the other hand is the uncertainty of different license agreements in different situations.

2.2.1 Open Access Content

2.2.1.1 Author-Oriented Open Sharing Policy Statement

According to the types of funding agency, research institutions and universities, the Chinese Academy of Sciences, the National Natural Science Foundation of China and Peking University are selected as cases to introduce their open sharing policies. They focus on the type of achievements, storage location, embargo period, funding form and storage, submission, use and preservation of contents.

On 15 May 2014, The Chinese Academy of Sciences and the National Natural Science Foundation of China issued "the policy statement of the Chinese Academy of Sciences on the implementation of open access for articles published by publicly funded scientific research projects"[57] and "the policy statement of the National Natural Science Foundation of China on open access to research articles of funded projects"[58]; they implemented open access requirements for academic articles written and published mainly by scientific research achievements funded by public funds (table 2.9), and then they published the implementation rules of open access policies of their respective institutional repository[59].

TAB. 2.9 – Open access policy statement of the Chinese Academy of Sciences and the National Natural Science Foundation of China.

Key points	Chinese Academy of Sciences	National Natural Science Foundation of China
Deposit type	Research article	Research article
Submit version	Peer-reviewed final manuscript	Peer-reviewed final manuscript
Deposit location	Repositories of CAS	Basic Knowledge Repository of NNSFC
Embargo periods	12 months	12 months
Depositor	Public funded projects	Funded project from NNSFC whether a part or whole
Open form	Support the public's open access through the Internet	Support the public to retrieve open access content through the network

Note: The policy of CAS has other contents related to open publishing and tracking monitoring.

Most of the open sharing policies of domestic universities are formulated by their libraries or institutional repositories. In September 2016, 17 University Libraries led by Peking University Library jointly established the "Federation of China Academic Institutional Repository (CHAIR)". By the end of July 2021, CHAIR had 51 member institutions[60]. CHAIR advocates that all member institutions formulate and publish open access policies. At present, Wuhan University Institutional Repository[61], Shandong University Institutional Repository[62], Xiamen University Academic Repository[63], Xi'an Jiaotong University Institutional Repository[64], Northwest University of technology institutional repository[65] and others have issued their own open sharing policies. The following focuses on the open access policy of Peking University's institutional repository, which was released earlier.

In July 2013, Peking University issued the institutional repository open access policy (Trial) document[66], which formulated a series of policies on the storage and open sharing of academic achievements of Peking University teachers and researchers. The policies have specific provisions on the content, submission, use, preservation, withdrawal and privacy of academic achievements (table 2.10).

TAB. 2.10 – Peking University's open access policy.

Key points	Content
Deposit type	Books, journal articles, conference articles, dissertations, research reports, data sets, learning objects, preprinted drafts, technical reports, speech introductions, working documents, pictures, audio recordings, software and videos
Deposit require	The author must sign the "authorization agreement of Peking University Institutional Repository", voluntarily submit the results in digital format, and submit the description metadata of the work at the same time
Embargo	Follow the requirements of the publishing house or sponsors
Use	For use for non-profit purposes such as personal learning, teaching and research, the author, title and bibliographic information must be given
Open form	Open to the public online, users can obtain all metadata free of charge, and all contents can be obtained permanently

2.2.1.2 Reader-Oriented Full-Text Online Access

At present, the two main forms of open access to scientific and technological achievements in China are green OA represented by institutional repository and golden OA represented by open access journals.

The open publishing form of articles in institutional repository is the most typical green OA. In response to the open sharing statement, the Chinese Academy of Sciences (CAS) and the National Natural Science Foundation of China (NNSFC) successively established and launched their own institutional repository from 2014 to 2015[67,68]. In the same year, Peking University Institutional Repository 3.0 Version was officially launched[69]. In 2016, the Chinese University Institutional Repository alliance was established[70].

Taking the NNSFC basic research repository as an example, until July 23, 2021, the open publishing achievements in the repository covered eight categories: mathematics, chemistry, life, earth, engineering and materials, information, management and medicine. There are 763 311 open access articles, with 2052 participating research institutions and 789 669 authors (table 2.11). At present, anyone can read and download the full text of all articles published in the basic research repository of the NNSFC for free without registering a special account.

The institutional repository grid of the CAS currently has 114 subordinate units, of which the institutional repository[71] of the Institute of high energy physics currently has the largest amount of uploaded data, views, downloads and user data. Until 23 July 2021, 66 705 published data have been opened in the repository, with 2 304 060 views and 219 963 downloads, and 2266 members (table 2.12). At present, some institutional repositories of the Chinese Academy of sciences are only open to internal personnel of various research institutes. Users need to log in with their internal account to read and obtain the original text.

Tab. 2.11 – Release of basic research repository of NSFC.

Division basis	Classification	Data volume/Item
Discipline field	Mathematical Science	81 388
	Chemistry Science	77 090
	Life Science	84 921
	Earth Science	72 421
	Engineering and materials Science	146 792
	Information Science	120 404
	Management Science	59 503
	Medical Science	117 898
Research field	Control theory and technology	8207
	Inorganic nonmetallic semiconductors and information functional materials	4946
	Coordination chemistry	4161
	Mechanical kinetics	3822
	Structural engineering	3580
	Catalytic chemistry	3430
	Agricultural and forestry economic management	3429
	Remote Sensing Science	3404
	Computer image and video processing and multimedia technology	3360
	Crop genome and genetics	3120
Publish journals	*RSC Advances*	4499
	Scientific Reports	3812
	PLoS One	3158
	Journal of Alloys and Compounds	2011
	Applied Physics Letters	1652
	Chinese Physics B	1545
	Chemical Communications	1529
	Oncotarget	1479
	Optics Express	1474
	Applied Surface Science	1466
Funding type	General items	356 059
	Youth Science Foundation Project	211 883
	Regional Science Foundation Project	49 903
	Key projects	19 331
	Joint fund project	6171
	National Science Foundation for Distinguished Young Scholars	5955
	Excellent Youth Science Foundation Project	4201
	Major research plan	3594
	Innovation research group project	3450
	Major projects	3275

TAB. 2.12 – Institutional repository of Institute of high energy physics, CAS.

Document type	Data volume/Item	Rate/%
Conference articles	32 821	49.20
Dissertation	2298	3.44
Journal article	27 021	40.51
Patent	345	0.52
Monograph	210	0.31
Presentation report	78	0.12
Award winning achievements	37	0.06
Research report	1	0.00
Other	3894	5.84
Total	66 705	100

Most journals included in DOAJ do not charge APC (84 kinds), accounting for 58.74% of the total. The price of APC publications varies from 100 to 25 000 yuan, with an average price of 5333 yuan. APC pricing of Chinese Open Access Journals (page/yuan) is mostly 4000 ~ 6000 yuan. Among them, 13 journals have APC pricing of $P < 2000$, that 8 journals have APC pricing of $2000 \le P < 4000$, that 18 journals have APC pricing of $4000 \le P < 6000$, that 13 journals have APC pricing of $6000 \le P < 8000$, and that 7 journals have $P \ge 8000$. Therefore, in addition to the high price of individual APCs, the APC price of Chinese open access journals included in DOAJ is lower than the average APC price of global fully open access journals (9721 yuan).

DOAJ has included Chinese open access journals since 2008. New journals are included every year, but the number of new journals fluctuates (figure 2.5). Among them, in 2020, the newly added journals reached 33 that is the highest value than before, accounting for 23.08% of the total number of journals included in DOAJ.

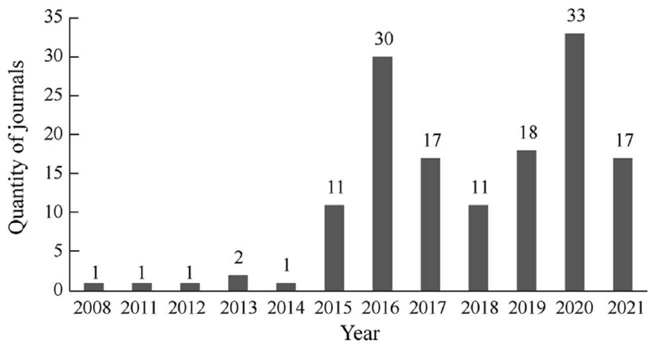

FIG. 2.5 – The number of new Chinese journals included in DOAJ from 2008 to 2020.

Until July 2021, the total number of articles published by Chinese journals included by DOAJ is 51617 items[3]. There are 11 journals with a total number of more than 1000 articles (table 2.13). There are 23 896 articles published by 11 journals, accounting for 46.29%. Among them, the journal with the largest number of articles is "International ophthalmology (English)" (4250 articles), accounting for 8.23%. According to the statistical results of the 2020 edition of the annual report on the impact factors of Chinese academic journals, the impact factors of the above 11 journals are 0.587 ~ 5.084, and the average impact factor is 2.139.

TAB. 2.13 – Journal information with a total number of more than 1000 articles in Chinese journals included by DOAJ.

Journal name	Articles/Item	Impact factor	Date of accession	Update date
International Eye Science	4250	0.879	2017-01-23	2017-01-23
Chinese Journal of Clinical Hepatology	3233	1.556	2017-02-24	2017-02-24
Journal of Hainan Medical University	3103	1.393	2018-01-08	2018-01-08
International Journal of Ophthalmology	2210	0.587	2016-11-11	2016-11-11
Chinese Journal of Lung Cancer	2152	2.131	2008-06-05	2020-02-18
Chinese Journal of Contemporary Neurology and Neurosurgery	2081	1.265	2013-04-03	2020-09-02
Chinese Journal of Aeronautics	1665	1.256	2016-01-07	2021-05-20
Acta Geodaetica et Cartographica Sinica	1418	3.548	2014-09-12	2021-05-25
Petroleum Exploration and Development	1333	5.084	2018-11-09	2021-01-26
Journal of Materials Engineering	1278	1.632	2016-10-12	2016-10-13
Geoscience Frontiers	1173	4.202	2016-12-01	2021-01-26
总计	23 896	–	–	–

The statistical results show that most of the Chinese journals included in DOAJ are medical journals (41), followed by engineering (28), chemistry (8), and Agricultural Science (8) (table 2.14)[4].

The Chinese journals included in DOAJ in China are shown in table 2.15[72]. The open license agreements adopted by these journals include CC BY, CC BY-SA, CC BY-NC, CC BY-NC-ND and the publisher's own agreements. The APC pricing ranges from 0 to 8000 yuan (the APC unit of some journals is US dollars). Since joining DOAJ, there have been

[3]Since most journals have not updated their number of articles on DOAJ website in time after being included by DOAJ, the total number of articles published is lower than the actual total number of articles published by journals.

[4]Retrieval time: July 8, 2021; Retrieval method—Scopus advanced retrieval; Publication time (2011 ~ 2020); Then, select countries (China/all) in the faceted navigation box of the search result interface; Document type (data article).

Tab. 2.14 – Discipline distribution of Chinese journals included in DOAJ.

No.	Discipline	Kind	No.	Discipline	Kind	No.	Discipline	Kind
1	Medical Science	41	10	Computer Science	4	19	Biochemistry	1
2	Engineering	28	11	Physics	3	20	Astronomy	1
3	Chemistry	8	12	Geology	3	21	Astrophysics	1
4	Agricultural Science	8	13	Basic Sciences	2	22	Library Information and Bibliography	1
5	Geography	6	14	Social Sciences	2	23	Agriculture and Environment	1
6	Multidisciplinary	6	15	Oceanography	2	24	Medical Geography	1
7	Technology	6	16	Pharmacy	2	25	Language and Literature	1
8	Biology	6	17	Military Science	1	26	Botany	1
9	Environmental Science	5	18	Arts	1	27	Zoology	1

Note: Sort by number of discipline journals.

Tab. 2.15 – Chinese (including Chinese and English) journals in DOAJ.

No.	Name of journal	Language	License type	APC/Yuan	Join time	Number
1	Journal of Clinical Hepatobiliary Diseases	CN	CC BY-NC-ND	2500	2017-02-24	3233
2	Chinese Journal of Lung Cancer	CN	CC BY	1000	2008-06-05	2163
3	Chinese Journal of Modern Neurological Diseases	CN&EN	CC BY	600 USD	2013-04-03	2082
4	Journal of Surveying and Mapping	CN	CC BY-NC-ND	600	2014-09-12	1418
5	Petroleum Exploration and Development	CN	CC BY-NC-ND	0	2018-11-09	1333
6	Journal of Material Engineering	CN	CC BY-NC	2400	2016-12-12	1278
7	Journal of Application of Electronic Technology	CN	CC BY-NC	1696	2018-12-13	947

Tab. 2.15 – (continued).

No.	Name of journal	Language	License type	APC/Yuan	Join time	Number
8	Journal of Shanghai Normal University (Natural Science Edition)	CN&EN	CC BY-SA	100	2015-08-28	907
9	Journal of the Third Military Medical University	CN	CC BY	0	2021-03-31	904
10	Prevention and Treatment of Oral Diseases	CN	CC BY	0	2019-05-16	872
11	Research on Cancer Prevention and Treatment	CN	CC BY	500	2019-07-15	724
12	Journal of Agricultural Resources and Environment	CN	CC BY-NC	2000	2016-10-24	652
13	Chinese Ship Research	CN&EN	CC BY	1200	2017-04-25	645
14	Journal of Northwest University of Technology	CN	CC BY	8000	2021-04-28	559
15	Journal of Hebei University of Science and Technology	CN	CC BY	0	2015-03-12	505
16	Journal of Aeronautical Materials	CN	CC BY-NC	1500	2016-12-12	387
17	Journal of Global Energy Internet	CN	CC BY-NC-ND	0	2019-07-15	242
18	Journal of Spectroscopy	CN	CC BY-NC	1000	2016-12-30	189
19	Isotope	CN	CC BY-NC-ND	200	2015-10-20	163
20	Knowledge Management Forum	CN	CC BY	0	2017-2-10	152
21	Macrolinguistics	CN&EN	CC BY	0	2017-10-6	112
22	Journal of Harbin University of Technology	CN	CC BY	4000	2015-09-11	76
23	Journal of Chinese Tobacco	CN	CC BY	0	2018-01-28	30

Tab. 2.15 – (continued).

No.	Name of journal	Language	License type	APC/Yuan	Join time	Number
24	Journal of Computer Science and Exploration	CN	CC BY-NC	3500	2021-06-24	2
25	Journal of Infrared and Millimeter Wave	CN&EN	CC BY-NC-ND	300 USD	2011-01-04	1
26	Journal of Chinese Oil Crops	CN	CC BY-NC-ND	6000	2021-07-05	0
27	Journal of Crop	CN	CC BY-NC-ND	6480	2021-04-07	0
28	Journal of Aviation Weapon	CN	CC BY	0	2021-03-31	0
29	Journal of Engineering Design	CN	Publisher's own license	3000	2016-12-13	0
30	Journal of Advances in Fishery Science	CN&EN	CC BY-NC	220	2016-03-23	0

19 576 Chinese open access articles (Until 23 July 2021), of which 51.8% are from the field of medical research, there are 17.4% from the research field related to geographical science, followed by the research in the fields of materials science, computer science and engineering. In addition, some university journals have opened access to some articles, There are also some journals and some journals that have just joined DOAJ. At present, the number of articles is small.

2.2.1.3 Publisher-Oriented Open License Agreement

In order to protect the rights and interests of authors of open publishing knowledge creation, it is necessary to apply a certain knowledge sharing license agreement. The following is a brief introduction of the agreement, the most commonly used version and the most widely used version of CC in China.

The initial version of Creative Commons license was released on 16 December 2002, and has undergone several versions since then (table 2.16). In order to make the CC agreement more widely applicable, the general version of CC 3.0 was launched in 2007[73], and each jurisdiction can localize according to its own legal system. In 2013, version 4.0, which is more applicable to the international environment and more situations (such as data sharing), was issued[73], and this version is still used today.

Creative Commons license consists of four authorization elements: attribution (by), shareAlike (SA), NoDerivatives (ND) and NonCommercial (NC) (table 2.17). These elements are combined into six common protocol types. The simplified version of each type of agreement includes three parts: allowable behavior, restrictive behavior and statement. In addition, there is a CC0 (The Creative Commons Public Domain Dedication), which means that the author waives all intellectual property rights of the creation.

TAB. 2.16 – Version of CC.

Version	Release time	Attribute
CC 1.0	2001	General
CC 2.0	2004	General
CC 2.5	2006	General
CC 3.0	2007	Localizable
CC 4.0	2013	Internationalization

TAB. 2.17 – Types and icons of Creative Commons license.

Licensing type	Element	Icon
Attribute	BY	
Attribute-shareAlike	BY-SA	
Attribute-NoDerivatives	BY-ND	
Attribute-NonCommercial	BY-NC	
Attribute-NonCommercial-shareAlike	BY-NC-SA	
Attribute-NonCommercial-NoDerivatives	BY-NC-ND	

In March 2006, the "International Conference on intellectual property and knowledge sharing in the digital age" was held in Beijing. At the conference, China officially signed cooperation with knowledge sharing organizations and released the Creative Commons license[74]. The Chinese mainland project[75], knowledge sharing Chinese mainland project started in 2010, and started localization of CC 3.0 agreement. The agreement shall be amended in accordance with the copyright law of the people's Republic of China and relevant laws and regulations. Chinese mainland version CC 3.0 has adjusted[76] in the following aspects: neighboring rights, databases, original authors, public dissemination, copyright management system, personal rights and non-restrictive clauses in accordance with China's laws and regulations and CC 3.0 compatible with non-localized or other jurisdictions.

Compared with CC 3.0, CC 4.0 has greater improvements and various advantages. Firstly, in terms of text, CC 4.0 is clearer and easier to read. At the same time, on the original basis, more clear restrictions have been added to some unspecified Rights: ① more international license agreement; ② Clarify the rights other than copyright; ③ Signature request adjustment; ④ Improve anonymity; ⑤ Allow 30 days to correct the violation of the license; ⑥ Increase readability; and ⑦ Clarify the difference between BY and BY-NC[77].

In addition, Chinese delegates have also signed two other letters of intent for open access agreements, one is the OA2020 initiative and the other is PlanS. On October 26, 2017, the National Science and Technology Library (NSTL) became the first national institution in China to officially sign the OA2020 Initiative[78,79]. Until 22 July 2021, 17 institutions in China have signed agreements with OA 2020[80]. In early December 2018, a delegation composed of National Natural Science Foundation of China (NNSFC), NSTL and National Science Library CAS (NSL, CAS) attended the 14th Berlin open access conference. At the conference, China clearly expressed its support for OA2020 Initiative and Open Access PlanS, and supported the immediate open access of research articles on publicly funded projects[81].

2.2.1.4 Public-Oriented Open Science Benefit

In the open science environment, open access to academic achievements is becoming a new trend. In 2015, the number of OA articles published in China jumped to the first in the world for the first time[82]. In recent years, more and more academic articles have been published in OA journals at home and abroad, which has increased the visibility of local research results in the world and made it possible to continuously improve the influence of local articles. With the continuous increase in network users, network information resources, social media and tools, the overall impact of OA articles shows a cumulative growth trend[83].

The practice of open access has improved the visibility of local scientific and technological achievements in the world. At the beginning of 2020, COVID-19 broke out, and to open up and share relevant research data globally, many publishers launched COVID-19 column or data backup system to publish academic publishing results for the first time. Studies have shown that nearly 75% of the publications related to covid-19 are open access journals[84]. During the epidemic period, the proportion of international cooperative research and open access publishing increased to a certain extent[85]. In special times, the funding agency not only accelerates the approval progress of relevant research projects, but also actively invites scholars from all over the world to exchange and share. There are 11 public and private institution funded health research worldwide that have open access to covid-19 related research data[86]. The National Natural Science Foundation of China (NSFC) also actively appealed to ensure opening and sharing of data and research results on time[87]. China Academy of Sciences (CAS) launched COVID-19 thematic and knowledge service and research and research platform[88], and the national bioinformation center and other agencies jointly launched the COVID-19 information base[89]. A large number of newly released the protein sequence data of COVID-19, meta information, academic literature, news trends, popular science articles and other information were integrated to carry out genome sequence variation analysis of different coronavirus strains and provide visual display.

Existing studies have shown that open access journals have a significant impact on the dissemination of scientific research results, and researchers increasingly choose to publish research results in open access journals[90]. The survey found that most researchers believe that open access publishing can significantly improve the dissemination speed, dissemination breadth and utilization rate of scientific research achievements. The earlier journals implement open access, the more obvious this impact[91]. In recent years, some scholars have pointed out that open access can improve the visibility, accessibility and utilization of scientific research achievements[92]. It can be seen that the practice of open access can promote the reuse of scientific research achievements, and then enhance the extension and derivation of their value. Open access plays an important role in promoting the benign development of academic exchange system and the sustainable development of science.

Journals are influenced by academic influence, social practice influence, social reputation and reader recognition[93]. With the continuous development and deepening of the open access movement, open access journals have also been developed rapidly. Research shows that many practitioners recognize that open access can speed up the exchange of academic information, improve the reading volume of journals and improve the influence of journals[94]. The inclusion of academic journals on open access platforms (such as DOAJ) helps to improve reputation[95]. In recent years, data publishing has gradually attracted the attention of academic and publishing circles. Some studies have pointed out that data publishing can not only protect the author's intellectual property rights, ensure data quality and preserve data for a long time, but also improve the influence of the data itself[96].

Nowadays, with the continuous development and progress of Internet technology, the types of social media are becoming richer and richer, and the influence of social platforms is also increasing. It is an important medium for disseminating information in the network environment[97]. The increasingly rich social media also plays an important role in the field of academic publishing. They not only provide researchers with a platform for sharing and exchanging academic information and research results, but also provide diversified ways for people to obtain academic resources[95]. For example, Research Gate, WeChat official account and other exchange platforms, because of the large number of users, fast dissemination speed, wide scope and low cost, greatly promoted the promotion of scientific research achievements to all sectors of society, expanded the scope of academic exchanges, and accelerated the speed of knowledge dissemination. New services based on various social media also continue to meet the personalized information needs of different users.

In order to actively respond to the call for open access action, China's funding agency and research institutions release their own open access policies, while colleges and universities take their own libraries as the lead institutions to formulate and deploy open access policies and related work.

In recent years, academic society, library society and publishing society have begun to pay attention to open access publishing. At present, China's open publishing mainly has two forms: Green OA and golden OA. However, at present, the number of open access journals in the real sense of China is still small, for many reasons; However, after more than ten years of development and progress, many journals have gradually adopted open license agreements, and many new journals have been positioned as open access journals at the beginning of their establishment.

2.2.2 Data-Driven Digital Inclusion Services

2.2.2.1 Data Communication Capacity

Data publishing refers to publishing peer-reviewed dataset, data description and metadata on the Internet. Data journal is a new type of the STM journal with the development of information demand and the trend of Internet and scientific data sharing. Compared with traditional academic journals, data journals have obvious differences in object, audience, characteristics and essence[98]. Similar to the traditional academic journals, the data journals also need peer review, public publication, recognition by authoritative index institutions, and calculation of citation degree[99].

China's data publishing is not the newest in the world. In the initial few years, China has successively established some country-wide data journals that have learned from the existing world-wide data journals. Recently, data journals are upgrading to be a part of the global open science. In 2015, the computer network information center of CAS founded China Scientific Data (Chinese and English online edition). In 2017, the Institute of Geographical Sciences and resources of CAS and the Chinese geographic society jointly founded the Journal of Global Change Data and Discovery (Chinese and English), its trial publication began in 2014. In 2018, the Institute of remote sensing and digital earth of CAS, together with Taylor & Francis and the international society for digital earth, jointly founded the world's first open access journal of earth science, Big Earth Data (English version) that publishes research articles and data papers at the same time; In June 2020, for the integrated publishing (make high quality and enhance peer-review) of the metadata, the data products and the data papers into one, the Global Change Research Data Publishing and Repository (Chinese and English) was officially launched.

On 2 April 2018, the State Council issued the regulations of scientific data management[100], in which Article 22 clearly states that in order to promote the sharing and utilization of scientific data, the competent departments and legal entities should actively promote the publication and dissemination of scientific data, and support researchers to sort out and publish scientific data with clear, accurate and complete property rights and high shared value. Article 23 states that users of scientific data shall abide by the relevant provisions of intellectual property rights and indicate the scientific data used and referenced in the publication of articles, patent applications, monographs and other work.

The "information technology—scientific data citation"[101] standard has been implemented since 1 July 2018, marking that scientific data can be standardized and quoted like scientific research articles[102]. On 9 March 2021, the National Standardization Administration Committee issued three scientific data standards: "scientific data exchange formed by science and technology plan—technical management and specification"[103], "scientific data exchange formed by science and technology plan—General data element"[104] and "scientific data exchange formed by science and technology plan—General code set"[105], which were officially implemented on 1 October 2021. It can be seen that China has paid full attention to data publishing and supported it from the policy level.

In addition to the policy level's support for data publishing, China has also begun to actively promote data publishing in terms of infrastructure to create a good development environment for data publishing. In compliance with the requirements of the national data policy, in order to standardize the management of the national scientific and technological resource sharing service platform, improve the scientific and technological resource sharing service system, and actively promote the opening and sharing of scientific and technological resources to the society, the Ministry of Science and Technology (MOST) and the Ministry of Finance of China (MOF) have carried out a series of optimization and adjustment work on the original national platform, forming a total of 20 national scientific data centers through departmental recommendation and expert consultation[106]. In the future, these data centers will become important long-term preservation systems of scientific data, integration systems of scientific research materials, tools and products, and data evaluation and data service systems in China.

2.2.2.2 Data Registering Services

Similar to traditional academic publishing, data publishing also follows a complete publishing process. Data publishing process usually refers to the activities and processes of online publishing data, relevant metadata and document attachments, software code, etc.[107]. The publishing processes and specifications under different modes also have their own characteristics. This section will introduce the process specifications of data publishing according to different data publishing modes.

Many scholars in academic circles summarize data publishing into three modes[108–111]: independent data publishing; Data publication as the supporting material of the article; and Published in the form of data papers[112].

(1) Independent data publishing
Independent data publishing refers to the storage and publication of data in the data center or data repository, rather than relying on publications. This kind of publishing method assigns a unique identifier to the data set for retrieval and use when storing the data to the specified storage place. These data repositories are often those of government or national data centers, public repositories and research institutions.
(2) Data publishing as supporting materials for research articles
Data publishing as the supporting materials of articles refers to submitting data as the supporting materials of academic articles to the designated repository for sharing. It is a kind of data publishing attached to publications. This kind of data is highly related to the related articles. Many of them are the data of scientific research results and an important part of the articles. In order to enhance the review of additional data of articles, some publishers provide corresponding data availability statements for article citations[113–116].
(3) Published in the form of data papers
Publishing in the form of data paper means that the data are published as the publication itself. Data paper is a scientific research article formed by the standardized description of a class or a data set with scientific value[117]. The complete publication of data paper shall include two parts: data paper and corresponding data set, which are related through unique identifier and published after being reviewed by peer experts. Such publications are generally subject to certain open access agreements.

2.2.2.2.1 International Scientific Data Publishing Process

(1) Independent data publishing process
There are two main ways to publish scientific data independently: First is the independent submission of data producers, second, the 'staff assisted' in the submission. When submitting independently, the data submitter shall complete it independently according to the submission guidelines of the data platform. Taking Dryad[118] as an example, the submitter logs in with ORCID, inputs metadata before submitting data, and then uploads a copy of data that can be opened (ensure that it does not contain

sensitive information and complies with CC0 license), and uploads a copy at the same time the .txt format data description file. After submission, the platform staff will review the data. Once approved, the data set will be published and made public, and the data submitter will be notified in the form of an e-mail. In the e-mail, the DOI registered for the data in the repository will be informed. If the cost of the data set is not reimbursed by journals, institutions or countries, the submitter will receive the electronic invoice. When the staff assists in submitting data, the staff of the data repository shall assist the data producer to evaluate, format and adjust the data and upload them to the repository. The specific operations can be divided into data evaluation, data preparation and data submission. Evaluation is mainly to evaluate whether the data set meets the requirements of repository according to certain standards. The preparation process includes formulating data submission plan, describing data set, standardizing data format, determining data acquisition and use conditions and transmission methods[119].

(2) Data publishing process as the supporting material of the research article

When the data are published as an annex to the article, in addition to peer review of the article, the data set shall also be reviewed as necessary. In recent years, with the continuous improvement of academic publishing requirements, many publishers have formulated their own data review requirements and data policies to increase the transparency of research data. When reviewing the data, we mainly focus on whether the research methods are applicable to the research problems and whether the collected data can support the research conclusions[112]. Taking Dryad as an example, integrated publishing mainly includes the following processes: ① the author submits the manuscript to the journal editorial department; ② Journals peer review manuscripts and create temporary records for them; ③ Journals invite authors to submit data and provide links to interim records; ④ Authors submit data and use links to temporary records; ⑤ The journal sends the password and DOI to the author; ⑥ After the article is accepted, the editorial department shall notify the repository; ⑦ The repository publishes data sets with links to related articles, and journals add the DOI provided by the repository to all forms of articles[120].

(3) Publishing process of data papers

The data paper publishing process can refer to the data paper demonstration project launched by Global Biodiversity Information Facility (GBIF) and pensoft publishing house. The specific publishing process includes the following steps[121]: ① the data publisher creates metadata for the data set and assigns permanent ID; ② After the metadata are created, the article data are automatically integrated; ③ The author conducts self-examination and uploads the article to the Journal online submission system; ④ After peer review, the comments on the first draft shall be returned to the author; ⑤ The author modifies the article according to the comments of the reviewer; ⑥ The same as ②, the marked modified version is automatically converted into an article here; ⑦ The article is accepted, enters the proofreading stage, adds the submission date, modification date and receipt date, and registers the DOI number; ⑧ After proofreading and final confirmation, the data paper will be published in various forms, including printed version, PDF format consistent with the printed version, semantic enhanced HTML format and XML format.

2.2.2.2.2 Chinese Scientific Data Publishing Process

The process of independent publication of Chinese data can refer to the data collection and submission process of the national Qinghai Tibet Plateau scientific data center[122], mainly including: the author submits data and metadata; submit to experts for review; the system automatically assigns review experts and releases the data after passing the review (figure 2.6).

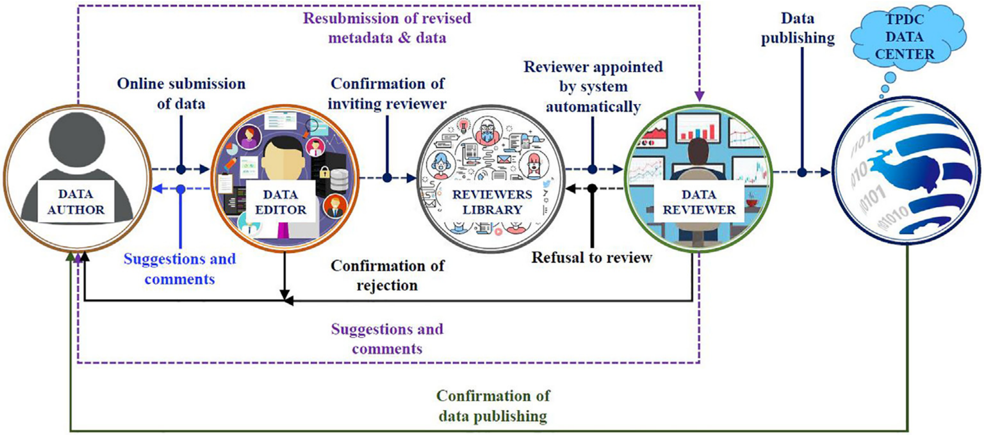

FIG. 2.6 – Data collection and submission process of the national Qinghai Tibet Plateau scientific data center[122].

The publishing process of China data as the supporting material of the article can refer to the data publishing process of ScienceDB[123], which mainly includes: registration and login; Data submission; Data review; and Data publishing[124]. Figure 2.7 shows the complete business process of ScienceDB.

The publication process of data papers in China can refer to the *Journal of Global Change Data & Discovery (Chinese and English)*, which is a self-established publication in China. It mainly includes several links[125]: accepting authors manuscript → data review and data paper review → editing and processing → proofreading journals → printing → Journal publishing, including the collection of layout fees, payment of printing fees and distribution of manuscript fees, The publication order is that the data are published first, and the data paper is published later (figure 2.8).

2.2.2.3 Data Quality Control

Data publishing is for data sharing and reuse. Quality audit is the core link of academic publishing[126]. The quality control of data publishing includes the control of data quality, article quality, metadata quality, as well as the selection of database. Data quality control is a series of policy standards, tool platforms, activities and methods that make the published data reach or even exceed the data quality standards on the basis of clarifying the meaning and scope of data publishing, determining different data publishing modes and

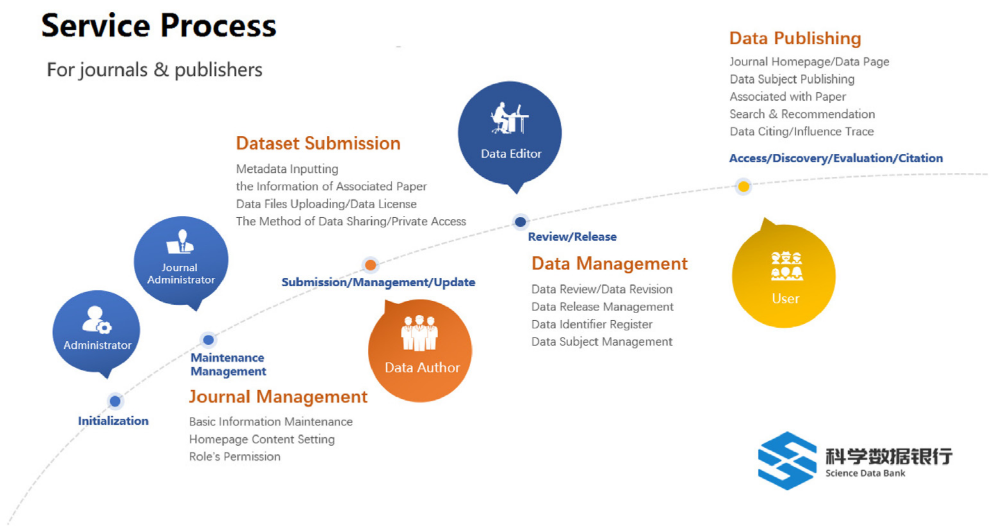

FIG. 2.7 – The complete business process of Science Data Bank[123].

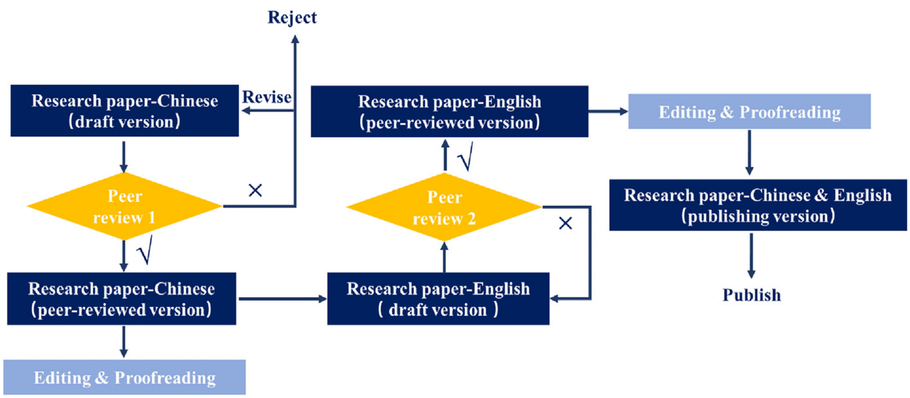

FIG. 2.8 – The publication process of the *Journal of Global Change Data & Discovery (Chinese and English)*[125].

processes, and understanding the connotation and standards of data quality. The contents and methods of data quality control include publishing links, quality control objects and evaluation system[127].

For the quality control of data publishing, different publishers have different practices. For example, Springer-Nature stipulates that the data review Editorial Committee must include at least one data standard review expert to evaluate the quality of the data submitted by the author; Elsevier requires journal editors to make a preliminary assessment of the timeliness, objectivity and authenticity of the data when evaluating articles[128]; PLoS and Dryad jointly reviewed, and the data and articles were reviewed and published at the same time[129]. In addition to the control of data quality, the quality control of articles mainly adopts the method of peer review[130], and the quality control of data repository also includes the quality control of data itself, metadata and related documents[131].

(1) Quality control of independent data publishing
The quality control under the independent data publishing mode is mainly the selection of data repository and the quality of metadata. In this mode, users submit data to the specified repository independently, and there are no special standards and requirements for the quality of the data itself. In this publishing mode, data repositories are mostly national data centers, data repositories of national research institutions, professional data centers, etc. after the data are submitted, the administrator of the data repository will perform data review (technical level), including the integrity of data files, data integrity, and data standards. There are also individual data repositories that evaluate data by implementing data management plans. The quality control standards of data repository can refer to the principles of trust: transparency, responsibility, attention to users, sustainability and technical support[132]. The quality of data publishing is also closely related to the quality of metadata. High quality metadata can not only ensure the usefulness of repository, but also effectively describe data resources and help users better understand and use data. Therefore, when submitting data, the data repository usually requires the submitter to provide some necessary descriptive metadata, and some repositories also provide some metadata for the submitter to choose to further enrich data description. Metadata quality evaluation usually focuses on several characteristics: integrity, accuracy, source, consistency, timeliness and accessibility[133]. The quality controlled data shall meet the fair principle: Findability, Accessibility, Interoperability and Reusable[134].
(2) Quality control of data publication as supporting materials of research articles
Under the publishing mode of data as the supporting material of articles, the focus of quality control is mostly the peer review and review of articles. In this publishing mode, journals usually cooperate with some large data repositories, while data quality control tends to be completed by repository managers. The content of quality review includes data and metadata. In order to facilitate reference and tracking, some repositories will allocate DOI separately for data sets. At the time of publication, many journals will require the author to provide important evidence as the research conclusion (the processed data of the original data) for peer review experts and editorial departments to review, but there will be no strict requirements on the data quality, and there is no unified standard in the review process.
(3) Quality control of data paper publishing
The quality control of data paper publication mainly includes article review, data review and other requirements[135–140]. In order to ensure the quality of articles, data journals continue to follow the peer review mechanism adopted by traditional academic journals. The article review focuses on the content and format, the integrity and effectiveness of reference materials, and the publishing requirements. The data review link focuses on: data accessibility, data format, data integrity (including tools and environment), detailed description of research methods, metadata quality, consistency

of data with articles and metadata, scientificity and uniqueness of data, reusability of data, etc. Other possible focuses include data collection and analysis background, knowledge sharing license agreement, scientific contribution, etc.

Although data papers are subject to quality control before publication, there is still a lack of unified process and evaluation standards for data publishing quality control, and there is also a lack of recognized understanding in academic circles[141]. The above three data publishing modes have several similarities: ① all pay attention to the accessibility of data; ② It is recommended to submit complete data; ③ the data are required to be stored in a pending repository. The differences of these models are: ① publishing based on repository or relying on journal publishing; ② whether to conduct peer review.

The quality control of China's data publishing is mainly manifested in that a few data publishing subjects independently explore and try for their own problems and future development. The quality control of most data repositories is the responsibility of characteristic or representative scientific research institutes in the field[142].

The article quality and data quality control of the *Big Earth Data (English)* are integrated into one process, which mainly includes three aspects: checking the location of data storage; reviewing the quality of data and articles; and evaluating the quality of related data[143]. The *Journal of global change data & Discovery*'s data publishing quality control mainly focuses on the data review link, focusing on: whether the metadata are complete and standardized, whether the data signature information is complete, whether the property right of the data set is clear, whether the content of entity data is consistent with that described in the data paper, and whether the content, spatial resolution, time frequency; whether there is intellectual input in spectral band or data format, whether the quality of spatial data and attribute data in physical data conforms to the principle of less than 10% error under the specified space and time scale, whether the data records quoted from others conform to the principle of less than 10%, whether the data format is standardized, whether the data paper is complete, whether the data visualization diagram is clear and the expression is accurate, whether the references are standardized and whether the bilingual correspondence between Chinese and English conforms to the semantic principle[144].

2.2.2.4 Data Journal Publishing

China's data publishing started relatively late, but the pace of exploration and practice has gradually accelerated in recent years. *The Big Earth Data (English)*[145] is an interdisciplinary, open access and peer-reviewed academic journal. It is also the first geoscience big data journal in the world. It is included by DOAJ, Scopus, EI Compendex, GEOBASE and ESCI. The topics of articles published in the journal include but are not limited to: Earth observation, geographical location, geology, atmospheric science, marine science, geophysics, geochemistry, etc. Publication types include research articles, reviews, data papers, technical notes and software articles. The journal aims to provide an efficient and high-quality platform for promoting the sharing, processing and analysis of "big data", so as to completely change people's understanding of the earth system. Until 3 August 2021, the data papers published by the Big Earth Data have been read up to 9486 times and cited up to 68 times in CrossRef.

The *Journal of Global Change Data & Discovery* has four main columns[146]: overview, data policy and scientific plan and data technology; data paper column; Keywords column of world geographic data encyclopedia; Capacity building and academic activities. Until 3 August 2021, the journal has published 47 issues of data sets, a total of 932, with 75 717 registered data users from 97 countries or regions, with a total number of visits of 6 054 574. There are 1482 authors that from 12 countries and published 337 data papers.

The purpose of the *Journal of Global Change Data & Discovery* is to adopt the associated publishing mode of scientific data and data papers, publish scientific data papers on global change, promote data sharing and intellectual property protection, drive scientific discoveries and improve China's international influence in this field. The basic principles of running the journal are: domain integration, clear property rights, academic freedom, open data, detailed information, bilingual parallelism, standardized publishing and network interconnection. Major innovative initiatives of the journal include comprehensive field content, bilingual editing of the same journal, scientific research projects, academic conference author groups and 100 school communication plans.

The *Digital Journal of Global Change Data Repository*[147] is an important part of the infrastructure of "Global Change Research Data publishing & Repository"[148,149]. It is a platform for official publication and release of original data sets or data products submitted by data authors, reviewed by peer experts, open to the whole society and in line with the norms of the world academic publishing community. This and the *Journal of Global Change Data & Discovery* undertake the task of publishing global change entity data sets and data papers, respectively. The journal aims to promote high-quality and reliable scientific data sharing in global change and related fields (including geography, resources, ecology, environment, sustainable development, etc.), takes the coordination of data intellectual property protection and data open sharing as the purpose, and takes publishing and disseminating the latest entity data results of global change scientific discovery as the core task. Through the publication of entity data sets, it ensures that the property rights of data sets are clear, safe and reliable, the quality is credible, the computer can be recognized, the system can be interactive and the data can be reused. The main tasks of the *Digital Journal of Global Change Data Repository* include: publishing entity data sets; the publication content takes into account the basic data, the latest scientific discovery data and social sustainable development data; Permanent data preservation and services; Network interconnection; and Promote international cooperation.

The China scientific data (online)[150] is currently the only academic journal in China that specializes in publishing scientific data in multi-disciplinary fields. It is one of the first pilot projects of national network continuous publications and the source journal of China Science Citation Database. This journal focuses on basic data and data products in the fields of life science and medicine, earth system science, space science and astronomy, physics, chemistry and chemical industry, material science and engineering, information science, social science and so on. All data of the journal are published in ScienceDB[151]. Until August-3-2021, ScienceDB has published 487 820 open data sets, with a total of 4 018 724 views and 13 059 750 downloads.

The journal is committed to the openness, sharing and citation of scientific data, promoting the long-term preservation of scientific data and data asset management, exploring the effective evaluation mechanism of scientific data work, promoting the development of data science, and promoting the findability, accessibility, interoperability and reusable of scientific data.

As important scientific research materials, the demand for public publication of data is growing. In order to publish scientific research data, data journals and data publishing platforms came into being. In line with the international trend, many institutions in China have begun to actively take the lead in establishing local data journals and data publishing platforms, and the state has also given strong support from the policy and infrastructure levels. At present, there are three common data publishing modes: independent data publishing, data publishing as the supporting material of articles, and data paper form publishing. The publishing process and quality control focus of different modes also have their own characteristics. At present, the development purpose of several data journals established in China focuses on data disclosure, sharing, peer review, citation, long-term preservation, reuse, interaction and promoting international cooperation. Compared with the international, the number of data journals in China is still small, and the subject field also has a large expansion space. However, the existing national environment also gives it vigorous vitality and a good development situation.

2.2.3 New Evaluation Progress

The STM journal is the basic carrier for the centralized recording, exchange and dissemination of scientific research achievements[152]. Evaluating STM journals provides a fair and scientific evaluation basis, helps researchers and research institutions objectively understand the academic influence of STM journal, and helps them make reasonable decisions in the scientific research process such as article submission and academic evaluation, It is an important content in science and technology evaluation. Traditional journal evaluation is mainly carried out from two dimensions: qualitative evaluation and quantitative evaluation. The qualitative evaluation method of journals is mainly based on the opinions of experts in the field. It is an important aspect of journal evaluation, but it faces some problems, such as inconsistent expert opinions, time-consuming and laborious evaluation process etc. The journal quantitative evaluation method is mainly based on the relevant quantitative indicators constructed by the articles published in the journal. Because of its objective and efficient characteristics, it is often used in the practice of science and technology evaluation[153]. The journal quantitative evaluation method includes a series of indicators headed by journal impact factor (JIF or IF). However, in recent years, many academic journals have been confused by the negative impact of citation and moral evaluation, including the confusion between the author's citation and other factors[154].

The Chinese government and relevant departments are also gradually aware of the abuse of similar indicators and rankings in scientific research evaluation. In November 2015, the China Association for Science and Technology (CAST), the Ministry of Education (MOE), the State Press and Publication Administration (SPPA), the Chinese Academy of Sciences (CAS) and the Chinese Academy of Engineering (CAE) issued several opinions on accurately grasping the role of STM journals in academic evaluation[152], pointing out that it is necessary to prevent the tendency of "only journals and articles", and appropriately separate the evaluation of journal articles from the evaluation of journals, from paying attention to the quantity of journal articles to the quality of scientific research achievements, from paying attention to the journal country, impact factors and journal grade of published articles to paying attention to the innovation and social value of the articles themselves.

The Ministry of Science and Technology (MOST) issued a notice on the correct use of several SCI indicators in February 2020[155]. It is pointed out that in order to reverse the phenomenon of one-sided and excessive use of relevant indicators of SCI articles in the current scientific research evaluation, standardize the use of relevant indicators of SCI articles in all kinds of evaluation work (including the number of articles, the number of citations, highly cited papers, impact factors, ESI ranking, etc.), resolutely abandon the "Journal Evaluation" and encourage the comprehensive evaluation method of combining qualitative and quantitative evaluation, explore and establish a scientific evaluation system. In the same month, the Ministry of science and Technology issued the notice on several measures to eliminate the bad orientation of "article only" in science and technology evaluation (for Trial Implementation)[156], requiring that the number of representative works and the level of influence factors should not be used as quantitative assessment and evaluation indicators in science and technology evaluation. In August 2021, the State Council Office issued the guidance on improving the evaluation mechanism of scientific and technological achievements[157], which once again emphasized that the number of articles, the number of representative works and impact factors should not be used as the only quantitative assessment and evaluation indicators.

2.2.3.1 Article's Academic and Social Impacts

In the open science environment, article evaluation returns to the article itself. The separation between article evaluation and journal evaluation is the general trend in the future. How to make the article-level evaluation is a question that needs to be solved in collaboration among academia, STM journal and publishing society, and funding agencies. At present, the evaluation of the scientific and technological articles in China in the open science environment is considered on a combination of qualitative and quantitative evaluations.

The quantitative evaluation methods mainly include article-level metrics (ALM) and Altmetrics measurement[5], among them, the citation forms of the article are main evaluation indicates, including the number of downloads, reading times, social network mention times, etc. Qualitative evaluation is mainly the user behavior in open science environment. However, at present, these data are still on various STM journal publishing platforms or in CNKI or WANFANG DATA.

In the open science environment, some international organizations and projects are actively promoting the new generation of research evaluation system, including the Declaration on research assessment (DORA), Leiden manifesto, article-level metrics, and F1000 prime field expert scoring method[158]. China STM journals have studied on those recommendations and new standards.

The general recommendation of San Francisco Declaration on Research Assessment is that do not use journal-based metrics, such as Journal Impact Factors, as a surrogate

[5]The indicators refer to altmetric.org, but the data refer to altmetric.com, which are different.

measure of the quality of individual research articles, to assess an individual scientist's contributions, or in hiring, promotion, or funding decisions[159]. In addition, the Leighton declaration puts forward ten guiding principles for research evaluation[160]. Because Chinese researchers and scientists attach great importance to those declarations, China STM journals pay higher attention to them and the new publishing trend.

Article-level metrics is a citation index used to measure the use and influence of a single academic article[161]. In March 2009, PLoS, an open access publisher, first introduced article-level-metrics indicators for all its published articles, including download times, citation times and altmetrics indicators. The statistical indicators of Altmetrics are composed of impact story and Altmetrics.com, PlumX and other companies. PLoS, BioMed Central, NPG, Elsevier and other publishers all provide Altmetrics services[161]. In March 2014, PLoS announced the provision of article level counter electronic resource usage statistics[162].

At present, the study of evaluation method in China mainly focuses on traditional evaluation indicators (citation frequency and citation network). While deeply excavating the emotional mechanism, innovation and innovative evaluation and other knowledge unit contents cited in the article, it gradually began to integrate Altmetrics indicators, peer expert evaluation (F1000 and peer review context) and other methods. China STM journals support the evaluation of scientific articles, which is still on the way of exploration in many aspects.

Some China STM journals also use altmetrics services, such as *Cell Research*, *Acta Pharmacologica Sinica* and *Light* published on the platform of Springer-Nature Publishing Group. The front page of the article will display the views number (accesses), cited number (citations) and altmetrics indicators of the document in real time. Click metrics to view detailed indicator data sources and explanations. The index data of the service are from Altmetric.com, the online attention received by this article, which is mainly calculated based on the number of references in social media and mainstream news media. Since new articles usually score low, altmetrics also gives the percentiles of all articles published in the same year.

Some Chinese journals may not use Altmetrics.com or PlumX, but its publishing platform will also provide similar measurement indicators, take *Chinese Journal of Organic Chemistry* as examples, click metrics to view the number of times the full text and abstract of this document have been read in recent 12 months; Click this article evaluation, and you can also log in to your personal account to score and comment on this article.

Some researchers develop new tools for China STM Journals, for example, professor Le Xiaoqiu who works in the National Science Library of CAS has developed an evidence-based analysis tool for the evaluation of the academic contribution of representative works for the content analysis of citation sentences[163].

On the other side, starting from content analysis of citation sentences of the cited literature of the representative works of scholars, Chinese researchers find the evidence of peer evaluation of the academic contribution of representative works (breakthrough, major improvement/solution of key problems, innovation, application, etc.). It provides an objective basis for academic evaluation and can be used as an auxiliary tool of "representative works academic peer review system" to realize the new academic evaluation model of "peer review" + "evidence-based analysis". Those new progress is as same as the new development of open science in other countries.

2.2.3.2 Data Usage and Citation

Data evaluation can break the traditional academic evaluation mechanism, and China's data evaluation still needs more exploration and experiment. Internationally, a data index database similar to the scientific citation index has been constructed. However, this evaluation method has not been widely recognized because of its own problems and the nature of scientific data.

At present, data evaluation at home and abroad is more inclined to data-level metrics (DLM) or altmetrics indicators, including data citation times, download times, etc. In China, STM journal editors and scientific data experts have put forward data quality evaluation index system and influence index, and some individual index systems are in practice. However, the evaluation of data quality and the evaluation of data influence are two different aspects. How to realize the combination of the two to be better used for data evaluation and large-scale promotion is what editors and graphic experts of China STM journals need to think and explore.

The quality of open scientific research data in open science environment is becoming more and more important. Internationally, the practices related to scientific data evaluation mainly include: ① data Citation Index (DRCI) established by Clarivate company; ② The concept of data-level metrics is proposed by PLoS and applied to the evaluation of data sets; ③ CODATA, WDS and other scientific societies put forward a series of principles to be followed by scientific research data, data center or data repository (such as transparency and openness promotion guidelines, TRUST principles, FAIR principles and data citation principles). These principles not only ensure the openness and sharing of data, but also ensure the standardization and quality of data to a certain extent. China's STM journals have considered those principles into data evaluation.

The data citation index is an index established by Clarivate in 2012 to discover high-quality scientific research data in the data repository of all disciplines in the world[164]. DRCI mainly includes data sets or data research stored in the built database with data governance, and it is best to have quality control and editing policies in the data management of the data repository. DRCI does not store or upload actual scientific data. DRCI provides data reference retrieval, but the reference is not from the data, but from the reference of other types of literature (such as books, journals, conferences, etc.) on the WoS platform.

Data-level metrics is a set of multidimensional indicators to measure the influence range and use of data as research output, mainly including standardized data reference, data use statistics and data-oriented altmetrics indicators. Data-level metrics is mainly used to standardize the reference of data (set) and data use in articles. Using statistics to evaluate scientific data, such as Google Analytics and Jacobs and Worley, users of some data repository can download data records[165]. Data oriented altmetrics indicators are conceptually the same as the alternative measurement indicators of journal articles. Research data can also produce indicators similar to other types of academic output, that is, the number of references to data in blog posts or tweets. In addition, there are some alternative measurement indicators specific to data, which can realize data reuse and experiment (such as GitHub forks) and collaboration mode (GitHub collaborator)[166].

Chinese research on data evaluation mainly includes: ① constructing data quality evaluation index system; ② The use of research data and influence data; ③ Data measurement, data level and data substitution measurement. The research contents are mainly introduced and expanded on the basis of foreign research and practice, or introduced to data evaluation based on the research contents and methods such as traditional journal evaluation and article evaluation.

In 2009, the scientific data center of computer network information center of CAS drafted the "data quality evaluation method and index system", which pointed out that the data quality should be evaluated from the basic level and criterion level. The basic layer includes form quality, content quality and utility quality. The criterion layer includes: availability, consistency, comprehensibility and integrity; accuracy, correctness, objectivity, effectiveness and reliability; relevance, usefulness, background, appropriateness and timeliness.

The regulations of scientific data management issued by the General Office of the State Council in 2018 pointed out that the legal entity should establish a scientific data quality control system to ensure the accuracy and availability of data[167]. The "data quality evaluation index (GB/T 36344—2018 ICS 35.24.01)" issued by the National Information Technology Standardization Technical Committee (NITSTC) in 2018 constructs the data quality evaluation index framework from the aspects of standardization, integrity, accuracy, consistency, timeliness and accessibility[168]. On 19 March 2021, the release meeting of the national standard "data paper publishing metadata" led by the computer network information center of CAS was held in Beijing. The project will standardize the metadata of data papers in China[169].

Some disciplines and data journals are also actively exploring data evaluation. For example, Kong Lihua *et al.*[170] put forward the scientific data quality evaluation index system according to FAIR principles, which has been used in the peer review of *China Scientific Data*. The Data Impact Score method constructed by Liu Chuang[171] is also used in the data published by *Journal of Global Change Data & Discovery*.

In addition, the "CAS data application environment construction and service" project constructs the scientific data quality framework for data life cycle and the "CAS human-environment interaction data quality management specification", puts forward the scientific data quality maturity model for the data quality capability of production institutions, and puts forward the quality function deployment (QFD) method, developed scientific data quality software based on expert repository[172]. The results of the project have been verified and practiced in the work of scientific data quality.

Among them, the scientific data quality software based on expert repository has been fully applied in the practice of quality control of long-term ecological detection data by China ecosystem research network comprehensive center (CERNCC) and the soil sub-center. After being tested and improved, the "CAS human-environment interaction data quality management specification" has been applied and popularized in many thematic databases in the field of geosciences of the Chinese Academy of Sciences[173].

Chinese data evaluation has gradually developed from focusing on the metadata evaluation in the information system to the evaluation of scientific data entities, and even the evaluation of data journals in the future. However, generally speaking, the practice in China is mainly in geographical science, the practice subject is mainly the Chinese Academy of Sciences, and other institutions and departments are not yet all involved. With the global open science movement and the Chinese science and technology progress, there will be more and more disciplines and faculties jointly participating.

As a type of scientific research output, with the introduction of open and shared policies and requirements of the people's government, research institutions and funding agencies, its role and influence are gradually enhanced and recognized by people. Data evaluation, like Article evaluation, will be paid more and more attention. Although the current data evaluation has not yet formed a unified and effective method and conclusion, relatively recognized norms have been formed in terms of open data principles and data citation. Some international organizations and institutions are also actively promoting the research and practice of data unique identifier, data citation, data-level-metrics etc. In the future, data evaluation is also likely to be included in the scope of research achievement evaluation, institutional achievement and influence evaluation. China is also actively exploring the evaluation of datasets.

2.3 Challenge of China's STM Journals in Open Science Environment

Since the reform and opening up, China has always pursued the strategy of opening up, sharing and cooperation. With the continuous progress of China's science and technology, China STM journals are also growing. Today, nearly 5000 kinds of the STM journals in China are facing new challenges of academic publishing and communication in the mode of global academic publishing, recording, communication, storage, service and sharing in the open science environment, and are undergoing major changes from content, quality, specification to development mode[174].

2.3.1 Global Open Science Brings the China STM Journal Revolution

2.3.1.1 The Changed Functions of STM Journal

STM journals have a new registration function. For a long time before open science, researchers' labor achievements and conclusions were mainly published in the STM journal. If it is confirmed that the scientific research work is the result of the work carried out by an individual or team at a specific time, it can be signed. The registration function of this academic dissemination can determine their priority in reputation, intellectual property rights, achievement interpretation, achievement transfer and transformation, and even financial and goods interests.

With the rise and popularization of the Internet, people can publish and obtain information at anytime, anywhere and in various ways. Therefore, the way of science communication, which was originally printed and circulated through article journals, is challenged and affected. On the one hand, under the influence of digitization and networking, the STM journal has relaxed the conditions for readers, authors and running journals, on the other hand, the born-digital content makes the situation of multiple true and false science, true and false versions and true and false information more obvious, and the self-requirements of the STM journal become more and more important. At present, the registration function of the STM journal not only does not become less important due to the popularity of the Internet, but also highlights the importance of registration and authentication on STM journals. In addition, there are more and more "overlay journal" models in the global publishing industry, which select and publish content that can be obtained online for free.

STM journals have a new review function. One of the core functions of STM journals is authentication, that is, peer review. This function is more important in the era of open science and has characteristics that are mainly different from other "digital economy" undertakings. The identification of the effectiveness, reliability and authenticity of scientific research achievements can only be accurately judged by peers. After peer review and published in the STM journal, it is a recognition of the author and the achievements.

The meaning of "open science" for the STM journal lies in the expansion of the scientific community, which not only includes small circles within peers (Journal editorial board or more familiar reviewers), but also includes large peers outside small peers (in some disciplines, experts from other disciplines with cross nature), but also extends to various social groups outside large peers. While creating a more relaxed communication atmosphere, open science is also shaping a more rigorous audit mechanism.

In theory, the number of people who can participate in scientific undertakings is increasing. However, due to the different degree of professional training (or scientific quality), it is necessary to formulate a stricter or more open and transparent evaluation mechanism. In order to maintain and ensure the effectiveness of this academic recognition function, two methods are emerging: one is the two-way choice, that is, the author and the reviewer can choose whether to disclose their names and units in advance; The second is to introduce the review content into academic records, that is, the person who reviews the author and his article and the content itself should also be reviewed.

STM journals have a new preservation function. For a long time, the STM journal has been the only and most reliable carrier and a way to preserve academic records. To a certain extent, academic records also mean the phased results of each scientific research, a series of achievements accumulated, overturned, re-studied and re-confirmed. The STM journal is actually an important medium to ensure the long-term preservation of the "scientific records" of human society.

In the open science environment, more and more researchers pay attention to the timeliness of publishing as soon as possible, registering as soon as possible, communicating as soon as possible, verifying as soon as possible, correcting as soon as possible and applying as soon as possible. Therefore, the STM journal of many disciplines has abandoned the traditional practice of only accepting articles with complete and reliable conclusions, and gradually accepted those articles with phased research and some innovative breakthroughs.

The preservation function of STM journals was originally for the purpose of "recording version", that is, recording various versions of various periods, ideas and experiments of some major discoveries or inventions. In the era of open science, the mode of "version record" is added, that is, the communication contents of Party A, Party B and various parties of various evaluations, comments and opinions are realized through digitization. What is saved is not only the text of the article, but also the context information of the text.

The STM journals have a new communication function. There are many different voices in the global open science movement, including but not limited to: ① open source movement; ② Copyleft; ③ Open access (Berlin3); ④ Open access (BOAI, 2015); ⑤ Open government data and open data sharing; ⑥ Others: open innovation, open collaboration, open research, open knowledge, etc. These movements have the purpose and concept of "knowledge sharing", but the means, paths and requirements are different.

The STM journal also assimilates the concept of knowledge sharing. The above-mentioned theories of open science have caused the change of the communication function of STM journal, which is mainly not to encourage journals to consider the ownership or loss of their own rights, but to promote the change of mode, influence and scope. In the era of the rise of the Internet, the access ability of the STM journal mainly focuses on: academic works and their indexes can be easily found and obtained; In the current and future of "Internet plus" that the Chinese government emphasized on many times, it is mainly extended to various convenient services, such as extending publications continuously, from laboratory records to scientific research results.

2.3.1.2 The Derived Diversity of STM Journals

Firstly, the scientific article could be divided to text, graph and table, and metadata. If we take the STM journal as a form of production and trading of goods, its underlying assets is an article. However, this description is not complete, because the article itself also includes text, graph and table, metadata and list of references.

Many elements constitute articles, many articles constitute journals, and many journals constitute trading objects. Trading objects form purchase objects through portfolios. Text, chart and metadata can all be used as digital objects, but only when they become purchasing objects can they be traded. This is the commercialization of the publishing market, which is different from the meaning of scientific knowledge However, the challenge is that the China STM journal needs to unify them.

In the era of open science, this general and consistent approach has two directions: the first direction is to subdivide the elements of the articles of journals internally, so that they can serve the scientific productivity, the second direction is to commercialize each element from research project process, distinguish and preserve the versions of various stages before the publication of the article, and mark the right subject and exchange form. Different versions of Journal articles are listed in table 2.18.

Secondly, the scientific data could be divided to dataset, data description and metadata. If the main function of scientific articles is to record the creation of ideas and the discovery of results, the recording and preservation of evidence and the subsequent reproduction of results need scientific data to open access. Although the data as the underlying assets are regarded as one, they still need to be divided into three parts:

(1) Dataset: also known as data entity, that is, evidence used to repeat scientific research results.
(2) Data description: describes the collection instrument, method, generation process, sponsor, etc. of the dataset.
(3) Metadata: describes the contributor, organization, discipline, date, version, etc. of the dataset.

Among them, datasets of different disciplines have different forms, including: the social sciences often used sheet table with variables and values; the life sciences and other coded data that often describe the organizational structure; the physical science used

Tab. 2.18 – Different versions of Journal articles.

Versions	Description
Pre-print	Manuscripts that have not been officially released by peer review can be received. On the preprint platform, without complete peer review, it has the characteristics of priority publication. Open peer review can be conducted
Post-print	The manuscript subject to peer review or open peer review may be partially revised or has not been changed, and is not the final draft
Accepted author manuscript, AAM	The version of the manuscript (accepted manuscript) that has been received by the publisher for publication
Final-peer reviewed manuscript, PRM①	The final revision of the content of the article is formed before publication after several modifications by the author. Its substantive content is no different from that published. This version usually carries the author's title, journal information, and may have an issue number or page number
Final-published article, FPA	The version published by the publishing house is also the version quoted by other researchers. Usually, the author, title, journal volume number, page number and other information will be marked. There may also be unique identifiers for digital resources, such as DOI numbers
Version of record, VOR	The final version of the manuscript is processed by peer review and publishers. It is usually a unique identifier with complete metadata content and digital resources. It's an existence as a file entity

①PRM is the version required by the National Institutes of health to be stored on PMC; It is also the version that the Chinese Academy of Sciences and the National Natural Science Foundation of China require the author to deposit on the open access institutional repository.

computer-simulation model data (modeling); and digital image and voice record of different disciplines dominated by observation and recording.

Moreover, for different research purposes, datasets produce different data classified levels in different processing stages, including the raw data collected by instruments, the derived data extracted or combined, the research data selected with verification results.

When it comes to data sharing, because of the volume and sensitivity of data, the openness of data can be divided into four levels: ① data should be completely open and shared; ② Metadata can be disclosed, and datasets need to be applied; ③ In principle, it cannot be shared. If necessary, share some datasets; ④ Not shared or cannot be shared.

The scope and implementation of data sharing include both the way in which Party A and Party B sign the contract, and the way in which multiple parties participate in a common organization, give priority to sharing within the organization and make it public after an embargo. In the foregoing way, it can also be agreed that some contents are open and some are only for the use of both parties, in the latter way, researchers can also agree on the free use of metadata, but the dataset needs to be applied for or paid for use. Researchers can also agree on the use order, use degree and method inside and outside the organization.

In the era of open science, if we discuss open government data, it usually refers to public access to citizens' decision-making information on public policies, including not only general statistical information of the public sector, but also information disclosure of scientific and technological decision-making and financial support. Therefore, it involves open research data (ORD). Therefore, ORD should be implemented under the framework of data sharing and data security; Moreover, ORD has always been the main source of data publishing.

However, scientific data mainly serve science. If the community recognizes the contribution of the author team who provides scientific data, it should try to integrate into the STM journal system and give citations. The data papers of data journals mainly come from the data description. However, because of data diversity, they are required to have complete dataset and metadata, which should be stored in the data repository to realize open access.

Influenced by the systems of the above data sources, the openness of scientific data is different, as shown in table 2.19. In order to facilitate memory, summary and promotion, the above situations are collectively referred to as open data. As another cornerstone of open science, the China STM journal will find its blue ocean that the new commercial market combined the existing scientific knowledge character in the open science environment.

TAB. 2.19 – Five star deployment scheme for open data[175].

Levels	Description	Cost and benefit
OL (online)	Data with open license	Make your stuff available on the web (regardless of format) under an open license
RE (machine-readable)	Mechanically readable structured data, such as Excel files	Make it available as structured data (for example, an image scan of Excel rather than a table)
OF (open format)	Unrestricted file formats, such as CVs, can be used in Excel, SPSS and other software	Make it in a non-proprietary open format (for example, CSV instead of Excel)
URI (uniform resource identifier)	The ID number of open standard format from W3C, such as RDF or SPARQL, etc.	Use URIs to represent things so that people can point to objects
LD (link-data)	LOD (link open data)	Link data to other data to provide context (digital objects, associations of transactions)

Thirdly, the new data asset is made by the integrated metadata made by scientific articles and data. The texts, charts, metadata and reference lists of scientific articles, as well as datasets, data descriptions and metadata of scientific data, can be used as the metadata required by the information dissemination system. According to the metadata framework and interoperability standards, it can preliminarily integrate the literature field and data field, jointly become the implementation basis of open science, and give play to the minimum functions of registration, review, dissemination and preservation of the STM journal. For example, in order to improve the quality of documents and metadata provided by BASE search engine, it not only points to the "global" metadata, but also improves the quality of documents and links.

Metadata are very important for the discovery and reuse of documents and data, and are the basis of directory service. Catalogue has become a new underlying asset. If understood in the form of commodity, it is a new data product. Metadata standards strongly depend on formats and rules, so organizations such as DataCite and DCAT are trying to expand more diverse data elements. The International Organization for Standardization (ISO) has developed many domain specific standards (such as ISO-19115 for geospatial information), the STM journal should recognize the importance of developing the value of metadata and understand those standards[176]. The metadata integration in the field of literature should not only have enough coverage, but also have high quality, and should be updated in real time. The generated knowledge base has become an indispensable data product for any set of exploration and discovery system through the market mechanism. At present, the super large metadata integration formed in the field of data and literature is developing towards similar data products.

Finally, the new data asset is made by the citation relationship made by scientific articles and data. In the era of open science, the fields of literature and data are increasingly dependent on each other. At present, many scientific funding institutions require the transparency and openness of scientific research achievements, including articles and data. The China STM journals start to require the author of research article to submit or to publish their data, even the code used to produce results. Data sharing and open data are very important for scientific progress. Data reuse has produced important scientific discoveries. The public information is not equal to the open data and also has the difficulty to become commodities or even data products. The only way is to ensure: ① the real existence of documents; ② The data are real; ③ Literature and literature, data and data, and the relationship between literature and data are true and reliable, and the new underlying assets has a value basis. That from information to data assets and sharing in the open science environment is based on a newest paradigm of the intellectual property protection and reuse; however, before the next-generational science community behavior comes in, the existing publishing system of the STM journals and its four functions are currently the only effective reference.

The current open science ecosystem has gone from the first generation based on both literature repository and data repository to the second generation based on the stage of data products of reference association, metadata association and third-party thesaurus association between each literature and each data. That is because the data and literatures are constantly updated, the data products are also constantly updated, So it has a new value and becomes a new commodity.

Its transaction mode is to provide new services, rather than data entities selling one-time metadata. However, through the interoperability of standards and specifications rather than metadata, the third generation of open science ecosystem is building an "Growing organism" of software, code, data, article, citation and evaluation content[177]. On the one hand, it relies on fair principle to ensure the authenticity, reliability and usefulness of data, on the other hand, it relies on the STM journal system to ensure that all elements in the ecosystem can become the object with the significance of data products.

2.3.1.3 The Enriched Content of STM Journals

Firstly, the new publishing opportunity by using research process real-time phase. Open science promotes the publication of supplementary materials as supporting arguments for scientific and technological articles, as well as other achievements in the scientific research life cycle, such as ontology, software code, software package, multimedia as publishing object (video of experimental process), open education resources (pictures, power point slides, etc. can be divided into publishing units as digital objects).

Some new publishing modes, such as Octopus platform, have produced new publishing mechanisms. It breaks down the research process into eight elements, and publishes them: question, hypothesis, methods, design, data, results, analysis, interpretation, applications and comments. Its reasons are[6]: ① The publication of all details of the research process, including how to fail and how to succeed, is also the important part; ② The immediate publication of those experiment results allows people to comment and score, which may accelerate the research; ③ Accurately evaluate the personal contribution of each researcher in the cooperative article or project team; ④ As a way to solve the reproducibility of science; ⑤ to create collaborative opportunities between researchers; ⑥ the quality of scientific research can be improved as a whole.

Secondly, the new publishing opportunity by using article-level metrics. The ALMs trace the immediate impact and social impact of scholars' work which is something that the citation method cannot do[178]. Traditional Bibliometrics have been the basis for evaluating the importance of recent articles for many years. However, in the academic exchange mode in the era of digitization, networking and openness, the influence of personal articles on publications can be more easily analyzed and calculated separately. The first article of San Francisco Declaration on Research Assessment reads: the need to eliminate the use of journal-based metrics, such as Journal Impact Factors, in funding, appointment, and promotion considerations[179]. The "Leiden Manifesto for research metrics" states that Quantitative evaluation should support qualitative, expert assessment[180]. These declarations have shown that scientists recognize this change.

At present, Chinese scholars have made exploratory research on Altmetrics, article level metrics and Webmetrics. The official websites of many STM journals have been able to provide quantitative service measures suitable for research evaluation based on a single article, such as the number of abstract readings, the number of full-text downloads, the number of citations in the journal etc.

Thirdly, the new publishing opportunity by using data-level metrics. One of the main features of open science is the open access of scientific knowledge (including data). Therefore, it is suggested to pay more attention to the provision of open data and its verification standards to ensure the reliability and reproducibility of scientific achievements[181]. The commonly used measurement indicators (Citation Index, influence factor and h-index) often aggravate the fierce competition at the expense of openness and sharing. If the China STM journal has the intention to tap the full potential of open science, the new indicators should go beyond the tradition and no longer only focus on continuous printed

[6]This content is consistent with the requirements of Article 22, paragraph 3, 22. VI. (c) of the draft UNSECO open science recommendation.

publications, but should develop in a new direction, that is, encourage people to share data and pay attention to the value of scientific data.

Data level metrics (DLMs) can accurately calculate the used relationship between data and the contribution of individuals. It is more comprehensive, systematic and scientific than the reference records reflected in the literature. Academic records are regarded as the computable object of scientific research output[182]. The contribution of scientific research output is divided into two parts: at first, the methods involved in data release (including software, digital laboratory records, sample structure, instrument observation, etc.), evaluation (dataset, new or supplemented first-hand literature, links), demonstration (blog, conference report, funding plan) etc. The second part includes the reuse (*e.g.* F1000), revision (*e.g.* figshare), discussion that involved in data reference.

At present, Chinese scholars have made exploratory research on the data audited account, the data level metrics and the data Citation Index (DCI). There are quantitative formulas and their laboratories based on data and between data and literature.

Finally, the new publishing opportunity by using the content of peer-review, software code and program script. The peer review refers to the process of anonymous review by experts in the academic community before the publication of scientific research articles. At present, the scope has been expanded. For the peer review of software code, in addition to whether it is true and available, it also reviews, manages, publishes and publishes according to open standards. For example, the Journal of open source software (OSS) has published 1000 articles since its inception in May 2016 to August 31, 2020[183]. The international open standards for open source software and source code refers to a standard or protocol with five characteristics[184]. Those new things are interesting to China's STM journals.

Peer review of scientific research is the core of the publication of STM journals and the way to test scientific research before publishing scientific research results. Originally, this was a social labor among elites in the scientific community.

One of the many features of open science is public participation in scientific research. With rapidly increasing members, it also expands the scope of evaluation, but it does not mean lowering standards. In China, only members who are recognized as members of the academic community can assume the responsibility of peer review and honor.

Open peer review mainly eliminates unscrupulous statements and emotional vent comments on the Internet, and encourages rational discussion on the open sharing of scientific research achievements. The social peer review is based on reasonable communication in public domain that can review the review experts. It considers the diversity of peer review process and the diversity of rating evaluation. To combine both advantages, they form peer review suitable for different fields and degrees.

2.3.2 China STM Journals Contribute to Global Open Science

2.3.2.1 The Comprehension of the Open Access Movement

There are more and more STM journals in China supporting institutional repository and preprint platform. The global open science depends on world the open access movement, and OA depends on the open publishing and the open access institutional repository, this is not only relative to IT, content, law and policy, but also the mind of open collaboration and open culture.

Open access means that scientific literature should be made public free of charge on the Internet so that interested people can read, download, copy, distribute, print, search, reference, and use the full text in any other conceivable legal way without encountering any financial problems, except for legal or technical barriers related to Internet Governance[185].

In the process of realization, various countries have different political and economic systems, different scientific and technological development levels and different characteristics of STM journals; so various open access channels have been derived. For example, hybrid open access journal means that some articles in the journal are open access. It usually has a significantly higher publishing price (compared with fully open access journals, in some subscription journals, some articles are open access because the author pays the open access fee, or due to the open access strategy of the publisher or publisher, some but not all articles of the journal are open access), while others still need to pay for access[7].

Green and gold are complementary ways to achieve open access[186]. Green open access is to store the final draft of scientific and technological articles, and there is still an open access lag period (6–12 months) after the official publication of the journal, before the full-text open access will be implemented. In essence, it cannot replace the publication of articles, but it retains the intellectual property rights of research institutions, and can play the effect of knowledge sharing through the Global Open Access Repository Alliance. Therefore, it has the function of temporarily replacing scientific and technological articles, and can provide a stable knowledge supply when the negotiation of Open Access Publishing Agreement breaks down or deadlocked. Thus, it can correct and correct the pricing, price structure and transparency of golden open access. It is precisely because there is no need to worry about the lack of institutional constraints on the golden open access, so the golden open access has the credibility of commercial negotiations and the preconditions of openness and transparency.

Institutional repository plays the role of culture cultivation of open access even open science, because it is a world-wide collaboration, it needs that researchers automatically and spontaneously deposit and share their research results. It requires researchers to understand the significance of knowledge sharing, to respect intellectual property rights, and to clearly know the different roles of what they write in preprint, publishing platform and institutional repository.

At present, the Chinese Academy of Sciences, the National Natural Science Foundation of China and some colleges and universities have built an institutional repository, and some China STM journals have become fully open access journals. China STM journals supports the development of China's institutional repository, which will make researchers pay attention to the responsibility of verifying the authoritative version. Even if the decision of funding STM journals to turn to open access is made, there is also "green open access" as the bottom card, so that we can safely negotiate.

In addition, the STM journal acknowledges that the "rapid disclosure" function of the preprint and the role of "open peer review" are very important for the development of the preprint platform. The platform is also very important for the "priority publication" and "transparency and openness" of science and technology competitions. For example,

[7]In the term "Open Access Journals", such journals are not called Open Access journals. This special term is used only in special cases to illustrate the open access of some journals to some articles.

SciELO, a Latin American open access electronic journal platform, began operating the preprint server "SciELO preprints" in April 2020 to encourage the sharing of research results, especially reliable information on coronavirus diseases[187].

The responsible researchers will verify the authoritative information, that is, the scientific articles officially published by researchers in the STM journal. However, in order to obtain information as soon as possible, sometimes it is necessary to read the first published scientific research achievements on the preprint platform, and sometimes the full text cannot be obtained, and other versions can be obtained through library interlibrary loan or green open access.

The author's manuscript and the journal publication manuscript are the underlying assets of the preprint platform and the STM journal publishing platform, respectively. Their contents are similar, but they are different in essence. The world's first preprint arXiv platform recently released the "arxiv labs" Community Innovation Framework in September 2020, allowing arXiv cooperative developers to directly develop and share new arXiv functions on their websites[188]. China arXiv service working group was established and operated in 2012. It not only supports the interface and promotion of arXiv, but also learns and improves the platform. Chinaxiv, a Chinese version of preprint platform, began to operate in 2017. At present, it has received the support of some China STM journals.

Chinese researchers and China STM journals have studied on the world-wide pre-print situation, such as indiarxiv (India), arabixiv (Arabic), inarxiv (Indonesia) and the Open Science Center (COS)[189]. In addition, the Australian Research Council issued policies on per-print documents in September 2021[190]. If there is no preprint platform supported by STM journal, it will be difficult to develop; There are a few of research institutions and companies in China that continue to innovate the preprint platform service and have received the suggestions from China's STM journals in communication and business models.

2.3.2.2 The Efficiency of the Timely COVID-19 Open Data

China's STM journals are aware of data sharing in recent years; they not only maintain the international standard but also practice. Especially, data and information of COVID-19 got released on time to fight for golden time for mankind all over the world.

Open science is an inclusive framework integrating various movements and practices. It aims to realize that everyone can openly use, acquire and reuse scientific knowledge, promote scientific collaboration and information sharing for the benefit of science and society, and carry out an open process of scientific knowledge creation, evaluation and dissemination for social actors outside the traditional scientific community[181]. However, the expansion of the author group, reader group and review group does not mean that the standard is reduced.

Data sharing depends on researchers to master the subject repositories that are most suitable for their field. These repositories need to have "trustworthiness" and how to pass the certification standards to enable people to access data, check data documents, and use data services such as statistical analysis[191]. Most of the supporting evidence sources of the thesis arguments of China STM journals come from data repository under the principle of trust. At present, China has carried out the construction of scientific big data centers. Open data require that the data comply with the fair principle, that is, the data must be searchable, accessible, interoperable and reusable, and strive to achieve data sharing and research transparency in scientific research[192]. At present, several data journals developed in China are formulating standards in this direction.

In response to global public crisis events, human society pays more and more attention to STM journals to provide correct, timely and responsible information and verifiable and consultable information sources (author team, affiliated institutions and funders). During the time of COVID-19 outbreak in 2019, the Ministry of Science and Technology of China (MOST), the National Health Committee of China (NHC), China Association for Science (CAS) and Chinese Medical Association (CMA) jointly established the "New Coronavirus pneumonia research achievements academic exchange platform"[193], to provide correct scientific research information on time. Among them, it includes scientific articles, scientific data, as well as presentations and expert explanations on topics of public concern.

In addition, the Chinese Academy of Sciences (CAS) selects the internationally recognized publishing platform, namely digital science, for cooperation for the first time. On the one hand, it as transparent and open as possible to the international community, on the other hand, it is recommended to use dimensions to span publishers and integrators. The platform creates a deep link with covid-19 virus prevention suggestions (https://covid-19.dimensions.ai). China's scientists can collect coronavirus pneumonia research information with the fastest speed to publish on WeBlog, Chat and other social media using the one-stop platform[194]. This service model can serve Chinese society and its citizens, and also simultaneously disclose information on the Internet, strive for "prime time" for other countries and regions, and eliminate the information gap.

2.3.2.3 The Construction of the Next-Generation Scientific Culture

Open science is an important way for researchers to work, cooperate, influence each other, share resources and disseminate results; It is not only the cooperation of the global scientific community, but also the interaction between science and society within the country, which affects knowledge dissemination, scientific and technological application and cultural communication of the global society. New technologies and big data drive the systematic transformation of open science, providing possible solutions to many challenges of this era; Therefore, it is necessary to construct a knowledge innovation society, especially the willingness, methods and ways for the public to participate in the science enterprise[195]. The faster a country integrates scientists and citizens to achieve open science, the more it can spread its international influence through non-governmental exchanges and specific cases of science and technology serving human society.

At present, in China's "Outline for building a reinforced intellectual property country (2021–2035)"[196], data assets and data trading market are particularly mentioned to promote the development of high-quality cultural and social environment. China has formulated the "law of data security" (2020) and the "Global Initiative on Data Security" (2021). China STM journals have gradually integrated with the scientific data center to jointly promote the open sharing of articles and data benefiting global scientific and Technological Development under laws, regulations and national strategies. China STM journals have understood the "UNSECO open science recommendation" that emphasizes the fair participation of all knowledge producers and users[197].

Open science is not only the realization path of an innovative country and a world scientific and technological power, but also the realization scheme to promote scientific communication and technological progress. As a responsible country, China has spared no effort to promote the open access of scientific articles and the open sharing of scientific data. The core of open science is the open access of scientific knowledge. Scientific publications are the main carrier of scientific knowledge. The STM journal has a new mission, challenges and development prospects (figure 2.9).

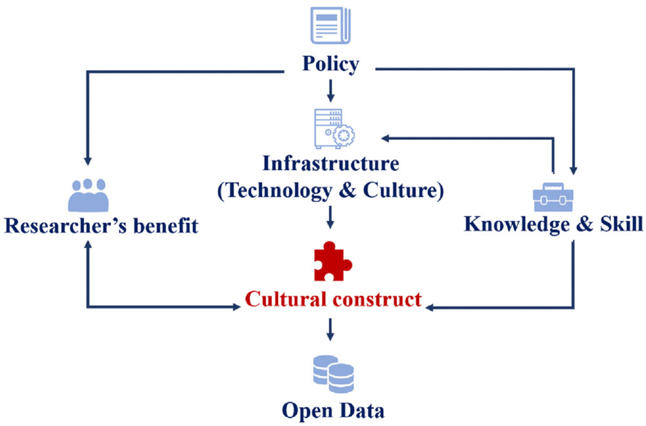

FIG. 2.9 – Cultural practice of Open Science[198].

Chinese researchers have always attached importance to research integrity. In the "Several Opinions on Further Strengthening the Construction of research integrity"[199] in 2018, it is clearly required to establish and improve the management and early warning system of academic journals, and pointed out that "academic journals should give full play to their role in the construction of research integrity, effectively improve the quality of manuscript review, and strengthen the examination and control of academic articles". To strengthen the construction of research integrity, open science is the most important step, because the open access of the STM articles enables people to test through reading or text mining, that is, whether the earliest ideas, arguments and conclusions have been plagiarized and deliberately ignored; The open sharing of scientific data enables people to recombine and test through data-driven, that is, whether the most basic evidence, materials and methods have been shared, recognized and paid attention.

The development of human society needs scientific progress and technological application, the importance of research integrity to scientific research and development is self-evident. The premise of research integrity is that scientific research achievements can be open and transparent, and everyone can test them, but it cannot be done without open science. Therefore, the importance of open science to research integrity is self-evident. In addition to open access and open data, open science also has an open platform that integrates the two and promotes the development of STM journal, and expand the scientific community, so that everyone in China can follow the principle of research integrity, carry out or participate in the cause of citizen science and data science, and discuss scientific and technological applications and scientific and technological issues in a scientific spirit among international scientists enterprises and public.

The common progress of human society is the main goal of advocating open science. There are many principles. Research integrity is one of the indispensable outlines, and the subject of practicing open science and realizing Research integrity is STM journal.

The revitalization of the STM journals a systematic project, and the development of global open science is also a systematic project. They rely on scientific and technological talents to devote themselves to the cause continuously. At present, the policy focus of China's national strategic talent force is on young scientific and technological talents[200].

The new generation of young scientists should face not only the new changes in academic publishing, but also the new impact of open science. However, the ultimate beneficiaries of these reforms are still young talents.

The STM journal is an important force to gather the output of scientific and technological achievements, unite the strength of scientific and technological talents and maintain a good order of scientific and technological exchange. Through open science, it can amplify the influence and accelerate dissemination. In order to expand the scope of the scientific community and establish new scientific and technological exchange rules, open science needs the STM journal to play a role in four aspects: registration, review, preservation and communication.

2.3.3 Competition and Collaboration with International Publishing Groups

2.3.3.1 International Publishing Groups Forward Actively the Open Science Wind

Openness is not without preconditions and limits. It has its open boundaries in terms of commercial and economic interests, personal privacy, confidentiality and security. At present, China has successively promulgated new laws or revised laws to establish open boundaries and management basis for the boundary and development path of open science, including the law of internet security (2016), the copyright law (2020), the law of data security (2020) and the law of personal information protection (2021). China also launched on time the global initiative of data security in 2020.

Many countries in the world and the international publishing groups, with predictable national public capital investment, mainly change open access from the cultural mode to commercial mode. According to the history of development and evolution, it can be divided into three stages and now move towards the fourth stage.

The first stage is to resist green opening and develop mixed open access journals. First of all, resist, do not support or passively support open access, green open access in the Berlin Declaration, and strive to develop open publishing, especially the business model of mixed open access journals, that is, research institutions subsidize authors to publish open access articles and pay open access fees for publishers. The main contradiction at this stage is to separate the integrity of open access, which hinders research institutions from preserving intellectual property rights on the one hand, and increases the cost of scientific research authors' publishing and exchanging scientific research achievements on the other hand.

The second stage is to turn to the business model of fully open access journals. The journal series under the international publishing group implements the recommendation of articles that are not included in subscribed journals to open access journals, so as to promote the hierarchical separation of subscribed journals and open access journals. In terms of article quality, well-known journals and second-class journals of the first tier and the third tier are formed. The latter are mostly new journals, giant journals and even fraudulent open access journals, which have become the trend of large-scale publication creation, forming the impression that the representative level of open access is not high.

The main contradiction at this stage is: in the process of internationalization of local journals around the world, international publishing groups provide such "create new journal" services in the name of open access, which makes it difficult for the intellectual property rights (final draft of articles) of research institutions to stay in research institutions, squeeze the space for temporary knowledge sharing. Those STM journals that use their mother language, focus on their local problem themes and be supported by their science societies, has long been in the third class or reluctantly entered the second class. Funding agencies, universities and research institutions cannot unify their financial budget, due to the growing expenditure in supporting their authors to submit to the international and well-known journals—the financial resource support on the world-wide first class journal but not the local country journal.

In the third stage, they push the subscription journals to become the golden open access and the "gold expensive" journals. In view of the green open access that has been fragmented, it cannot get the support of local journals internally and cannot form a structural network externally, it has lost its temporary replaceable function and has no ability to resist the rise of subscription journal prices; at the same time, the open science is the need of the human community; then, the only way is to take the "best" commercial model by "big deal" and "consortium purchasing" for the subscription journals to be open access journals that have pushed up the price because the other new journals elevate their position in the second stage.

The capital power will continue to maintain the status that high prices are not restrained by substantive prices, and continue to maintain the trend that this kind of international high-level open access journal cluster is higher, better and stronger than local journals around the world.

In the fourth stage, the international publishing groups will vigorously support the commercial model of open science, including the research articles to open access and the scientific data to open sharing, under their capital power and world people's taxation, to be financial increased capacity.

2.3.3.2 China STM Journals March on the Open Science Wave

Open science is a systematic engineering. The actors include social representatives (*i.e.* stakeholders) of all parties including China's STM journals. Its practice form includes not only open access to scientific articles, but also open sharing of scientific data.

Open science has the potential to improve the quality, influence and interests of science, make it more reliable, efficient, accurate and understood by the public, and make rapid adjustment and appropriate response in social emergencies. These advantages will accelerate knowledge progress and achieve economic growth and create new jobs by reusing scientific results from stakeholders at all levels of society.

However, scientific and technological levels and social needs around the world are not consistent. Therefore, only a few countries have good conditions that support to expand open science to: open standards for software and hardware, public sharing of instruments and equipment, property protection of digital information, fairness and inclusiveness of educational resources, etc. Other countries can only follow and rely on these new developments and their subsequent standards.

China's STM journals have noticed several new international standards and trends:

(1) Data production: The TOP principle to ensure authenticity and credibility.
(2) Data quality control: The TRUST principle to ensure reliable storage.
(3) Data access: The FAIR principle to ensure the reuse of data available.
(4) Data exchange: The SRD standard to ensure price can be set.

China's STM journals have therefore their new development directions:

(1) Registration function: from publishing digital content to publishing born-digital resource.
(2) Review function: from organizing peer-review to recognizing reviewers.
(3) Preservation function: from presenting the research result to making each element objectivation during the whole research process.
(4) Communication function: from publishing the newest findings to supervising the accelerative implementation.

However, the time and space of these new blue oceans (developable, expandable and reclaimable) depend on the development of China's science and technology industry and the rapid and effective organization of various components of the scientific community, but it is also inseparable from the active participation and investment of China STM journals.

2.3.3.3 Scientific Community Grows, Extends, and Cooperates Across the World

According to the contents of UNESCO's open science recommendation, that has traces of international standards and developing directions, China's STM journals face the challenges of internationalization, commercialization, and opening sharing in the future-oriented open science environment.

In fact, China's STM journals have long term collaborative relationships with international journals to face the challenges from open access and open data.

The Sino-German Center of the National Natural Science Foundation of China held a Sino-German open publishing seminar in February 2014, which gathered the STM journal editors, experts and scholars and decision-makers for the first time to explore the digitization, internationalization and openness of local STM journals.

In early May 2014, the Chinese Academy of Sciences (CAS) and the National Natural Science Foundation of China (NSFC) jointly issued their own open access policies.

At the end of May 2014, Premier Li Keqiang delivered a speech at the third general assembly of the Global Research Council (GRC), echoing the theme of the conference, indicating the strategic determination of the Chinese government to support open sharing and intellectual property rights, and supporting the development and communication of young talents in the world.

There are several presses that have good partnerships with international publishing groups in the past years; China's STM journals have many opportunities in some areas to make new services in the future, including at least:

(1) Scientific community: from experts and scholars to social actors.
(2) Scientific publications: from literature and data to software and hardware.
(3) New technology application: from infrastructure to ecosystem.
(4) New service paradigm: from document access to value-added transactions.

In October 2017, President Xi pointed out in the report of the 19th national congress that education on the theme of "never forget the original heart and keep the mission in mind" should be carried out. As Royal Society report with title "Science is an open enterprise", the openness is an essential of science. That China's STM journals are also an part of open science, the re-understanding brings new opportunities to develop China's STM journals themselves.

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Chapter 3

Expert Views: Scholarly Publishing in the Open Science Environment[1]

Editorial Note

As the Royal Society pointed out in 2012, science is essentially an open enterprise, which increases the efficacy of scientific collaboration, facilitates the sharing of research resources, integrates multiple intelligences, and eventually improves scientific research through developing an open science mechanism and supportive foundation. Open science facilitates knowledge sharing through open access to research data and open approaches. The development of open access, citizen science, public scientific participation also supports social innovation. As such, many countries have vigorously implemented open science strategies to build a solid foundation for Science and Technology (S&T) innovation in an innovative society. These strategies include open-access mandates for publicly-funded research outputs, open sharing of research data and other research resources, new norms of reproducible scientific research, development of research infrastructure, the platforms and policies for knowledge sharing, citizen science and open research, and public participation in S&T decision-making.

Aiming to boost scholarly publishing in the era of open science, China Association for Science and Technology (CAST) organized several themed symposia and forums attended by scientific journal publishers and experts to discuss the theories and approaches for scholarly publishing and communication in the open science setting. Multiple stakeholders participated in the conversations and consultancy regarding open science policy and governance, including journal editors and managers, open science researchers, top scientists, academic publishers, and the leaders of academic institutions.

This chapter is based on the reports and keynote speeches of these symposia and forums, including the CAST High-Level Symposium on Open Science 2021, the Symposium on the Impact and Application of Open Science in Scientific Data Management, the 4th Forum for World STM Journals themed "Promoting Open Science: Co-shared,

[1]Edited by Shengli Ren, Qun Yan, Hejia Xie.

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Win-win and Sustainable". Experts and scholars in relevant fields jointly explored China's STM journal development in the open science arena. Regarding the current situation of open science in China, invited experts and scholars discussed various issues including the concept and policy narrative of open science, the theories and practice of open data, and academic publishing strategies relating to open science. The development of China's STM Journals in the open science context was a key topic of discussion, from multiple perspectives such as policies, open publishing, open data, technical issues, information service, based on which the practical suggestions were proposed.

Review of the Open Science Ideas and Policies

As a major contributor to scientific publications and data, China is an active member of global open science movement. China has achieved substantial progress at the national level in scientific data management, open access to S&T information, open science infrastructure, and international cooperation in recent years. With the development of open science, the Chinese scientific community needs to work with international colleagues to embrace new opportunities, cope with new challenges, and provide new solutions side by side. The Chinese scientific community is committed to participating in the global trend of open science and making its unique contribution.

Considering both open science ideas and the Chinese context, experts and scholars reflected on developing strategies of open science in China. Jinpeng Huai argued that science faces a transformation to open science, which leads to profound changes in innovation and governance. This paradigm shift requires a joint promotion from publishing, education, and industry communities to build a global win-win academic ecology. According to Wei Yang, the implementation of China's open science may encounter three main barriers: who is the promoter, how to narrow down the price difference gradually, and how to stabilize the development of local journals. Ke Gong believed that open science is a historical necessity. The relevant Chinese authorities should look at the big picture and start from the small to take active actions along with international organizations to facilitate the global development of open science. Juncai Ma thought that open science functions as leverage for advancing global multilateral collaboration in science and technology. China should focus on effectiveness through making significant achievements and taking advantage of China's strong infrastructure. In the view of Xiang Ren, the focus of the open science movement is changing to open infrastructure and ecosystem. We will see more diverse research outputs and evolving scientific communication models, which also provide innovative opportunities for the open transformation of scientific journals.

The Practice and Development of Open Data Sharing

Scientific data has become a fundamental strategic resource for scientific research and innovation in digital transformation. Accelerating the open sharing of scientific data is of active and vital significance for the evolution of the innovation system. In recent years, China has increasingly focused on open data management, evidenced by the policy documents like *Management Measures for National Science and Technology Resources Sharing Service Platform* and *Management Measures for Scientific Data*. 20 national scientific data centers have been established.

Despite many existing models for data sharing established in other countries, it is crucial to understand the Chinese picture comprehensively while developing China's science data sharing system in an open science environment. We should acknowledge that open science and open data can benefit science and technology innovation while taking data security, independent intellectual property rights, and other practical issues into account. A "pilot first" approach can be adopted to explore the way forward. In Guoqing Li's opinion, open science has a considerable impact on data policy, data management, and data services. The genuinely reliable and original impetus for open science should come from the government's public-interest support, and open science needs to be integrated into the national science governance system. According to Xin Li and Jian Wang, the upcoming scientific data-sharing service model is likely to be the fusion and upgrading of a "centralized" sharing model and a data publishing model. Juanle Wang proposed that data sharing in the discipline of Earth Science in China can be strengthened and accelerated through three aspects: scientific data repository construction, data governance capabilities in scientific data centers, and a paradigm shift in big data-driven Earth Sciences discovery. Hong Xiao suggested four issues that deserve attention: appropriate policies for open data at a national level, effective mechanism for open data collaboration and operation, well-organized open data management system, and the coordination of conflicts between open data and data protection.

Coping Strategies for Academic Publishing Development in the Era of Open Science
With the rise of the open science movement, various forms of knowledge production, communication and dissemination are also evolving. In adapting to the new demands of scientific research and communication, traditional publishing media represented by academic journals have constantly been transforming into new models of knowledge production and dissemination (*e.g.*, open access journals, preprints, etc.). In addition, an expanding number of resources such as software applications, statistical data, news reports, and government policies, have also become essential components of open science resources.

The experts put forward many valuable suggestions on promoting the development of open access publishing for China's own scientific journals in the open science environment, associated with the global trend of academic publishing. Yongshuo Chi identified future trends in scientific publishing as a more inclusive world of research, with a growing demand for technology solutions, and a stronger commitment to scientific integrity. Steven Inchcombe discussed how publishers could help advance the global vision of open science by addressing the administrative burden of open access, motivating authors to choose open access, and addressing societal challenges. Bin Peng concluded that open access publishing in China can be promoted in several ways: policy assurance and funding support, standardized operation, independent and open access platforms, cluster development, and all-around publicity and promotion to help open access platforms to achieve sustainable development. In the base of Guilu Long and Yuhong Bai, open science has accelerated changes in scholarly publishing patterns in line with the shift in communication patterns, which has brought overarching effects on journal development. Xiaodong Qiao argued that building a new academic information service for open science is part of the construction of "High-end Platform for Scientific Papers and S&T Information". Open science and academic information service mutually facilitate each other's development.

Suggestions on the Open Sharing of Scientific Paper and Data in China

(1) Establish and optimize national-level data sharing policies and actively promote open science institutionalization. National-level policy formulation is essential to provide organizational safeguards for open science as to achieve the FAIR principles advocated by ICSU in terms of Findability, Accessibility, Interoperability and Reusable.
(2) Accelerate the development of open science infrastructure and the cultivation of talents, and strengthen resource sharing. Building a world-class "open science and service platform" in China, we should have professional teams for information analysis, platform operation capabilities (stream computing, servers, application teams), competitive open science resources (type, quantity, and quality of information), reputable, multi-dimensional and customizable service capabilities.
(3) Reinforce intellectual property protection, science and technology ethics, and the self-regulation of the research community, ensuring the feasibility of knowledge sharing. It is valuable for the research community to facilitate open science through the protection of intellectual property rights, the safeguard of original scientific discoveries, and the safe and reliable validation of scientific results. Research institutions, administrative departments, open science and knowledge service platforms, academic journals, and other relevant parties should take active action to jointly develop legal and ethical codes of conduct in the open science process, prevent potential ethical risks, and ensure the quality and integrity of open data and resources.

3.1 The Concept Development and Policy Review of Open Science

3.1.1 Jinpeng Huai: Promoting Open Science and Building a Global Win–Win Academic Ecology[2]

3.1.1.1 Background of Open Science

Science is faced with a paradigm shift towards open science, and the economic and technological worlds are already ahead of the curve in this regard. The most used computer was Windows or Unix system in the information technology area 20 years ago. Mainframe machines mainly use Unix, and personal computers are based on Windows. The software does not have intellectual property rights like traditional tangible products; it creates a new way to protect intellectual property rights: A license, *i.e.*, a licensing model. As an essential element of intellectual property protection, this licensing model has promoted a rapid evolution of software technology and industry.

At the same time, the license made the software become a closed and separate system, which resulted in the infeasibility to carry forward knowledge, serious software duplication,

[2]Jinpeng Huai, Academician of Chinese Academy of Sciences.

and the difficulty in improving innovation efficiency. Thus, the information technology domain promoted open-source code in the late 20th century, taking open-source code as a spirit of open science, arguing that human beings' intelligence should be shared collectively. As a result, we now see various types of operating systems, chip designs, new software, and innovative elements.

At the current stage of development, I understand that advocating open science is concordant with supporting science and technology that promotes human well-being. Over the past 20 years, open science has opened a new window, along with the evolution of scientific paradigms and communication methods, the advocation of scientific spirit by the scientific community, and the influence of the publishing and commercial sectors on science communication. It enhances knowledge dissemination, peer review, research communication, and knowledge sharing. A decade ago, it is impossible for us to predict the current development of preprints, nor could we understand that scientists could obtain significant results without publishing journal papers. Now we realize that preprints play a critical role in high-level innovation. We also feel that open science will reshape the ecology of the scholarly publishing community, creating a socially engaged science that is better understood and supported by the public.

Science is a cause of openness, a cause of cooperation, and a vital force for human civilization progress and social development. Open science is coming to us, showing flourishing and diverse development momentum. The open science movement is anchored in open access, open data, open evaluation, and open research. It has not only played a pivotal role in enhancing the efficiency of knowledge dissemination, promoting the exchange and sharing of research results, and supporting high-level innovation, but also driven the systematic reshaping of the academic publishing ecology and the profound change of the traditional research paradigm. I believe that embracing open science should become the scientific community's consensus. It is of great significance to promote open science to benefit society and the welfare of human beings.

3.1.1.2 Reflections on Open Science

In the face of open science, the publishing, education, and industry sectors are all thinking about how we should confront and embrace it. The following three aspects, I believe, are worthy of our consideration: First, we should think about the ideals or vision of open science, that is, what is the future direction of open science? Second, what is the attainable state for open science to achieve and the possible conflicts at present? Third, we need to study possible paths and feasible strategies to realize open science collaboratively.

The Chinese scientific community should and must actively participate in global open science events, trends and platforms, contributing its strength to open science. Such participation will create new advantages and opportunities for China's science and technology with international exchanges and cooperation, making openness, trust, and cooperation as a calling card of the Chinese scientific community. I will discuss three points from this perspective:

First, open science is a new paradigm of science and technology progress and innovation. With the advent of the Internet and a new generation of information technology, there are increasingly diverse and convenient paths for storing and acquiring science and technology results. Digitization and networking have brought a revolutionary leap in scientific communication and human civilization. Science is no longer the research locked in ivory towers, but an intellectual activity based on concepts of free and open, cooperating and sharing. Global open science has gradually emerged. We are currently confronted with threats and challenges to human survival and evolution posed by energy shortage, environmental pollution, human health, and major diseases. Open science has again become a grand and emerging experimental paradigm implemented in the light of cross-boundary pluralism, inclusion and trust, and joint efforts to weather challenging times. It is highlighted by scientists' collaborative efforts worldwide to address the Covid-19 challenges since the epidemic outbreak.

Second, open science brings profound changes in innovation and governance. Open science may profoundly affect our research paradigm. Using digitization and networking as open tools, the contents we access have changed significantly. From the evolving of deductive logic in Aristotle's time to inductive reasoning, and now to big data, from the transformation of decomposition principles to a reductionist approach, these research approaches depend on the comprehensive content we can get access. Science is moving toward a new development paradigm, and open science fuels the scientific paradigm's transformation. In turn, the intensification, evolution and transformation of the scientific paradigm will further influence open science progress.

Third, we should jointly explore a cooperative and developing path of open science. In this theme, the Chinese scientific community is already on its way and is making active contributions. The Chinese scientific and publishing communities are closely involved and following open science dynamics, actively engaging in open science practices, boldly and proactively exploring new opportunities. As statistics show, the number of golden OA papers published by Chinese authors has risen to the first place in the world since 2016. In the 2020 pandemic, one out of every four golden OA papers comes from China. We compiled statistics on open access to newly created journals across major countries during 2013–2020, and the proportion of open access to new journals in China reached 35%. Compared with developed countries globally, we are proud of our efforts in this regard. Indeed, we must better identify and assess our own risks and shortcomings as well, and better mobilize the scientific, publishing, and educational communities to promote open science, benefit from open science, and contribute to open science.

3.1.1.3 Proposals for China's Response to Open Science

Open science is a grand science and technology revolution and a major trend. The Chinese scientific community should join hands with the world scientific community to grasp new opportunities, address new challenges and provide innovative solutions. We should be part of the general trend of global open science and make China's perspective contributions.

First, we should focus on global human welfare and explore pluralistic and diverse open paths. There are no two identical rivers in the world, and the road to open science is not the only one. We must establish an effective consultation and communication mechanism, fully respect the realities of each country and region, work for common goals and visions, reinforce coordination and cooperation, and construct long-term stability. Building a global cooperation network for open science is a top priority, which will be the main platform for our future communication and exchange.

Second, it is necessary to accelerate infrastructure construction and technical support for sharing resources in an orderly and organized way. Regarding open access publishing and preprints, the scientific community has different views and understandings. Various spaces deserve more explorations, as with social evaluation approaches, talent training capacity, public and policy support. We need to establish an effective information superhighway to support open science and build a digital infrastructure that allows funding to serve the development in a practical and well-organized way. Meanwhile, through this process, the wisdom and spirit of humanity will be shared.

Third, in the reform era, we need to bolster intellectual property rights protection, science and technology ethics, and the self-regulation of the scientific community. It is highly valuable for the scientific community to promote open science by protecting intellectual property rights, the first scientific discovery rights, and the safe and reliable validation of scientific results. Posing questions is extremely important to understand the problem, and asking valuable questions relies on our unique perspective. We expect the publishing and scientific communities to think together and propose new useful questions.

3.1.2 Wei Yang: Open Science—From Academic Embrace to Implementation Pathway[3]

The open science movement is driven by Europe, with the active participation and support of the Third World countries in general. China's active involvement is beneficial, and it plays a role in building a scientific community with a shared future for humankind. For researchers, open science is conducive to improving data reliability and access to scientific data.

Regarding the number and impact of global research output, China has turned out to be the top one in the world in terms of a decade-long cumulative impact of chemistry, engineering, materials, and computer sciences. Many subject areas are ranked first in the world in terms of the number of international papers output. Concerning the development of world-class journals, China has just stepped up its efforts from 2020. It is hoped that by 2030 it will be able to take its place in global scientific publishing, and by 2050 it will reach a level comparable to that of Europe and the United States.

With scientific research and communication development, there has been an irreversible change in the form of scholarly publishing. This change is open access (OA), or open science as a whole is already on the agenda for advancement. The trend of international scientific publishing shows that OA has become a major model with a clear business and sales pattern. The business pattern is shifting from the original subscription model to Article Processing Charge (APC) model. Driven by the transformative journals, the sales pattern is continuously promoted by negotiating free APC for group purchases. China currently faces many challenges and opportunities in advancing open science.

[3]Wei Yang, Academician of Chinese Academy of Sciences.

3.1.2.1 Two Requirements for Embracing Open Science by Academia in China

China's substantive involvement in open science is insufficient and should be actively facilitated in this area. If we want Chinese academia to embrace open science, there are two requirements:

First, how to achieve a win–win situation for stakeholders? There is an asymmetry in the right and responsibility changes of readers, authors, publishers, libraries and funders in full OA. Is there a balance between the new rights and responsibilities that scientists gain in open science? What are the responsibilities of readers who have the right to read and do not have to pay for it? Authors benefit in terms of literature references and citations. They need to pay APC, but few authors pay double fees: APC and subscriptions. However, authors without funding support may have complaints. Publishers have a new business model (from subscription to APC) with a new sale pattern (group purchase). Libraries do not have to pay for subscriptions, but they no longer own the data. Funders avoid double funding and replace academic institutions as the primary payers. What is the rationale for funding institutions to pay more?

Second, how to build OA journals' reputation in Chinese academia? OA journals started with a poor reputation. China has now surpassed the United States as the top country for publications in OA journals, but the average impact factor of OA journals in which Chinese scholars publish is low. This creates a bimodal distribution. Of these, 75% of papers are published in lower end OA journals, many of which are predatory journals. The reputation of OA journals is getting better; for example, top journals (such as the Nature series) are moving from hybrid to transformative, with nearly one hundred journals joining the process. Most journals in the *Chinese STM Journal Excellence Action Plan* adopt the OA path. At the same time, we have published journal balcklists of predatory journals. Therefore, OA journals' reputation will gradually become better. OA has a citation advantage, and the impact factor of all OA journals is growing relatively fast. A shift in the global publishing paradigm is looming.

3.1.2.2 Open Science may Encounter Three Barriers to Implementation

First, who is the driving force? The main body of group purchase to the subscription model is the China Academic Library & Information System (CALIS), which leads the negotiation of the pricing framework from 2000 to 2035. Specifically, CALIS is responsible for subscribing to journal and database services for each library, and the academic institutions to which each library belongs pay the fees. This subscription entitles rights to libraries for using the purchased database in a specified IP networking. As for the OA model, authors pay APC for OA papers at a standard price, while academic institutions no longer own databases located in the cloud. It is inappropriate for government departments to negotiate group purchases directly with vendors. There is a question regarding who forms the group and who pays.

Second, how to narrow down the price difference asymptotically? China has evolved from a developing country to an academic power in 20 years. In the subscription model, CALIS leads the pricing framework negotiation, and the starting price of subscriptions for developing countries will reach 80% of the world average from 2000 to 2035. However, the APC for OA papers is set based on the world average price. China pays about 6% to 8% of the worldwide total of publication fees (including subscription and APC) currently, while the proportion of publications from China, as indexed in Web of Science, has reached 28.5% in 2020. If the subscription model is changed to the OA model, the payment price will increase 3 to 4 times. How to gradually narrow down the price gap?

Third, how to stabilize indigenous journal development? After an ill-considered conversion to open access, China's 5000 local scientific journals will likely fall into the doldrums. In a scenario of a global switch from the subscription to the open-access model, the funders consortium negotiates a group purchase agreement with publishing platforms. After the group purchase, major Chinese academic institutions acquire reading rights and limited publication rights to scientific data from corresponding publishing platforms, *i.e.*, APC-free within the agreed-upon share. In this case, authors from major Chinese academic institutions will submit most of their papers to publishing platforms after the group purchase payment, because these platforms are famous, influential, open, and non-paying. In contrast, China's 5000 local journals are distributed belonging to 4000 legal entities, which makes it challenging to initiate group purchasing and may lose most of the high-quality submissions as a result.

3.1.2.3 Four Paths for Chinese Scientific Journals to Achieve Open Science

The first is to build a world-class academic data operation and service platform in China. This platform should have a technical information and analysis team, platform operation capability (stream computing, server, application team), open scientific data (type, quantity and quality) comparable to competitors, the multi-dimensional capability of customizable service, and a good reputation among scholars.

The second is to constitute a composite entity to purchase open scientific data. The library union from academic institutions remains the main body, and the price framework in subscription agreements is used as the starting pricing for group purchases. The IP networking of academic institutions is maintained as reading rights coverage, and the address range of academic institutions is used as APC free subscribers. China National Publications Import and Export (Group) Corporation (which is granted the right to import and export scientific data), or the National Natural Science Foundation of China, acts as the principal unit.

The third is to adopt the price strategy combining base price plus funding subsidies. The academic institutions related to group purchases pay a base price not lower than the price of the previous data subscription model. It is necessary to enable funding agencies that initiate scientific data construction to act as a national strategic power for open science. This strategic power should establish a special national fund to subsidize the price difference for group-purchasing scientific data in multiple ways with state financial and social support. The group-purchase data should be used to support operating *Open Science and Services Platform*, and part of Platform profits should be used to supplement the special fund.

The fourth is to encourage group-purchasing China's own high-level open access journals. Seven ministries and commissions, including the Chinese Association for Science and Technology (CAST), have formed leadership in our journal community through the *Chinese STM Journal Excellence Action Plan* and other programs. The CAST could take the lead in developing an open-access assessment mechanism for 5000 local scientific journals in China. The CAST can create a journal list for journals included in the *National Open Science Database* based on assessments. Following the group-purchase data model from international open science publishing platforms, the selected journals would be group-purchased through national or institutional funds. The above process can be carried out in a dynamic adjustment manner.

3.1.3 Ke Gong: Reflecting on Open Science upon the UNESCO Recommendation on Open Science[4]

First, it is essential to recognize the historical inevitability of open science. From its inception, science has had an inherent need for open communication. Ways of communication are from the earliest correspondence between scientists to academic organization establishment, academic symposiums organizing, and academic journal creation. Venues of knowledge exchange and dissemination have become broader and expanded in spatial scope. It has been developing along extending openness direction. There are two significant changes at present. First, it is the global informatization since the 1990s. The Internet has freed and stimulated communication demands. It has provided unprecedented means of exchange and dissemination across time and space and offered feasibility to open science. Second, science and technology have become the first productive force permeating social production and daily life, which has led to widespread public concern about scientific results application. Scientific issues have transcended the realm of the scientific community to become a public concern, which creates a need for open science.

Second, it is worthwhile to understand the historical development of open science itself. Many concepts related to open science have emerged since the 1990s, such as post-normal science and public science. These were original concepts of the Science of Science, however, they have developed into science policy, public policy, and social movements nowadays, propelling a change in the form or paradigm of scientific research. Open science has also undergone a developing process from open data to open access, open infrastructure, open research, and eventually comprehensive open science.

Third, it is relevant to focus on the active role of the United Nations in open science development. The United Nations Educational, Scientific and Cultural Organization (UNESCO) is vigorously engaged in promoting the open science movement. At UNESCO's 40th Session of the General Conference in 2019, it adopted the proposal to establish a World Engineering Day and an International Day of Mathematics and proposed developing a UNESCO *Recommendation on Open Science* that would give countries a policy framework. In early 2019, the UNESCO Global Open Science Partnership was founded, including more than 50 organizations, and a 30-member advisory committee was created. The International Science Council (ISC) and the World Federation of Engineering Organizations (WFEO) are two key partners. In March 2020, the first proposal draft was available for public comment online and received more than 2900 responses from 133 countries. The second round of comments was later solicited through the Permanent Delegations and National Commissions. The Recommendation was then adopted by the 41st session of the UNESCO General Conference in November 2021. It became a

[4] Ke Gong, President of the World Federation of Engineering Organizations.

significant milestone in global science governance. China is the largest contributor of UNESCO, and we have a strong voice, but currently does not play a sufficient role.

The fourth is about the main elements of the UNESCO *Recommendation on Open Science*. WFEO has studied the exposure draft and provided some comments, whereas overall is positive. Four main points deserve attention in the second-round exposure draft of the Recommendation. First, it emphasizes that equal access to science and consuming science is a universal fundamental human right and that open science is conducive to implementing the *Universal Declaration of Human Rights*. Second, it stresses a need for open scientific cooperation and open science to cope with complex global problems. Third, it highlights that open science can play a role in science, technology and innovation (STI) and reduce differences in STI across countries. Fourth, while promoting open science to eliminate imbalances in scientific and technological development within and among countries, it underlines respect for cultural diversity and the plurality of epistemic sources and knowledge holders, including indigenous knowledge and citizen science.

Fifth, there is a need to thoroughly understand the UNESCO Recommendation and provide an international framework for open science policy and practice. UNESCO currently has 193 member states and requires consensus on open science. Feedback from two-round consultations already indicated that there is no problem to adopt the Recommendation by the 41st session General Conference. The Recommendation proposes an international framework with a fundamental consideration that recognizes regional differences in open science and is by no means a one-size-fits-all approach. It is necessary to consider those different countries, especially the developing countries, which have different paths of transition and to respect different choices made by the respective country scientists and other participants in respective country in response to disparate local challenges. Special consideration should be given to developing countries. Meanwhile, particular focus is placed on reducing the digital technology divide and the knowledge divide, which is an important goal of the framework. The framework gives a definition of open science as "an inclusive construct that combines various movements and practices aiming to make multilingual scientific knowledge openly available, accessible and reusable for everyone, to increase scientific collaborations and sharing of information for the benefits of science and society, and to open the processes of scientific knowledge creation, evaluation and communication to societal actors beyond the traditional scientific community"[1]. The framework outlines eight key elements of open science: Open access, open data, open source software and open hardware, open infrastructure, open assessment, open educational resources, open engagement of societal actors, open knowledge diversity (including indigenous knowledge). The framework sets out five core values: Collective benefit, equity and fairness, quality and integrity, diversity, and inclusiveness. The framework also suggests six guiding principles: First, basic requirements for science, namely transparency, scrutiny, open criticism, and falsifiability; second, equal opportunity and access; third, responsibility, respect, and accountability; fourth, collaboration, participation, and inclusion; and fifth, flexibility; and sixth, sustainability. The framework articulates seven areas of action: Promoting a common understanding, fostering an enabling policy environment, developing infrastructure and services, investing in capacity building, shifting culture and aligning incentives, promoting innovative approaches to open science at different stages, and promoting international cooperation in the context of open science. The framework also proposes some monitoring and evaluation mechanisms, a framework for dissemination monitoring, and monitoring strategies.

In summary, open science can be summarized into four needs: An intrinsic need for scientific development, an epochal need for social development, a need for human development, and a need for global sustainable development. In terms of the scientific community, open science is a new paradigm of global scientific innovation and a shift from normal to post-normal science. It is a significant change for us to deal not only with scientists but also with the public and all stakeholders. For the public, it is a shift from accepting scientific results to participating in the scientific process, which requires specific competencies. For governments and administrators, it is a shift from a science management model oriented toward the scientific community to one oriented toward multiple stakeholders. This transformation is not a national but a global one, and it is a very important opportunity for China to participate in the worldwide research governance system. Given this, it is strongly recommended that relevant Chinese authorities actively engage in discussions with international organizations through multiple channels.

Finally, I would like to put forward two thoughts and suggestions on open science. One is problem-oriented. What are we missing in shifting to open science? A particular emphasis should first be placed on ethos and culture. Open science is a great responsibility and must come with inherent rigor; otherwise, it is catastrophic. We must have integrity and rigor ethos and an open and inclusive culture to achieve open science. Nowadays, there is the excessive domestic competition, and research units are not adequately open internally. Of course, there are cost, evaluation, and trust issues within it. Therefore, it is necessary to deepen the reform of scientific research governance from concept to institutionalization in order to shift to the new paradigm of open science. The second is to take a strategic approach, suggesting looking at the big picture and starting small. The so-called "big picture" considers open science from a global sustainable development perspective, insists on the tone for global sustainable development, and promotes solutions for pressing global problems. China can be an active force in promoting open science from this perspective. "Starting small" means to start with open data and realize the FAIR principles advocated by ICSU, to achieve "Findability, Accessibility, Interoperability, and Reusable".

3.1.4 Juncai Ma: Advocating Open Science and Promoting Global Collaboration[5]

3.1.4.1 It Is Inevitable Human Development and Social Progress to Promote Global Multilateral Cooperation and Build a Community with a Shared Future for Humankind

On January 25, President Xi Jinping referred to global multilateral cooperation 11 times in his speech at the World Economic Forum's Davos Agenda 2021. He also pointed out that all global issues faced by humankind cannot be solved by any country alone, but must be solved by global action, global response and global cooperation. World problems are

[5]Juncai Ma, Research Fellow of Institute of Microbiology, Chinese Academy of Sciences, Director of the National Microbiology Data Center.

intricate and complex; the ways out of issues are to maintain and practice multilateralism and promote a community with a shared future for humankind. Science and technology innovation is an essential engine to human society and a powerful weapon for addressing global challenges. It is also a necessary path for China to build a new development landscape and achieve high-quality growth. Scientific and technological achievements should benefit all humankind and should not become a means to restrict or curb other country's development. China will continue to promote science and technology innovation and advance international science and technology exchanges and cooperation with more open minds and initiatives. It will also join hands with other countries to create an open, fair, impartial, and non-discriminatory environment for science and technology development and facilitate mutual benefit and sharing.

3.1.4.2 Open Science is a Powerful Leverage Point for Effectively Advancing Multilateral Cooperation in Global Science and Technology

Open science makes scientific knowledge more popular, scientific processes more inclusive, and scientific results more accessible, addressing special societal needs of different countries. It has great potential to achieve the United Nations Sustainable Development Goals (SDGs). At the 40th Session of the General Conference of UNESCO in Paris, 193 countries decided to launch a multi-stakeholder, inclusive and open consultation process to develop a new global standard-setting normative document on open science—a Draft *Recommendation on Open Science*. It outlines definitions, objectives, values, guiding principles and criteria for open science and aims to provide an international framework for open science policy and practice. In the Recommendation, it proposes seven key areas of action: (i) promoting a common understanding of open science, associated benefits and challenges, as well as diverse paths to open science; (ii) developing an enabling policy environment for open science; (iii) investing in open science infrastructures and services; (iv) investing in human resources, training, education, digital literacy and capacity building for open science; (v) fostering a culture of open science and aligning incentives for open science; (vi) promoting innovative approaches for open science at different stages of the scientific process; (vii) promoting international and multi-stakeholder cooperation in the context of open science and with a view to reducing digital, technological and knowledge gaps. The effective promotion of global collaboration is the most important foundation to reach the above goals.

3.1.4.3 China is an Essential Practitioner in Advocating Open Science and has made Substantial Progress, Especially in the Development of Major National Science and Technology Infrastructure and the Expansion of Global Cooperation

China attaches high priority to open science and proactively facilitates it, and China consistently increases its investment in research funding, personnel and the layout of major science and technology infrastructure. Data from the 2019 *National Statistical Bulletin on Science and Technology Funding Investment* showed that China's total research and development (R&D) funding investment exceeded RMB 2.2 trillion in 2019, up 12.5% from the previous year, achieving double-digit growth for the fourth consecutive year. In addition, the total number of Chinese R&D personnel is expected to reach 4.18 million, ranking first in the world. At present, the National Development and Reform Commission has laid out and built 55 national science and technology infrastructures to enhance the opening of major science and technology infrastructures to the public, following requirements from the *State Council's Opinions on National Major Research Infrastructures and Large Research Instruments Opening to the Public* (Guo Fa[2014] No. 70). In terms of international science and technology cooperation, since 2013, when President Xi Jinping proposed the Belt and Road Initiative, joint construction of the Belt and Road has dramatically contributed to science and technology development in countries (regions) along the route. It has opened an opportunity window for extensive international cooperation in science and technology. During the 14th Five-Year Plan period, it is still necessary to adhere to open innovation and strengthen international science and technology exchanges and cooperation in the face of new situations at home and abroad, to build a new development pattern.

The National Science and Technology Resource Sharing Service Platform is a national science and technology innovation base that provides networked and socialized science and technology resource sharing services for scientific research, technological progress, and social development. It is oriented to the needs of science and technology innovation, economic and social development and innovative social governance, and building a safe China. It also reinforces the organic integration of high-quality science and technology resources and enhances the efficiency of using them. In 2019, the Ministry of Science and Technology and the Ministry of Finance carried out optimization and adjustment work on original national platforms, which has formed 20 national scientific data centers and 31 national biological germplasm and experimental material repositories. These optimization and adjustment are to standardize management of national science and technology resource sharing service platforms, improve science and technology resource sharing service systems, and promote opening and sharing of science and technology resources to society. In addition, the General Office of the State Council issued *Measures for Scientific Data Management*. The measures make institutional arrangements for scientific data archiving generated from science and technology programs (special projects, funds, etc.) funded by government budgets at all levels and further facilitate open sharing and utilization of scientific data.

The Institute of Microbiology of the Chinese Academy of Sciences (IMCAS) hosts the National Scientific Data Center for Microorganisms and the World Data Center for Microorganisms, leading global collaboration on big data in the microbiology field. The Center is currently leading the *Global Catalogue of Microorganisms* (GCM), an international partnership that will provide a unified global repository for valuable microbial resources scattered among conservation centers and scientists worldwide. At present, 142 microbiological institutions from 51 countries are participating in this global collaboration. The data platform has included collection, separation, conservation, usage, and patent information of 490 000 microbial resources, providing the resource information services of microbial strain for the scientific and industrial communities worldwide. In 2018, the World Data Center for Microorganisms of IMCAS proposed a global collaborative project on genome sequencing, data mining and functional resolution of 10 000 microbial type strains (GCM 10K Type Strain Sequencing Project). It was widely reported by international media such as *Science*. As an international big science program led by China, this program is established to cover major partners worldwide. It particularly aims to establish a system for sharing scientific and technological resources between developed and developing countries, to gather global advantageous scientific and technical resources and top scientific talents in the field of microbiology, and to help solve fundamental and frontier scientific problems of microbiology. It also contributes the Chinese wisdom and solutions to international cooperation in honoring an agreement with the *Convention on Biological Diversity* and compliance with the transnational transfer of biological resources and benefit-sharing mechanism in the *Nagoya Protocol*. Thus, it fully reflects China's competitiveness in science and technology innovation and its comprehensive ability to be an international leader in the field of microbiology.

3.1.4.4 Suggestions for Open Science Developments in China

China is a significant producer of scientific papers and data and an active leader and player in global open science. China has made substantial progress over recent years in scientific data management, open access to scientific and technical information, open science infrastructure, and international cooperation at the national level.

I have several suggestions for China's open science efforts. First, there is a need to actively and orderly advocate open science by focusing on practical results and significant achievements. Second, we need to take full advantage of China's major infrastructures, effectively use big data, cloud computing, artificial intelligence and other new technologies. Moreover, we should comprehensively increase the level of open sharing and the use of major national infrastructure, and new technologies, approaches and platforms, and enhance the usage value of scientific data. Third, it is necessary to actively carry out and lead global multilateral international cooperation dedicated to the collaborative governance and practical application of open science.

3.1.5 Xiang Ren: The Changing Role of Journals in an Open Science Ecosystem[6]

From open access to open science, the scholarly communication and research systems are undergoing a fundamental transformation across the globe. The open movement is disrupting the traditional academic publishing system led by high-impact journals and multinational publishers and profoundly changing the way scientific research is conducted, communicated, and assessed. For the scientific community, "openness" means not only the open access to scholarly content but also the open practices like open data, open scholarly communication, citizen engagement of science, as well as the collaboration between research institutions, industries, and communities.

The global Covid-19 pandemic has made open science and open knowledge sharing more important and necessary than ever before, and international organizations such as the World Health Organization to UNESCO are calling for open science to facilitate international scientific collaborations in the fight against the unprecedented epidemic. This has given further impetus to the development and implementation of open science policies around the world—both the EU and the UK have mandated that research results funded

[6]Xiang Ren, Research Fellow at Curtin Open Knowledge Initiative (COKI) and Western Sydney University, Australia.

by public institutions must be made freely available to the public immediately after publication; the Netherlands has even removed the impact factor as an indicator for research evaluation; China is also reforming its research evaluation system to break the existing framework that exclusively relies on the quantities of publications in order to comprehensively evaluate the value of research outputs and facilitate the translation of scholarly research into economic and social benefits.

In the global movement of open access and open science, scholarly journals seem to the target of wide criticism. However, as the primary vehicle of scholarly communication in the past centuries, have journals really fallen behind open science evolution? How can Chinese academic journals evolve to adapt to an open science ecosystem?

3.1.5.1 Three Key Points Regarding the Open Transformation of Chinese Journals

I would like to make three points regarding the open transformation of Chinese journals in the light of the global development of open access.

First, it is vital to resume journals' original function of scientific communication. The fundamental value of academic journals is nothing but officially publishing the peer-reviewed research results, but this function is misused and distorted as a mechanism of academic evaluation, especially driven by the industrialization and globalization of the neoliberal higher education system. In the environment of open science and digital publishing, journals have opportunities to harness technological innovations to reinvent their dissemination function and value propositions. For example, digital platforms could significantly reduce the costs of replication and distribution of content; big data and semantic analysis could be used to assess the impact of papers (instead of citation counts); the open and social models could increase the transparency and objectivity of peer review; the priority of scientific discovery can be registered more securely through blockchain technology; some European and American journals even use artificial intelligence to polish and re-write the manuscripts submitted by non-native-English authors to address the inequality caused by linguistic backgrounds. The core of all these innovations is to reallocate academic publishing resources whose scarcity is sometimes just artificially created and eliminate the distortion of journal functions, making journals truly a carrier and provider of scientific communication.

Second, the business model should move beyond the limited alternatives of either subscription or APC (Article Processing Charge). In the United States and Europe, the dominance of these two business models has become a bottleneck for OA development. The expensive journal subscription fees set by the big publishers have made it unaffordable to libraries, resulting in the so-called "journal crisis" in the past decades. As a result, more than half of academic papers that are locked behind the paywall have not been read by anyone but their authors and reviewers. Commercial OA publishing models, though opening up content access, shift the cost from readers and libraries to the author side through the APCs, making the overall economic burden of academic institutions even heavier. The current discourse around OA business models in China is unfortunately greatly influenced by multinational publishing giants, and golden OA and APCs thus seem to be the only reasonable choice – which is misleading. The funding sources for Chinese journals are more diversified, and there is not yet a monopoly of commercial publishing giants. The industry structure of Chinese journal publishing provides more room for innovation in OA models, such as institutional crowdfunding, green OA repositories, public funding, government support, and platform subsidy. All these will help enhance the economic sustainability of open publishing and perhaps even establish a comparative competitive advantage over the European and American publishers eventually.

Third, China's open access journals should go international. The Chinese journal community has long been suffering from the lack of high-quality submissions from domestic authors. There are constant calls at the policy level for prioritizing domestic journals for publishing the research results. However, the open science ethos is to promote a global flow of knowledge exchange. China has become a global science powerhouse based on its indigenous research and innovation system and largely the Chinese language scholarly communication framework independent from the West. Such independence is an advantage, but may also mean a potential barrier against the free flow of global open knowledge exchange. Like the OA business models mentioned above, this is not a simple choice between "domestic and foreign", or between "Chinese and English". Chinese journals should expand the international publishing space in their own way, in terms of authorship, editorial board, peer-review, and content or information services. From the perspective of open science, it is more meaningful to integrate into the international system than viewing global academic publishing from a standpoint of the competition between the Chinese and foreign journals. Further, internationalization is not only about publishing English journals but harnessing the dynamics of bilingual publishing. One of the meaningful and urgent things to do is to invest in the translation of scientific papers between English and Chinese or develop advanced artificial intelligence tools for such translation tasks, which will significantly contribute to the open exchange of research outputs and scholarly content between China and the world.

3.1.5.2 From OA Journals to Open Science Infrastructure

In the open science environment, research communication is far beyond an academic publication. The rise of open data, for instance, has necessitated the transformation of journal publishing to data publishing or even platform publishing. Open data are a fundamental component of open science. Only through the sharing of scientific data can we truly achieve the openness of the scientific process and collaborate freely and conveniently. However, the storage, accessibility, and indexing of research data are highly concentrated and controlled by the monopolists of commercial academic publishing. As a result, a large number of precious data resources are not in the hands of the academic community. Meanwhile, neither individual universities nor small- and medium-sized publishers have sufficient resources to establish and operate open data infrastructures.

Therefore, the focus of the open science movement in Europe and the United States is shifting to the development of community-led open infrastructure and ecosystem, which thus connect various open initiatives and integrate them for interoperability. Many have designed and built their open science infrastructures following the principles of open scientific communication and addressing scientists' needs for collaborative research. The Chinese journal publishing industry has much to offer in this regard, which could change the future of scholarly publishing.

3.1.5.3 "Open Knowledge Institutions" and the Opportunities for Transformation

In recent years, I have been working with international colleagues to develop and advocate a concept of "open knowledge institutions" and the framework for its implementation, calling for a reinvention of universities (and other knowledge organisations) in terms of its roles and value propositions in the creation and communication of knowledge. The 21st century is characterized by innovation and uncertainty, and scientific research demands a more efficient, collaborative, and ultimately open model to address the world's pressing challenges. As an important aspect of open knowledge institutions, we advocate that the existing knowledge creation model and research evaluation system should be reformed, focusing on scientific collaboration and impactful research so that universities work closely with industries, communities, and the public to create and manage knowledge commons.

Regarding research communication and academic publishing, the research outputs should be presented and communicated in more diverse forms, which breaks the monopoly of traditional journals and thus provides opportunities for open transformation and innovations. How can we include more diverse forms of research outputs while keeping research evaluation reliable? How can we enhance citizen participation in science while maintaining peer review and reasonable quality control? How can we achieve the vision of "big research" through boundary-spanning cooperation and the reform of research communication and evaluation? These are the questions worth further discussion in the journal publishing industry and beyond.

3.2 The Practice and Development of Open Scientific Data Sharing

3.2.1 Xin Li: Enhancing Data Publication and Promoting Open Sharing of Scientific Data[7]

Scientific data are a fundamental strategic resource for national science and technology innovation. It is vital to encourage open sharing of scientific data for data full utilization, open science progress, and science communication acceleration. Open sharing principles of scientific data have transitioned from the Full & Open principle to the FAIR (Findability, Accessibility, Interoperability, and Reusable) and CARE (Collective Benefit, Authority to Control, Responsibility, and Ethics) principles, which are now commonly followed. The FAIR principles emphasize technological progress, while the CARE principles focus on policy change. They complement each other, reflecting technology and policy as the dual-wheel drive to scientific data sharing in the era of big data.

[7]Xin Li, Research Fellow of Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Director of National Tibetan Plateau Scientific Data Center.

China's Ministry of Science and Technology (MOST) issued the *Measures for Scientific Data Management* in 2018, specifying that data openness is a fundamental principle for research projects funded by government research grants. It aims to improve sharing service system to scientific and technological resources and promote these resources sharing to society. In June 2019, the first batch of 20 national scientific data centers was launched, 10 of which belong to the Earth and Environmental sciences. It indicates that the open sharing of geoscientific data in China has come into a new stage.

3.2.1.1 Urgent Demands Are Made on Data Publishing in the New Phase of Open Scientific Data Sharing

China has made significant progress on open scientific data sharing. Taking geoscience data sharing as an example, the Major Research Program in Geoscience of the National Natural Science Foundation of China and the Earth Big Data Science Project of the Chinese Academy of Sciences have become benchmarks for open geoscience data sharing. However, there are still some gaps between Chinese scientific data sharing in general and international, such as many challenges in management and technology. There is especially a lack of unified norms for data measurement and standardized data citation, which affects the incentives of scientific data contributors and opening scientific data.

Data publishing is an effective means to promote scientific data sharing. It can mainly take reference from academic paper publishing, which describes scientific data itself in a standardized way, undergoes strict peer review, and complies with academic publication norms. Data publication not only helps to better realize the FAIR principles and CARE principles of scientific data sharing, but also plays an essential role in ensuring scientific data quality and improving the discoverability, accessibility, and reusability of data. At the same time, data publication is conducive to effectively motivating data contributions, thus promoting more openness of data resources.

Data journals are an influential vehicle for data publishing and have become a new direction in scientific journal development in recent years. For example, *Earth System Science Data*, a data journal founded by the European Geosciences Union, and *Scientific Data*, founded by Springer Nature. These journals have grown rapidly since their founding and have published a large number of far-reaching data papers. In China, the Computer Network Information Center of the Chinese Academy of Sciences founded *China Scientific Data* in 2016. The Institute of Geographical Sciences and Natural Resources Research of the Chinese Academy of Sciences established the *Journal of Global Change Data & Discovery* in 2017. The Big Earth Data Science Engineering of the Chinese Academy of Sciences founded *Big Earth Data* in 2017. These Chinese journals have played an important role in promoting scientific data sharing. However, Chinese scientific data journal development is not precisely consistent with the needs of scientific data generation, development and openness, and it requires vigorous growth.

3.2.1.2 The Co-Development of Data Journals by Data Platforms and Publishers

Data platforms need to proactively adapt and support data publishing needs, reduce data downloading barriers, and standardize data citation. For example, National Tibetan Plateau Scientific Data Center supports the Digital Object Identifier (DOI) and China

Science and Technology Resource Identification (CSTR) to scientific data. The Center also adopts Creative Commons 4.0 protocol and supports login-free downloading. This data platform has been certified by Springer Nature and recommended by the American Geophysical Union (AGU) as a data repository.

In order to better adapt to the mutually reinforcing trend of data publishing and paper publishing in the era of open science, China's scientific journals and data centers can comprehensively cooperate in the following aspects.

(1) The first-class multidisciplinary journals in China (*e.g. National Science Review* and *Science Bulletin*) should take the lead in requiring synchronous submission of paper-related data when papers are submitted, with domestic data centers as preferred data repositories.
(2) Influential domestic geoscientific journals should cooperate with data centers to carry out paper-related data submission and archive as early as possible, and a certain number of data papers should be encouraged to be published in these journals.
(3) Scientific papers need to improve data citation and follow the data citation standards to cite key datasets supporting paper results. Meanwhile, it is necessary to improve the data citation analysis. The number of citations and other impact indicators can be used to represent the intellectual property rights and contributions of data authors, which can incentivize data sharing and serve to open data sharing and open scientific research.

3.2.2 Guoqing Li: Understanding Far-Reaching Implications of Open Science from the Perspective of Data Lifecycle[8]

Viewing the scientific data lifecycle from the perspective of data center management is the basis for our understanding and management of scientific data and the development of scientific data management policies. Whether studying data policy, conducting data governance, or carrying out data services, it is essential to fully consider data generation, transmission, storage, dissemination, and analysis. The data dissemination achieves data subjects' conversion and allows other types of users to analyze and generate new data, thus opening a new cycle. What is the effect of open science on the data life cycle in such a process?

First, in terms of data generation, the immediate effect of open science is that there are more data sources than before. Traditional scientific data come from laboratories, including analytical instruments, computational simulations, and observation equipment. These data are more rigorous for data production, with a complete set of control measures. By contrast, in the context of open science, the boundaries of data production are more ambiguous. More and more people from non-professional or interdisciplinary fields are not only consumers of data but also producers of data. Therefore, there will be more and more data from the public and people outside the field. In the open science environment, data managers are faced with a complex data generation process, and one of the most immediate

[8]Guoqing Li, Research Fellow of Aerospace Information Research Institute (AIR), Chinese Academy of Sciences, Director of National Earth Observation Data Center.

problems is data quality, which is an emerging issue worth the scientific community taking seriously.

Second, the data dissemination pattern is diverse. In the past, data dissemination was dominated by traditional data sharing, and the data publishing that we are discussing now is a new form of data dissemination. Apart from that, there are self-service forms. In the era of self-media, scientists have no time to wait or are unwilling to use the various new dissemination rules. In such a case, they can build their own websites to serve themselves and disseminate for themselves. In open science, new forms of dissemination will become more and more complex.

Third, the data storage landscape has changed. There are 20 national scientific data centers in China, and even more data centers at other levels. The core reason for data storage changing is that it is essentially an issue of replicability of digital objects when we deal with data objects. It is effortless for these data objects to be replicated. Once the data is assembled, it will have new scientific values and become a new data form. Massive combinatorial forms are created at this point, and these combinations will have their actual value and existence necessity. However, the boundaries of data organization and ownership become blurred. The complexity here is not only reflected in new scientific meanings of data combination, and it also reflected that the combination and decomposition of original data would bring opportunities to new service providers. It is further reflected in the management of multi-point storage and services due to the big data storage architecture on the Internet. Moreover, the diverse data custodians that emerged in the process is another kind of complexity, which will proliferate to countries, enterprises, and individuals. In short, the data storage landscape in open science is not a unified process but rather an increasingly diverse one.

Fourth, data rights will be subdivided. The issue of data rights is very complex and fundamental. Generally, data rights include at least ownership, attribution, storage, use, distribution, etc. When we used to perform data services in a closed system, we were not sensitive to the complexity of these rights, which is because many rights issues are shielded and simplified by the administrative system. However, in an open environment, these issues are sensitive. Rights that were not considered a problem in the past can now become a problem. Therefore, we have developed many mechanisms and rules that try to make these rights problems do not affect data circulating. It is indeed a complex issue requiring synchronized follow-up laws, policies, and technologies.

Fifth, the data ecology will change. The centerpiece of data ecology is the win–win benefit of all parties involved. Without a win–win situation, the ecology is not sustainable, and it will be a false and pseudo-ecology. At present, the most central issue in data ecology is the academic evaluation system, which is the primary motivation in scientific creation. Open science provides a new possibility for academic evaluation, which will enable us to give more consideration to human factors when we carry out S&T innovation. The initiative of scientists largely relies on the stimulation of academic assessment.

One final point is about who should pay. Openness is not equal to free of charge in open science, but people are always willing to say that "open" is the same as "free". When users ask whether the resource is open, they mean whether it is free. However, there is always a cost to do something, and it costs money. There is no way to make things work without spending money, which is the core issue that we could not elude.

Open science is a new scientific community and research architecture that benefits the entire human society. Open science is literally equivalent to providing us with a new research infrastructure, which is open to data itself. Since it is a type of infrastructure, major investors should be public beneficial. In the past, this issue was not considered in publishing activities because publishing activities were driven by active commercial publishers who intervened in the publishing process. In the new open science landscape, it would, of course, be great if the publishing community could have a better business model. However, I am not very optimistic about this because it always takes one to two years before the time comes to financial rip-offs. The commercial sharing behavior will eventually come to exploit and harvest consumers. Therefore, the real reliable original power to open science should come from the government's public welfare support. Open science should be incorporated into the national scientific governance system.

3.2.3 Juanle Wang: Progress and Development Recommendations for Earth Science Data Sharing[9]

Long-term geoscience data records are an indispensable foundation for scientific findings that reveal the evolution of matter, life, geography, and climate. Earth Science data sharing is also particularly relevant to address challenging and unprecedented global environmental issues such as climate change and to achieve the UN Sustainable Development Goals (SDGs) at this stage. However, the ubiquitous and ever-accumulating geoscience data records are spread all over the world. These deep-time geoscience data with diverse sources, heterogeneous types, different scales, and rich contents have long been challenging to share and utilize.

Geoscience data management and sharing received attention and appreciation at the International Geophysical Year (1957–1958). The World Data Center (WDC) was established under the International Science Council in the same period. The system developed rapidly from 1957 to 2007, and formed a group of World Data Centers mainly in Earth sciences but also involving many other research fields. With the continuous expansion of disciplinary groups, and in order to enhance WDC systemic construction, the WDC was officially renamed the World Data System (WDS) in 2008. Its mission is to provide quality-assured long-term preservation, management, and open services for scientific data, products, and information. As of June 2020, WDS has 83 full member organizations of data centers, and most of them are well-known scientific data centers in geosciences.

The management and sharing of geoscience data in China generally lag behind the developed countries, but there have been rapid growth and significant development in recent years. As early as in the WDC phase, China established nine disciplinary data centers in 1988. Many of these data centers have been retained and have successfully entered the current WDS phase. At the beginning of the 21st century, under a series of initiatives such as the pilot scientific data-sharing project of the Ministry of Science and Technology and the National Science and Technology Infrastructure Platform

[9]Juanle Wang, Research Fellow of Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences, Research Fellow of State Key Laboratory of Resources and Environmental Information System.

Construction Project, China has rapidly developed several scientific data platforms in different research fields, including Earth Science. The General Office of the State Council issued the *Measures for Scientific Data Management* in March 2018, the first scientific data management measure issued at the national level in China, which set an action agenda for scientific data work. In June 2019, to implement the requirements of *Measures for Scientific Data Management* and *Measures for National Science* and *Technology Resources Sharing Service Platforms Management*, the Ministry of Science and Technology and the Ministry of Finance carried out optimization and adjustment work on the original national platforms, and created 20 national scientific data centers. Approximately half of these scientific data centers are related to Earth Science.

In order to further narrow the gap with international geoscience data management and sharing, and to reinforce and accelerate geoscience data sharing in China, three recommendations are proposed was follows.

3.2.3.1 Strengthening the Construction of Scientific Data Repositories in the Earth Science Fields

The Data Repository is an effective mechanism and informational facility for storing and managing scientific data. The Registry of Research Data Repositories (http://re3data.org) is a comprehensive global research data repository registration platform. The number of research data repositories included in re3data.org exceeded 1000 in November 2014 and 1500 in April 2016, and as of July 2020, 3487 data repositories have been registered in re3data.org. Currently, there are 48 data repositories in China (without counting data from Taiwan, China), the number less than India (51), and even more disparate from the developed countries. For example, there are more than 1100 data repositories in the United States. The American Geophysical Union (AGU), for example, identified 228 data repositories affiliated with it in 2020, requiring that data from all papers published in its sponsored journals should be stored in these repositories. China has only 15 geoscience or public data repositories, which is apparently far behind the developed countries. From the above, China's international data repositories in geosciences are inadequate, and it is urgent to establish more geosciences data repositories.

3.2.3.2 Enhancing Data Governance Capacities in Scientific Data Centers

As a well-functioning data center, there are three exceedingly essential factors in data governance. First, it is necessary to have a permanent data coding system. The current international identification coding system such as DOI is mainly used, and China has also launched the China Science and Technology Resources Identification System. Second, the data center should have the ability to add value in processing scientific data. If it only provides a repository and intermediary data services, this data center will lack vitality. It is only by stepping up the research and development of data products and functions and increasing the value-added utilization of data, that the service quality and standards of data centers could have improved. Third, it is important to have a sustainable operating model. We could not simply rely on state investment but have to establish a sustainable development mechanism suitable for data centers' long-term survival. It is especially vital to promote a data center's own steady stream of sustainability. In this regard, a remote sensing data center of WDS Germany has done a remarkable job. The center has set up three internal departments, namely, the data archive department (whose function is to solve long-term accumulation and preservation of data); the data R&D department (whose role is to solve problems of new methods to boost data processing); and the data service department (whose function is to solve data management and service issues and provide value-added services). Indeed, the premise of the above elements is to do an excellent job in data quality. Only data that has undergone strict quality control has the meaning of long-term preservation and open service.

3.2.3.3 Facilitating a Paradigm Shift in Big Data-Driven Earth Sciences Discovery

Deep-Time Digital Earth (DDE), the world's largest geoscience consortium, is a scientific program launched by the International Union of Geological Sciences (IUGS) in 2019. DDE aims to enable and enhance data-driven discovery in geosciences and create deep-time geoscience data centers that are interoperable with other databases. Its vision is to "integrate global data on Earth's evolution, share global geoscientific knowledge, and promote transformative advances in the Earth Sciences." DDE will build a data infrastructure based on FAIR principles (Findability, Accessibility, Interoperability, and Reusable) that links existing deep-time geoscience databases and provides data sharing and services.

The most revealing aspect of the DDE science program is to fully explore the interaction between data and knowledge. It leverages big data to facilitate discoveries of deep-time Earth Science knowledge while using knowledge mapping and knowledge systems to enable data linking and sharing. With the help of big data, big knowledge, big platform, big science and big communication system, DDE drives research paradigm changes and significant scientific discoveries to Earth's matter evolution, life evolution, geographic evolution and climate evolution.

3.2.4 Jian Wang: The Model Evolution, Development Direction and Policy Recommendations of Scientific Data Sharing[10]

3.2.4.1 Scientific Data Sharing Models and Their Evolution

The "knowledge explosion" after World War II boosted the spread of science and technology. In the field of publishing, a large number of academic journals were created and developed. In scientific data sharing, production scale and sharing demand for scientific data have grown. The primitive "one-to-one" data-sharing model, which is limited to acquaintances circle, has increasingly exposed severe shortcomings in terms of dissemination efficiency and effectiveness. As a result, more efficient data sharing models mediated by disciplinary/domain scientific data centers have emerged. A representative example is the World Data Center, established in 1957. After more than half a century of development, science data centers have become the main body of scientific data aggregation and

[10]Jian Wang, Research Fellow of Agricultural Information Institute, Chinese Academy of Agricultural Sciences.

distribution. A "centralized" data-sharing model has also been formed and adopted led by these data centers.

The first significant paradigm evolution was from a primitive data sharing model to a "centralized" data-sharing model. The evolution is inherently driven by the quest for greater dissemination efficiency. The evolution path is to advance data dissemination from one-to-one and episodic direct delivery to intermediary-dependent, full-time, full domain community diffusion. This evolution not only improves dissemination efficiency but also brings the potential for more reliable and persistent data storage capabilities and data citation.

The Open Science movement has prompted academic journals to pay more attention to scientific data, making it a new force in the development of scientific data sharing. This attention, which was mainly manifested in recommendations for authors to submit supporting data for their papers in the early days, has gradually become a mandatory requirement and, more recently, has led to innovative forms of data papers. Leonardo Candela's team compiled a list of 115 academic journals that carry out data publishing in 2015. Fenghong Liu of the Chinese Academy of Sciences updated and presented a new list containing 168 journals in 2019. Although there are 168 journals, the data volume they publish is still small. However, it means that academic journals are starting to become a new vehicle for scientific data sharing. It also marks that the academic community accepts data publishing as a sharing model. It is important to note that "scientific data publishing" in this context is strictly defined. It includes four elements: unique identification, quality control, durable and reliable storage, and standardized citation. Furthermore, the recognition of academia is the ultimate criteria for whether a dataset can become a research element and thus a substantial part of academic dialogue.

Obviously, the current scientific data sharing is at the stage of competitive development between the two sharing models mentioned above. They differ significantly in the paths, media, institutionalization and capacity of dissemination. They eventually generate a complementary landscape in which both advantages and disadvantages of dissemination efficiency and effectiveness are present together.

By analyzing the internal logic of the above three evolution models, we can find that the pursuit for the dissemination efficiency and effectiveness of scientific data alternately becomes a primary driving force to model evolution. In addition, the evolution is often accomplished in the form of breaking bottlenecks or addressing challenges.

3.2.4.2 The Development Direction of Scientific Data Sharing

A review of the evolving logic of the three models described above helps us analyze the future direction of scientific data sharing. We believe that the future direction should be a combination of higher dissemination efficiency and stronger dissemination effect, and will be achieved in a way that overcomes current difficulties or challenges.

One of the critical challenges facing the "centralized" sharing model is the suspicion from academia about its dissemination effectiveness. Although several standards of data citation have emerged, concerns about the quality control mechanism continue to make data reuse and citation less effective than desired. In addition, the data publishing model suffers from both publication efficiency and effectiveness, while both bottlenecks ultimately will focus on the quality control issues in the basic form of "peer review".

We also note emerging initiatives in scientific data sharing and scientific journal publishing dedicated to addressing the challenges mentioned above. These initiatives are either focused on system optimization or change, as is the case with F1000Research, or are characterized by the proliferation of new technologies, as with the Orvium, or a combination of both, as in the case of Figshare.

Further analysis of these responses and their effects reveals that "decentralization" and "process transparency" have become the most important conventions among various stakeholders in scientific data sharing. Thus, it seems reasonable to predict that the decentralization and the transparent quality control mechanism are likely to be the core of the next scientific data-sharing model while maintaining the current institutional standards.

3.2.4.3 The Role of Open Science and New-Generation Information Technologies in Sharing Model Evolution

Our preceding analysis focuses on internal driving forces for sharing model evolution. In fact, changes in the external socio-technical environment are equally critical. Among them, open science and new-generation information technologies play a paramount role.

Open science has profoundly engraved the shape of modern scientific research and science and technology communication. On the one hand, open science has promoted more open, transparent and collaborative research behaviors within the academic community; on the other hand, it has built a bridge of communication and collaboration between the academic community and the public. It hence encourages innovation socialization, dramatically enhances the significance and necessity of scientific data sharing, and provides a good, even somewhat compulsory, external environment for sharing model evolution.

The new-generation information technologies provide necessary technical support for the development of scientific data sharing. Although scientific data sharing is not traditionally an information technology-intensive activity, as the digital economy and technological innovation continue to push up comprehensive values of scientific data, new-generation information technologies such as blockchain are widely and actively applied in scientific data sharing.

3.2.4.4 Policy Recommendations

China is currently in the overtake period to build into a powerhouse in science and technology and achieve science and technology innovation from following, paralleling to leading. Scientific data sharing is under pressure to provide better support for science and technology innovation, but it also has a favorable external environment, such as the accelerated development of open science. To further promote scientific data sharing in China, we suggest making the best of opportunities upon by the paradigm shift in scientific data sharing, aiming at independent development and enhancing international competitiveness, advancing institutional innovation and new technology applications in parallel, accelerating to construct a high-quality scientific data sharing system with Chinese characteristics. In this regard, we propose three specific recommendations:

(1) Further promote institutional innovation in scientific data sharing. With scientific journals and scientific data centers as the focus, we should encourage these two types of key sharing participants to explore and build sharing systems, business models, key technologies and infrastructures that fit disciplinary characteristics.
(2) Further formulate implementation mechanisms of academic performance incentives and economic values related to scientific data. It is essential to encourage various types of participants of scientific data sharing to explore diverse incentive approaches, promote establishing a sustainable scientific data ecosystem, and provide a dynamic and sustainable external environment for the model evolution of scientific data sharing.
(3) Prospectively conduct research on the next generation of national scientific data-sharing infrastructure. It is necessary to follow the evolution laws of scientific data sharing, and make full use of new-generation information technologies such as blockchain, artificial intelligence, cloud computing and big data. It is also important to prospectively deploy research on new cross-institutional, cross-system and cross-platform infrastructures to significantly improve scientific data sharing and the governance capability of data security, and further, strengthen the aggregation capacity of global high-quality scientific data resources and the support capability of science and technology innovation.

3.2.5 Hong Xiao: A Few Reflections on Open Scientific Data Sharing[11]

Whether open science and scientific data have a promising future in China depends on a game of strength and weakness, which will bring many new problems. I think advocating open science and open data in China is still an emerging issue, and four aspects deserve attention.

First, it is necessary to establish appropriate open data policies. Where is the organizational guarantee for data opening at the national level? How should laws and ethical codes of conduct be formulated, including managing intellectual property rights? What are the reward and punishment systems and incentives for data openness? How to raise public awareness and stimulate active and voluntary participation? All these issues need to be implemented step by step, taking China's national conditions into account, especially the differentiation of open models, as some are confidential while others are open to share. This difference may also arise in an organization, an institution, or a scientist. Since we emphasize open science, we also need to study ethical matters of open science, such as how to ensure open data for most basic sharing and its quality and integrity. Should we share the best or worst data? How to deal with it? Or share what authors believe essential, which does not seem to be the most important to third parties. These points involve ethical issues of open science and require us to set up some norms.

[11]Hong Xiao, Deputy General Manager of China National Knowledge Infrastructure, Vice Chief-editor, Senior Editor.

Secondly, we should establish an effective mechanism for collaboration and operation of data open. How to establish an effective mechanism of data collaboration between different organizations and different institutions? What kind of mechanism can we adopt to efficiently achieve open sharing purposes in cross-disciplinary, cross-regional, and cross-system collaboration? In this process, how to prevent the data monopoly? There are data from R&D institutions, from units with high research levels, and from units with inadequate research levels. Different scientists have different discursive power in front of the same selected subjects. Thus, collaborative innovation needs an effective open collaborative mechanism as a guarantee, and the support of a well-built platform and operator to sustain.

Third, there is a need to establish a well-organized open data management system. A complete knowledge management service system includes many key elements: data classification and processing, data citation, historical data sorting, storage and management, and data future storage. How to organize such a management system, who should participate, and how to function effectively? China still has relative weaknesses in these aspects. Some research units, especially state-owned research units, have built up some scattered open data platforms, and some of them have established links with international organizations. However, whether these platforms can be widely applied in the whole society of China is a critical issue and a systemic challenge. Moreover, such a management system also involves funding issues for sustaining open data development. Who should pay for the cost of management and services, to be supported by state project funds? What if there is no funding support after a project is completed? How to continue data processing afterwards? How to maintain and update? How to keep open services? If China adopts a market mechanism, there will be a problem of industrial return. Maintaining such a management system will be extremely tough if we cannot reach a sustainable operation mechanism.

Fourth, we need to coordinate the conflicts between data opening and protection. Many data need to be protected in practice. It undoubtedly has conflicts between different interest groups on whether to open up or not. It is a distinguishing problem between private or public ownership of data, which is a system issue of data and is related to the sovereignty of data, depending on who owns the data sovereignty. State-owned data can be shared as long as the state agrees and supports it. However, private institutions or enterprises, data generated from their own investments, if these institutions want to take out their data to share, where is the possibility of this kind sharing, and how to better pry data openness of this piece. Especially data publishers and disseminators have different interest demands. Some want to share data to achieve faster and better communication, but some want exclusive data access to maximize market interests. From a publishing perspective, this is a conflict between cultural industry and cultural business, a conflict between public service and market industry. If we emphasize that all state-funded papers should be open, do we still have a data industry if we develop in this way? Why have many international open platforms been established based on the industry? Papers on international publisher platforms can remain open because journals rent their platforms to make papers open access. It is to pay for open access, which is still a market-oriented and industrial open-access situation. However, the scenario is not that simple if these data are involved in data protection issues between countries, including conflict of interest issues between countries. In the 20th century, the U.S. Congress passed a bill to allocate $50–60 million per year to create a web-based version of *Index Medicus*, *Medline*. *Medline* is open to the world for free access, but also requires submissions of abstracts and full text from journals worldwide. In case of a political conflict, however, the platform turns off access to China, we scientists will not be able to do our medical research work. Therefore, there is a risk of national conflict of interest in data sharing, and it will involve the boundary of interest.

Open science has profound implications and impacts on the entire field of scientific data sharing. The implications are twofold, with the good side to be deployed in advance while the bad side to be studied to prevent risks. Eventually, we will explore a path to reach a sustainable operation ecology and development state.

3.3 Development Strategies for Academic Publishing in the Era of Open Science

3.3.1 Youngsuk Chi: Three Trends in Open Science and Scientific Publishing[12]

As the old saying goes, "When the Winds of change blow, some people build walls, others build windmills". The meaning behind this phrase is simple and universal: To accept and embrace opportunities offered by change. Perhaps the scientific community is particularly familiar with this phrase because it is at the forefront of technological innovation and has the power to change society.

In science, however, "change" does not refer exclusively to innovation. Over the centuries, human perceptions of science and how we do research have evolved. Today, the rise of open science mechanisms and processes has become part of new "winds of change". Open science aims to promote easier public access to all types of research results, and the movement has gained momentum in recent years. Global institutions such as the United Nations are also calling for a more collaborative and interdisciplinary approach to scientific information and innovation[2].

Open science is to be defined and enabled by explicit actions to make research more inclusive, collaborative, and transparent. Open science principles can be applied to all types of research outcomes, including open data, open evaluation metrics, scientific integrity and reproducibility, the impact of science on society, and open tools and software. Over the past few decades, scientific and technical publishing organizations have made great strides in integrating open science into their overall work plans.

At Elsevier, we introduce open science in all forms of scientific output. We have founded more than 500 fully open-access journals, and nearly all our 2600+ journals support open-access publishing, with all published articles openly available on ScienceDirect. Elsevier also provides access to 27.4 million datasets stored on Mendeley Data, a secure cloud-based storage platform that helps scientists around the world store, share, access, and cite essential data. It helps to improve not only the openness of scientific research but

[12]Youngsuk Chi, Director of Corporate Affairs for RELX, Chairman of Elsevier.

also reproducibility, as well as build trust and enhance transparency in scientific research. In addition to following the Center for Open Science's *Transparency and Openness Promotion* (TOP) guidelines, we have created the CiteScore metrics to provide more comprehensive and transparent insight into the impact of journals.

However, open science is still a work in progress and has much room for development. For example, a 2019 *State of Open Data Report* found that the biggest barrier to open data is related to a lack of trust in open data among researchers, particularly concerns about others misusing their data for unintended purposes[3]. In addition, researchers who are critical of the open-access model often point to threats posed by predatory journals and their slack peer review. While similar challenges are not insurmountable, it needs all colleagues in the research community to take concerted action to further advance open science practice where appropriate.

A concerted effort is essential to address these issues. There is also a need to address the high cost of open access publishing and ensure equal publishing opportunities for researchers in low- and middle-income countries. Extensively, publishers, researchers, research institutions, and funding agencies should focus on areas of open science that can be further developed. For example, we can support and encourage researchers to conduct best practices in open data, and we can establish new mechanisms for linking science to the broader community.

In the context of open science, future discussions about scientific publishing are likely to focus on three major trends: A more inclusive world of scientific research, increased demand for technological solutions, and a stronger commitment to scientific integrity. Open science practices can support researchers and publishers worldwide to adapt to these three trends.

First, we have seen an obvious increase in collaborative research projects in recent years. Even with an end because of the Covid-19 crisis, major research topics such as climate change and public health still require collaborative efforts across borders. Building an inclusive research and publishing ecosystem can help scientists access new funding, equipment, and knowledge, share resources and skills, and accelerate the research progress. To achieve these goals, scientific publishers and journals, as a source of essential content and inclusive platforms, will continue to support international research alliances to transcend national boundaries.

At Elsevier, we are helping to build a more inclusive world of scientific research. For example, as a founding member of Research4Life, we have provided nearly 100 400 peer-reviewed resources at affordable prices to research institutions in 120 low- and middle-income countries. As part of Elsevier's open science initiatives, we strive to connect science with society and get information to where it is most needed.

The second trend facing the science publishing industry is the growing importance of technology and artificial intelligence solutions, reinforced by the Covid-19 outbreak over the past year. Over the past decade, a wave of digitization and emerging technologies has swept through all industries, allowing data and analytics to play a more significant role and provide deeper insights. From demonstrating the impact of funded research to optimizing the peer review process, artificial intelligence tools have proven that they can revolutionize how research is done, understood, and shared.

To support researchers in storing, sharing, discovering and effectively using (reusing) data, Elsevier has developed AI-driven solutions to enable data sharing and data-driven report writing. For example, our *Sustainable Development Goals Report (2020)* (https://www.elsevier.com/__data/assets/pdf_file/0004/1058179/Elsevier-SDG-Report-2020.pdf), which presents the state of research in each SDG area, in terms of using capabilities of Scopus and SciVal, and publishing its full methodology on the Mendeley Data platform. We hope to increase data's impact, effectiveness, efficiency, and transparency by conducting and sharing this research using an AI-focused approach. As the international research community grows and expands and scholarship continues to grow at a record pace, open data policies and AI technologies will continue to support reliable and reproducible research for all.

It comes to the third major trend, promoting and protecting research integrity. Last year, the Covid-19 epidemic opened research "floodgates" with an unprecedented surge in research output that nearly saturated the publishing industry. Unfortunately, this has also meant that plagiarism, manipulation of citations, and image manipulation have occurred due to more rapid peer reviews. In addition, the interdisciplinary nature of scientific research has become more pronounced, with a correspondingly significant increase in the number of authors and contributors. Fortunately, the top two trends we have discussed, along with open data principles, can assist in addressing these challenges. Collaborative efforts, artificial intelligence tools, and registered reports can ensure that each step in the publication process (from designing the proper methodology to submitting ethically compliant articles) adheres to scientific integrity guidelines.

We should give researchers a sense that their data, discoveries, and published results are protected. Through partnerships with universities and tools such as CrossRef Similarity Check, Elsevier is improving editors' ability to examine the originality of papers and publishers' ability to investigate research integrity issues. As scholarship continues to grow, publishers, researchers, and policymakers must be equipped with appropriate tools to defend trustworthy science.

I firmly believe that the three major trends described above will define the scientific publishing industry in the coming years. All major players—whether at the national level, the institutional level, or the individual researcher level—will inevitably face demands created by these changes. China has made positive progress in promoting openness over the years. A deeper exploration of multiple approaches to open science could reveal pathways for China to unlock its full scientific publishing potential.

With a deepening understanding of open science, publishers will seek to implement ideals into their specific operations to remain competitive and meet the rising needs of their users. At the same time, new publishing models are undergoing more experimentation, and publishing under the subscription model continues to grow. To take the lead, China needs to explore new collaboration models, increase transparency, and make institutional changes.

Currently, although China produces more research than any other country in the world, only two of the world's 20 most-cited research institutions are from China. In fact, international collaboration opportunities should not be restricted to researchers or institutions —they can also include journals and publishers. Transparency is another important factor that could elevate Chinese research to global prominence, especially given recent misconceptions surrounding information security and intellectual property rights. To truly advance science and technology innovation, it is essential to make trust reinforcement in science as a global goal. Finally, institutional change can dispel researchers' doubts about open science. In an Elsevier article on research institutions and open science, researchers found that local and internal developments are essential to enable institutional change in openness[4].

How can we embrace open science principles and maximize the benefits it brings? One example is KeAi Publishing. As a joint venture between China Science Publishing & Media Corporation (Science Press) and Elsevier, KeAi's mission is based on its motto of "Chinese Roots, Global Impact". Today, KeAi uses the latest technologies to expand research results dissemination and improve publications' quality. KeAi has published more than 120 open access journals collaborating with leading Chinese research institutions. By conducting high-quality peer reviews, utilizing innovative tools, and fostering international collaborations, KeAi is well-positioned to create first-rate journals and put Chinese scholars in the global spotlight.

There is no single definition of open science, nor can a "one size fits all" approach to achieving it. Different countries, institutions and researchers can succeed by exploring the path that best suits their needs and goals. Moreover, to truly benefit from this, it is crucial to identify economically sustainable publishing models and explore all parts of the open science "pie" rather than focusing on just one. I am assured that with the proper resources, goals, and talented people, China can not only successfully adopt open science, but also play a leading role as its scientific research and journal industry is continuously growing. Open science is a process, not an end goal. It will eventually lead to a better, more sustainable future. The winds of change have blown and continue to push us toward open science. In this process, we must always keep in mind—to build windmills, not fences.

3.3.2 Steven Inchcoombe: Towards the Future of Open Science[13]

Springer Nature has a clear commitment to open science. Open science is key to driving scientific discovery and advancing scientific progress. By "opening up" all research outputs (data, code, experimental protocols and methods, as well as early versions of research released in preprints and, of course, official versions of papers published through open access), we are rewarded with a faster and more efficient research system. It allows the world to reap the benefits of vaccines, solutions to global challenges, etc.

When foundational data, methods, and published results are available to all, it will be easier for more and more people to see what these shreds of evidence convey. They can also trust (or comment on) this information and make decisions accordingly. This adoption helps us respond more effectively to global societal challenges based on adequate information.

In that way, how can publishing organizations help to advance the future vision of global open science?

The first step is for original research papers to be immediately accessible from the moment they are published. Springer Nature has made a clear commitment to publishing all original research in an open access (OA) format. We have about 600 gold OA journals and have just committed to transitioning all journals to OA in 2020, including journals under the Nature Portfolio. Currently, all authors can publish their research in OA in

[13]Steven Inchcoombe, Chief Publishing and Solutions Officer of Springer Nature.

almost all the 2900 journals in which we publish original research, demonstrating that there is no contradiction between a commitment to OA and a commitment to publishing high-quality, solid and impactful research.

However, we would not have been able to achieve current progress on open research without the success of our Transformative Agreement (TA), which has been shown to help achieve the transition to OA at scale. The Transformative Agreement, also known as reading and publishing agreements, is designed to transform subscription payments, which libraries and institutions use solely to gain access to reading, into payments that cover OA publishing and reading costs. We are proud to have 16 such agreements in place, including the world's largest TA by article volume with Projekt DEAL in Germany, and the first TA covering Nature Portfolio journals with the Max Planck Digital Library. However, there is no "uniform" path for TA. For example, TA can be signed with institutional consortia, as well as with single institutions and research funding agencies. Such agreements often cover different journals, have different requirements for identifying and verifying authors, and have special requirements for invoicing and tracking runs. We take all of these, into account to develop flexible solutions that meet these needs. The benefits of reaching such agreements are clear. The data show that in 2019 our country-level TA is effective for eight countries. Researchers in each country used gold OA for 70%–90% of research published with us, compared to a global average of 30%.

Addressing administrative burdens of OA: TA also helps all parties deal with the administrative burden that accompanies OA growth. OA business models and infrastructure are improving, but the existence of multiple, disparate funding sources, associated with the fact that institutions and research funding agencies may not have a good handle on it, make it more challenging to track and manage. By centralizing the management of both funds and payments through TA, the work complexity for authors and their institutions is reduced. Authors do not have to make their own payments, and institutions can clearly picture research outputs and OA costs through centralized reporting and billing.

Motivating authors to choose OA: Open access does not figure prominently in the reason list of authors for choosing which journal to submit in. It consistently ranks 8th or 9th out of ten reasons in our regular journal author satisfaction surveys. TA helps address this issue in two main ways: Facilitating authors' choice of OA options in hybrid journals and allowing authors in underfunded disciplines (*e.g.*, social sciences) to publish their research in OA. Since the funding agreed upon by TA is not discipline-specific, all disciplinary areas can receive focused support under TA. Thus, regardless of discipline or individual funding status, authors can publish their research in OA at no additional cost.

Solving societal challenges: It is not just about making research papers more open and discoverable. Other elements of open science, including content diversity, base codes, and access to data and experimental protocols, are equally essential in the modern research environment. The current Covid-19 outbreak is a stark example that exemplified the need for immediate access to research, data sharing and processing, and good data management, which could improve the reproducibility and reliability of research. Gold OA is the foundation of this broader effort. In contrast, the subscription-bound Green OA only provides access to accepted manuscripts without final processing, no post-acceptance improvements to the manuscript, and no relevant data, codes, or links to corrections/withdrawals that occur after publication. This lower version of OA is insufficient to deliver on the promise of future open science, whereas such a future is critical to the entire scientific enterprise.

Our recent study, conducted in collaboration with researchers from Maastricht University and the Association of Dutch Universities (VSNU), demonstrates open research's power to address global societal challenges. The study found that research focused on the UN Sustainable Development Goals (SDGs) gains greater use and attention when published as gold OA. It can be disseminated to large user groups outside of academia—groups that are more likely to share and use the findings and make them worthwhile.

This potential to significantly advance scientific discovery and promote scientific progress is the reward brought to all. A research system with increased speed and efficiency is allowing the world to reap the benefits of vaccines and SDG solutions. There is great potential for further collaboration, especially in ensuring that scientific research meets the needs to address societal challenges.

3.3.3 Bin Peng: A Few Thoughts on Promoting Open Access Publishing in China[14]

It is significantly meaningful for the Chinese scientific and publishing communities to advocate and promote open science, which will accelerate the construction of a new international scientific system, enable a framework of global governance based on "common consultation, common construction, and common sharing", and facilitate community building for a shared future of humankind. Open access is a significant transformation in the global academic communication mechanism. As a new academic communication mechanism to freely access and reuse academic literature online, open access publishing is becoming essential for the dissemination of scholarship and information, and an indispensable means to break the commercial monopoly and protect public interests. The *Opinions on Deepening Reform and Cultivating World-Class Science and Technology Journals* proposes to "build new communication platforms and effectively enhance international communication power and influence of Chinese science and technology journals." Therefore, facilitating open access publishing of science and technology journals is an urgent demand for implementing China's science and technology innovation strategy, and a practical need for constructing China's world-class science and technology journals.

According to Scopus statistics, Chinese OA papers (excluding Hong Kong, Macao and Taiwan) have grown at an average annual rate of 22.6% in the past ten years, higher than the average growth rate of global OA papers per year (10.3%). However, the total number of Chinese OA papers in 2020 was 225 000, accounting for 34.2% of the annual number of publications, which is lower than the global OA paper share (41.7%). Therefore, China's OA paper share still has more room for improvement. As of the end of July 2021, there were 142 OA journals (including 23 Chinese journals, 7 bilingual journals, and 112 English journals) in DOAJ with Chinese publishers (excluding Hong Kong, Macao, and Taiwan), accounting for only 2.8% of the nearly 5000 scientific journals in China. It is still far from

[14] Bin Peng, General manager of China Science Publishing & Media Ltd. (Science Press), Senior editor.

the 18.1% of OA journals indexed in Web of Science globally in the same period. However, according to research data from the *Blue Book on China's Scientific Journal Development*, 2220 Chinese science and technology journals are currently available for free access through journal websites and other channels, which indicates that many Chinese science and technology journals adopt free access model. However, few of these journals meet OA publication specifications.

To comply with publishing and exchange needs with the international research community, and to build China's brand of OA publishing and dissemination platform, Science Press has made a lot of efforts and attempts in recent years to promote open access of scientific journals and platforms, in the following major aspects:

Regarding single-journal practice, the *National Science Review* (NSR) has been successfully transformed from Free Access to Open Access publication since 2020. NSR was founded in March 2014 and is a multidisciplinary journal that reflects substantial research progress in natural sciences at home and abroad from multiple perspectives. It is committed to becoming one of the top international multidisciplinary journals. The impact factor of NSR is 17.275 in 2020, which ranked in third place among global multidisciplinary journals. The OA publishing transformation of NSR sets a crucial example and has reference value for exploring the OA publishing and operation of high-level academic journals in China.

In the practice of journal clusters, KeAi, a joint venture between Science Press (Holdings) and Elsevier, is dedicated to empowering English science and technology journals of China going global. KeAi has established many international high-level OA journals that can compete directly with other international journals and help to spread the outstanding scientific achievements of China to the international peers. KeAi makes full use of Elsevier's journal publishing model to establish an efficient editorial and publishing process, with a clear labour division. KeAi has developed very rapidly since its establishment in 2013. As of the end of July 2021, there are 117 OA journals (including 42 self-founded journals and 75 co-published journals), of which 17 journals indexed in Web of Science are all located in Quartile 1 and Quartile 2 portion.

In platform developments, Science Press started to develop a full-process digital publishing and dissemination platform (SciEngine) in 2014 considering national strategies and business needs. The preliminary construction of a one-stop full-process digital publishing system from submission, review, to publication, has been completed. At present, 292 peer-reviewed journals have been included, and 139 of which are OA journals.

Combining China's national conditions, with OA publishing practices of domestic and international scientific journals, there are a few thoughts and suggestions for open access publishing in China.

The first is to facilitate the growth of open access publishing in China through policy guarantee and funding support. Against the background of open science, scientific journals of China, particularly Chinese-language journals, urgently need guidance and advice on how to develop further. There is a need for policy guarantee and financial support (who pays for it) at the national level to promote open access to scientific and technical journals at the initial developing stage. Chinese administrative authorities need to adapt to the requirements of the Internet era and open science era, making policy adjustments to the online storage and dissemination mode of OA journals accordingly.

The second is to strengthen the standardized operation of open access publishing of scientific journals in China. OA journals refer to content that users or their institutions can get access for free, allowing any user to read, download, copy, distribute, print, search and link to the full text, or for any other legitimate use, without requiring prior permission from publishers or authors. Free Access is fundamentally different from Open Access, as standardized OA publishing requires a signed user permission statement and copyright statement between the journal and the author.

Third, China urgently needs to develop its own open-access publishing platform with independent property rights. Currently, China is vigorously promoting world-class scientific journal construction. English journals, with their language advantage, have received a much higher proportion of policy support and project funding than Chinese journals. However, most English journals of China make use of cooperative partners' resources, so most of them are not counted in China's camp when international statistics calculate journal numbers published by countries. In this regard, it is urgent to build a national open access publishing platform with independent intellectual property rights and construct a review and evaluation system that meets open science standards. The open-access publishing platform should be interconnected with databases and repositories, support bilingual metadata and resource information, and achieve a wider range of sharing and reuse. We should also enrich and strengthen cooperation with domestic and foreign libraries and institutions to build a global open-access publishing platform and social sharing network to help users establish worldwide dissemination and sharing channels. We should create a data-sharing mechanism for Chinese science and technology journals, raise the awareness of data sharing and standardized publishing among journal operators, and accelerate relevant open data construction.

The fourth is to accelerate the development of journal clusters in order to promote open access publishing. Clustering development is the mainstream development direction of international science and technology journals, which meets the needs for extending journal brand impact, digital knowledge services, getting the competitive market advantage. At the same time, it is also an inevitable path to build up the developments of Chinese high-quality science and technology journals and the robust scholarly publishing industry. Clustering development also requires accelerating the structural optimization of publishing teams and thus promoting open access publishing, which includes: A first-class disciplinary editorial team to enhance journal's core competitiveness; a first-class technical R&D team to accelerate platform construction; a first-class academic operation team to promote journal's OA process; and a first-class marketing team to promote journal's globalization.

Fifth, it is necessary to conduct comprehensive advocacy and publicity for the sustainable development of open access platforms. "Good wine needs no bush". Without the publicity and promotion of science and technology journals and platforms, it will be difficult to get academia's recognition and participation. Therefore, our platform and journals should focus on the market promotion of multi-dimensional and multi-channel and the marketing team construction of professional and international. We should also focus on customized and targeted journal market planning to continuously seek new channels to attract attention and stream.

On September 11, 2020, President Xi Jinping hosted a symposium with scientists in Beijing and gave an important speech, proposing "to establish first-class academic journals and various academic platforms, and reinforce domestic and international academic exchanges." We will adhere to the developing concepts of "openness, win–win, and sustainability", work together with Chinese science and technology journals, and walk together with Chinese science!

3.3.4 Guilu Long: Open Access Impact on Journal Functions and Countermeasure Suggestions[15]

As an academic author for many years, as well as a reviewer and editorial board member of many journals, I have developed some understanding of scientific journals. Therefore, I will discuss my views on open access journals from a researcher's perspective.

Open access journals are a part of a larger open science context. As explained by Wikipedia, open science is a movement to make scientific research, including publications, data, physical samples, software, and its dissemination, accessible to all levels of an informed society. It includes publishing open research, advocating open access, encouraging scientists to practice open-notebook science, and making it easier to publish and disseminate scientific knowledge.

Parts of open science can be traced back to the 17th century Enlightenment Movement. However, the formal phrase "Open Science" was coined by Steve Mann in 1998. There are various definitions of open science, but its primary purpose is to promote scientific development to meet the public's demands for knowledge, permeated by open concepts of "openness, cooperation, and sharing". Open science is not only applied in academic research and publishing, but also applied in government management, business, education, and other fields. I will only talk about my views on open scientific journals here.

In my understanding, scientific journals now have three main functions: first is to record discoveries and research results, which become the direct evidence of the priority of scientific discoveries, and can be found by others who want to read them; second is to disseminate scientific results, in which general readers and peers could get reach to your discoveries through journal distribution; third is to evaluate research, high-impact journals with good brand reputation often become the yardstick for assessing paper levels. Below I will briefly discuss the open access effects on these three functions of scientific journals.

Recording discoveries through journals serves two purposes: one is the core evidence of the scientific priority rights; the other is to allow access. Open access journals make research more accessible and make journal reading easier. Open access promotes more papers to get published, making it relatively easy to publish scientific results. It records publishing time and maintains priority rights, thus making it easier to be openly accessible. In fact, the scientific community has long had arXiv preprint and other preprint repositories that have implemented this feature. arXiv is approximately an open-access electronic journal that is published without peer review, which the payment to publish or read is not required. Back in days of a boom in research on high-temperature superconductivity, research groups around the world were scrambling to make higher-temperature superconducting materials. Every day, it was imperative to get a draft paper posted in arXiv before the end of the day. Otherwise, the publication will be one day late. Two of my

[15]Guilu Long, Professor, Department of Physics at Tsinghua University and Beijing Academy of Quantum Information Sciences.

original works gained priority rights through the chronological order in which they are made public at arXiv. One is quantum-secure direct communication, a novel theory of quantum-secure communication, made public in arXiv on December 13, 2000. The other is a proposed method of duality quantum computing with linear combinations of unitary operators, made public in arXiv on December 15, 2005. It is different from Paul Benioff's quantum Turing machine theory—computing with the product of unitary operators. Of course, the record function only comes into play when competing for first publishing rights. There are several examples in the quantum information field. Charles Bennett and Giles Brassard proposed a theory of quantum key distribution and published their results in a conference proceeding held in India in 1984. However, in 1987, Doug Wiedeman from the University of Waterloo, Canada, published a paper with the same content. After seeing the paper, Charles Bennett and Giles Brassard immediately published a paper under the title *Quantum public key distribution reinvented*, pointing out that Wiedeman's paper duplicated their work and defending the first publishing right. Paul Benioff proposed the quantum computer in 1980. Although a Nobel laureate published an article on the same subject in 1982, the first publishing right to the quantum computer clearly belongs to Paul Benioff. The timing of publication is primary. For significant original results, they are often published in less well-known journals. At this point, it doesn't matter in which journal the scientific results were published; the only thing that matters is who published it early. Both seminal works above were published in journals that were not well known. As the pioneered research directions developed, their citation counts increased rapidly so as to become classic papers.

The record function is used more in access than for scientific priority. When later scholars read other papers that refer to a previous piece and want to read that article, they need to find it and study it. With the popularity of digital publishing, most papers can be found online. Even university libraries subscribe to journals, most of which are available digitally. In this way, we do not have to go to the library in person, but download papers and read them in the office, at home, or even on a business trip. However, it was not so convenient in the past. In the early 1980s, Beijing and Shanghai had the unique advantage of having rich research resources. However, friends who were graduate students in other cities had to go all the way to Beijing and Shanghai, spend a week or even a month looking up and making a copy of research materials, and bring them back to do research. After a while, it will be necessary to come back again.

The second function of journals is to disseminate your discoveries to a broader audience. Open access journals have a two-fold effect on this function. Open access makes it easier to download and enables more people to read. As a result, open access journals will have more citations, and they will have a higher impact factor than the same kind of non-open access journals. However, there are more and more journals and papers which generate an information explosion, and it makes readers have no idea to choose which articles to read, resulting in aesthetic fatigue. For traditional journals, it is basically possible to classify papers into grades based on the journal impact factor. For example, in physics, papers in *Physical Review Letters* are generally of a higher level and more important than those in *Physical Review* series journals. As journals such as *Nature* and *Science* are valued by readers, papers in *Nature* and *Science* will generally be considered of the highest level. Papers in their sub journals are of the next highest level. The level of *Physical Review Letters* or *Physical Review X* is probably close to that of *Nature Physics*.

As such, readers will first focus on papers published in *Nature* and *Science*. However, there is a small number of high impact factor journals, so their total volume of publications accounts for a small percentage, such as *Science*, which publishes about 3000 papers per year. Among them, there are limited papers in physics, and readers can quickly finish browsing, so these papers naturally get more reading. Thus, journals with high impact factors serve as advertisements for paper dissemination. These high impact factor journals mainly report a limited number of significant results, like fancy stores in *Wangfujing Avenue* specializing in luxury goods. In contrast, journals published by specialized societies focus on publishing many progress-type results, like stores and food markets frequently visited by people everyday. Open access boosts medium and low impact factor journals positively, while an adverse effect happens to high-end journals. Thus, the open access publishing model mixes some significant discoveries with staged progress results, which affects significant results dissemination. Of course, in the future, it is possible to adopt an approach of charging huge page fees, *i.e.*, changing journal publishing costs and subscription income into the form of article processing charge (APC) to let authors bear and contribute. Such change would shift *Nature* and *Science* into open access journals while still maintaining high impact factors. As a result, open access would positively boost dissemination and promotion in general.

The evaluation function of journals has often become a yardstick to evaluate a paper or even a scientist's level. There are many journals, and scientific and technical information agencies have divided them into several ratings based on their impact, such as Elsevier's CiteScore, Web of Science's Journal Impact Factor and Journal Citation Report, etc. In this way, many people, especially laypeople, evaluate other professionals' results by referring to which journals their results have been published in, such as counting the number of papers a researcher has published in *Physical Review Letters*. Many people used to consider *Nature* and *Science* as popular science journals, but now they are deemed to be the highest-level journals in science and technology, and scientists are proud to publish in them. Nowadays, the journal's evaluation function grows bigger, exceeding other functions. As a result, when evaluating researchers' achievements, it only counts that they have published several papers in *Nature*, *Science*, *Physical Review Letter*; however, the specific content of their accomplishments is ignored. One of the objectives for breaking up "Four Onlys" is to get rid of evaluating scientific results by counting the number of journal papers only and letting the research evaluation return to assess science itself. "Four Onlys" includes measuring paper-only, professional title-only, academic qualification-only, and award-only in research assessments. The effect of breaking up "Four Onlys" has already begun to appear, as the Journal Impact Factor is no longer allowed to be mentioned in the application materials of the *National Science Fund for Distinguished Young Scholars* and *Excellent Young Scientists Fund*. Such practice has already been adopted internationally, and the European Union has explicitly disallowed the Journal Impact Factor and H-index in their fund's applications.

Open access journals have a negative effect on the evaluation function of journals. To enable journals to be sustainable or profitable, journals in the open-access model must publish a large number of papers. Due to massive papers published in open access journals, the level of paper varies, which reduces the evaluation function of journals. For example, there is a journal under Springer Nature, which was treated as a *Nature* sub journal when it was started. However, as the number of papers published by this journal increased, its paper quality was far from its original positioning. Although it is published by Springer Nature, it has not changed people's impression of it. Some universities and research institutes include it in their warning journal lists. Although open access has affected the evaluation function of journals, its huge circulation and integration with modern digital technologies have had a significant influence. The emergence of such large-volume mega journals has even influenced the publishing model of open access journals from established professional societies. For example, the *New Journal of Physics* published by IOP Press is also moving toward large volumes.

Another critical element affecting the development of open access journals is economic reasons. Journal publishing costs have increased rapidly, and there have often been disputes between university libraries and publishers over subscription prices. There were some cases that some U.S. universities boycotted a particular publisher. Some academic groups have also taken it upon themselves to organize their own digital publications; for example, John Preskill of the California Institute of Technology and others started the *Quantum*. The journal has a high impact factor and has been indexed by the Web of Science. Open access journals can strike a balance between authors and publishers to resolve this conflict and benefit scientific journal development. More journals will adopt open access in the future, which will be a significant developing direction.

Since 2014, Chinese scientific journals have developed by leaps and bounds. The development is mainly in terms of quality, as shown by a substantial improvement in Journal Impact Factor, growing recognition of domestic journals by the scientific community, and increasing Chinese scholars turning to submit papers to excellent domestic journals rather than international journals. China has introduced several encouraging policies, the effects of which have begun to appear. However, Chinese journals still have much room for development regarding the paper volume they publish.

Most domestic journals are published in cooperation with large international publishers who publish journals mostly in traditional subscription models. In contrast, access to journals is essentially free in China, using domestic IP addresses, and free downloads are available on journals' domestic web pages. Most domestic journals are available for free download in China but not abroad and have not yet achieved open access in the real sense.

In conclusion, the overall impact of open access on journal development is positive. It strengthens the record function, expands the communication and dissemination of low and medium impact factor journals, reduces the evaluation function of journals on scientific results, and helps to eliminate "Four Onlys". Moreover, open access is conducive to an economic balance and sustainable development of all parties in publishing, and it is a significant development direction for future science and technology journals.

Through the above analysis, my suggestions regarding open access journals are:

(1) Some high impact factor journals are still published in the traditional publishing model, similar to *Nature*, *Science*. Such journals have a greater ability to disseminate and promote research results and have strong evaluation functions.
(2) For journals published by professional societies with a large number of publications and a broad scope of reading audience, open access is gradually realized in an orderly manner.
(3) For the weak evaluation function of papers in open access journals, it is possible to add a comment button to promote at the time of publishing and use WeChat official

accounts to spread. After publishing, papers can be starred and graded according to citations, in this way to enable journals to play an evaluation role. After introducing ESI highly cited and hot papers in Web of Science, the evaluation role of these indicators has rapidly emerged and even become an index for discipline evaluation in China. Chinese science and technology information institutions could consider introducing a similar indicator system to establish a new evaluation system for open access journals.

3.3.5 Xiaodong Qiao: Reciprocal Development of Open Science and Academic Information Services[16]

Once society's demand for scientific knowledge sharing reaches a certain level, the emergence of new research methods becomes inevitable, which is also the basis for open science development. The production, dissemination, utilization, and value-added reproduction of scientific knowledge cannot be achieved without the support of various types of academic information services. The emergence of open science promotes the upgrading of academic information services, while academic information services provide continuous resources, tools, and services for open science. Therefore, open science and academic information services are like two main keys in a double helix, promoting each other and alternately advancing each other's development. Specifically, we can understand the mutual promotion and correlation development of open science and academic information services from the following aspects.

3.3.5.1 Open Science Enables New Patterns of Scholarly Information Production and Dissemination

Open science is triggered by society's demand for scientific knowledge sharing. Traditionally, the production, exchange, and dissemination of academic information have relied mainly on books, journals, and academic conferences. The traditional forms of publication, such as books and journals, are the most important among them. In the era of open science, where society's demand for scientific knowledge sharing has increased dramatically, academic information production and dissemination under the traditional publishing model need to adapt to new requirements as soon as possible and evolve into a new model. The new model should solve some constraints of production and dissemination under the traditional model.

(1) A new publishing model combining unbiased rapid publication and peer review, shortens the publication cycle and promotes timely publication and dissemination of the latest research results. Traditional journal publishing must go through paper submission, peer review, editorial review, and publication. The whole cycle takes at least 2–3 months and commonly takes more than half a year. This format affects the rapid and timely dissemination of knowledge. The open publishing model developed in open science can significantly help to solve such problems. The novel science and

[16]Xiaodong Qiao, Research Fellow and Deputy General Manager of Wanfang Data Co. Ltd.

technology paper publishing platform, represented by Open Research Europe (ORE), has dramatically shortened the publishing cycle of research results by adding preprint release (preprint released for viewing and citation within ten days) before peer review and official retrieval in the repository. Beihang University collaborated with F1000 to launch the "Digital Twin" open access publishing platform. It also adopts a publishing model that combines rapid publication without editorial bias, peer review, storage, and indexing, which significantly improves the timeliness of academic information exchange.

(2) Atomization and modularization of publishing units enhance the flexibility of academic information production, which in turn promotes the efficiency of academic information dissemination. Under the traditional publishing model, academic information is produced in article units. The academic information is generated in a relatively fixed layout, leading to subsequent dissemination of academic information in a whole article only. According to a study published by STM in 2018, the time spent by researchers reading each article has dropped from 45–50 min in the mid-1990s to 30 min in 2012 in recent decades due to a dramatic increase in massive volumes of papers. It is critical to help researchers to get the academic information they need efficiently and accurately. The article-based publishing model will undergo a significant disruption in the age of open science. The UK's new scientific publishing model, Octopus, for example, will provide a new "elementary research record" to record and evaluate the "going on" research. The publication unit will change from an entire research project to a single step. Each module of a paper, "Problem, Hypothesis, Methodology, Data, Analysis, Interpretation, Application", can be pulled out and published independently. Elements on the Octopus are linked together to form a collaborative work chain. These smaller publishing units encourage faster and more flexible forms of sharing.

(3) Open peer review, and mandatory submission of linked data, will improve research reproducibility, accessibility, and verifiability, and increase openness and transparency. Currently, the lack of openness and transparency in some parts of traditional academic information production and dissemination (*e.g.*, scientific data, peer review, etc.) has caused increasingly severe academic misconduct and scientific integrity problems. In open science, new review models such as open peer review will significantly enhance hidden issues of injustice in traditional peer reviews, such as ORE peer review, which adds review comments and expert information to be published together and allows authors to respond and readers to comment. However, the associated scientific data is required to submit at the same time with papers in the traditional paper publishing model, which greatly ameliorates reproducibility, accessibility, and verifiability issues in research.

(4) We need to break down traditional disciplinary boundaries, facilitate the production and dissemination of multidisciplinary research results, advance connections and promote cooperation among different fields to address global challenges and sustainable development goals. In the open science environment, disciplinary boundaries have blurred, and there is a growing need to produce and disseminate research results in joint interdisciplinary collaborations. Multidisciplinary journals, represented by *Scientific Reports*, are striving to advance disciplinary diversities in the production and dissemination of scholarly information.

(5) In the open science environment, the production and dissemination of novel academic information have new characteristics. There are still large gaps in related projects, platforms, and journals settings in China throughout these new characteristics. For example, most existing OA platforms in China belong to re-integration and free use of already published resources. A few preprint systems fail to establish a complete set of publishing processes and operational models to go with them. In addition, there are some e-only publishing and the advance online publication services, but they follow the traditional journal publishing process. How to provide corresponding support, in terms of mechanism, supporting infrastructure platform, academic information production and dissemination process, and operation model, still needs to formulate a reasonable framework with multiple stakeholders' participation based on an in-depth study of existing cases abroad combined with the existing infrastructure in China.

3.3.5.2 Open Science Fosters New Scholarly Information Resources

While solving issues that constrain the production and dissemination of academic information in traditional publishing, open science has also contributed to the unlimited sharing of a broader range of scholarly information resources and facilitated the development of an academic information sharing environment.

Although open science has dramatically advanced open access journals, open science and open publishing are not equivalent to open access journals. Many types of scholarly information required for new open innovation research have been tremendously developed in the open science environment. There is a need for a clear understanding and a precise positioning for these new academic information resources.

First, open science has led to a paradigm shift in publishing. This shift has not only led to accelerating preprints development, but also has facilitated the decomposition of "questions, hypotheses, methods, data, analysis, interpretation, and applications" in papers into independent research modules for publication. These types of academic information build up a new kind of academic information resource collection that is different from traditional literature resources. Secondly, an expanding number of resources such as software applications, statistical data, news reports, and government policies, have also become essential components of open science resources. Some examples are data.gov (open government affairs), CORDIS (open grant information), re3Data (scientific data), Open Science Grid (computational resource sharing), etc. Finally, in this open environment, working links between different stages of academic information become possible. For instance, the Overton platform is dedicated to tracking relationships between science policies and scientific research. The TRIMIS platform collects academic information generated in different research stages, from project creation to project closure.

To advance the generation and utilization of multiple types of academic resources, it is necessary to thoroughly study the roles and functions of various academic resources in each open science phase from a work chain perspective. On this basis, it is crucial to construct a flexible framework for describing academic resources, and to develop strategies of academic resource integration and preservation, so as to provide an essential foundation for heterogeneous resources in the open science environment.

3.3.5.3 Open Science Creates New Demands for Academic Information Services

To promote novel academic publishing in the open science environment, it is also necessary to consider building a new information service infrastructure and useful methodological tools for open science. It includes a professional and comprehensive academic information platform for publishing, review, and open access. It also includes the supporting platforms of academic research and publishing, which cover registration, preservation, disclosure, and open service for scientific data, image information, software tools, and other scientific research elements. In addition, it comprises scientific and technological evaluation methodological tools that help to assess new open science academic outputs. Moreover, there are also information services that support the construction of research integrity of open science and the management of academic misconduct cases, and value-added services such as integrated discovery and correlation, analysis, evaluation, and mining of open science information resources.

3.3.5.4 Building a Novel Academic Information Service for Open Science is Part of the Construction of "High-End Platform for Scientific Papers and S&T Information"

The Fifth Plenary Session of the 19th Central Committee of the CPC put forward a request to build a national platform for the high-end exchange of scientific research papers and scientific and technological information. The ultimate purpose of this high-end platform is to meet high-end needs, namely, to provide high-end services. Open science provides a new application scenario for the high-end platform. Open science is both an ongoing development of scientific research mode and a future direction of scientific research development, so it becomes a focus for innovative construction and application of high-end platforms.

How can we better understand several keywords relative to academic publishing in the open science environment?

Scientific research papers and scientific and technical information: The first is the paper itself, which is the so-called content; the second is the associated information surrounding the core content, including projects, institutions, individuals, disciplinary backgrounds, teams, results, etc.; the third is other research materials and supporting conditions around papers and research results, such as scientific data, methodological tools, software, etc.; all these are the scopes that should be considered for the content construction of the high-end platform.

High-end: First, it responds to the high-level, high-quality and latest academic achievements, including academic research and scientific innovation at the national level; second, its authority and core value; third, it will connect to the latest development of international open science academic publishing services; fourth, its role in guiding and supporting the whole scholarly publishing and information services.

Communication: It is not a one-way information release, retrieval or download, but a model of information exchange and mutual promotion between publishers and authors, between the platform and users, and between researchers and readers.

Platform: The high-end platform is not a relatively closed single information system or an independent platform, but a collection of multi-level, multi-discipline and multi-form platforms and services. It should be an open ecosystem. In addition to the content authority, it should emphasize the multi-dimensional services for academic research and S&T innovation and stress the support for sustainable construction and development mode of S&T information service ecology.

3.3.5.5 Combining Public Interests and Market Benefits, Building Diverse New Models for Open Scientific Information Services

We should encourage constructing pluralistic models of scholarly publishing and information service in open science, rather than a uniform model with a single standard. More is better than less, and partially open is better than no open. Common models in China include preprint, open publishing, institutional knowledge base, delayed open, mandatory open, etc.

The government should play its role in policymaking, interest coordinating, and leadership. The authoritative should put forth efforts in the combination of mandatory requirements and guideline recommendations, the recognition and use of open science results, and the research and application of evaluative standards and systems, to scientific results in open science. Moreover, it is important to promote open publishing integrated into the existing publishing management system (*e.g.*, publishing qualification, online journal serial number, and how to put through with traditional journal publishing).

Opening the scientific information services can be implemented gradually in research areas and different phases, focusing on leading and demonstrative roles. For example, we could choose key areas such as life sciences and medical sciences to open first, or we could set up requirements and norms to manage key national scientific research programs, funding projects, key publishing projects to realize opening information services.

It is necessary to promote every engaged actor in open science to undertake and implement their primary responsibilities. These roles include research administration, academic funding agencies, participating research units and researchers, reviewers, platform operations, readers, etc. In addition to taking advantage of open science benefits, we should also be a contributor. In response to international open science development, we should encourage exploring and experimenting with development models of scientific publishing and information services in the open science environment with Chinese characteristics, without pursuing to settle all at one step. Taking scientific data in academic publishing as an example, high-end top journals, aiming to build international world-class academic journals or having been included in national key publishing projects such as the *Chinese STM Journal Excellence Action Plan*, can adopt open sharing models that are in line with international standards for scientific data management, archive, and identification. Domestic outstanding academic journals are encouraged to use the required scientific data strategies through registration, identification, revealing, correlation, institutional preservation and editorial support, and scientific integrity.

We should encourage more institutions to participate in open academic publishing services. The public beneficial open platforms and the market-oriented professional information services are not contradictory, and open resources and traditional content service resources complement each other. Open resources also need in-depth data governance, knowledge organization, and correlation revelation, which require specialized support; many third-party services are required around the peripheral services of open science, such as registration, preservation, detection, and evaluation. Open science resources provide specialized academic information services with more knowledge bases, physical data, factual resources, for exploiting in-depth, specialized products and services. The traditional information service industry also needs authoritative institutions to regulate standards, accreditation, and service recommendations to "responsible" third-party services.

In conclusion, to promote China's academic publishing reform in an open science environment, it is necessary for management departments such as science and technology management, academic funding, and press and publishing to play a leading and supporting role. Moreover, we should encourage all kinds of academic research, academic publishing, and information service actors to make bold attempts in various modes. While focusing on open academic publishing and the excellent academic journal construction, we should actively facilitate various supporting infrastructures of open science and sustainable market-oriented industries of scholarly publishing and information services. Focus on the big picture and start from the small. It is essential to integrate open publishing topics into a larger context of open science ecological construction.

3.3.6 Yuhong Bai: Scholarly Publishing in an Open Science Environment[17]

Before open science emerged, traditional academic publishing was limited to a few people, regions, and countries. In fact, more and more countries and people are learning, mastering, and using science and technology, which has been a common goal pursued by human society. It is also the motivation for open science to flourish. With open science expansion rapidly worldwide, academic publishing mode has been accelerated along with the change of communication mode. As a front-line publisher, the changes I experience are mainly as follows.

3.3.6.1 The Capacity Increase in Academic Resource Aggregation

Let us take seven journals of our Light Publishing Group as an example. We have three English journals, of which *Light: Science & Applications* (*Light*) is on Nature's website, *eLight* is on Spring's website, and *Light: Advanced Manufacturing* (*LAM*) is on a self-built website. We have four Chinese journals: *Chinese Optics*, *Optics and Precision Engineering*,

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Chinese Journal of Luminescence, and *Chinese Journal of Liquid Crystals and Displays*. Each of these journals has its own website. There are some advantages for *Light* on Nature's website. *Light* was launched in a completely open access way at the beginning of its creation, which, together with the support of Nature's first-class journal platform, made *Light* develop rapidly in a short period and achieve an outstanding international influence. However, there are also disadvantages. The first disadvantage is that domestic readers find it inconvenient to read because the journal is launched on the journal platform of foreign websites, as shown by minimal citations from Chinese journals in *Light*'s total citations. The second disadvantage is that *Light* itself has little room to manipulate the website's content and format on Nature's platform and must accept website's functions provided by Nature passively. As for the other several journals that work individually on their own, each journal's impact is limited to its small peer circle, and its influence scope is narrow. With open science concepts, we have integrated resources and contents of all seven journals and Light-sponsored activities. It includes academic conferences, new media distribution, news reports, live streaming online, the annual Top 10 socially influential events of Chinese Optics, the National Academic League for Doctoral Students in Optics and Optical Engineering, the global "Raising Stars of Optics" competition, and the UNESCO International Day of Light activities, and all of these aggregates on the Light Publishing Group rich media platform. Seven journals and other academic activities are independent and interconnected so that readers can simply click on any article or any activity or any author. Moreover, the content available in our database will be pushed to readers in order of relevance and importance, which will greatly save readers' time and improve access accuracy to relevant content. The most significant difference between nowadays scientific journals and traditional ones is the trend of transforming from single-content academic journals to highly relevant science and technology media in our field. The rise of open science provides a favorable opportunity for this transformation. In addition, artificial intelligence and big data mining are technological innovations that have changed the traditional publishing model.

3.3.6.2 The Diversification and Convergence of Multiple Cooperative Patterns

On the rich media publishing platform of Light Publishing Group, it fully integrates Founder Group's XML intelligent production service, WeChat official account graphic message production and publishing service, bilingual page switching dissemination platform, machine translation function based on deep learning, aggregated retrieval based on journal content resources, support for journal thematic planning based on disciplinary themes, and journal group independent operation function. It also realizes CSCD citation linking, Baidu official website authentication, Baidu Scholar inclusion linking, Altmetric linking, ORCID linking, search engine SEO Optimization Support, PubMed/PMC linking, CrossRef linking, etc. The platform provides Beijing Renhe's integrated typesetting service, literature online service, reference proofreading service, accurate email push service, PDF article aggregation service, article citation statistical analysis and domain analysis service, etc. The platform has also realized the cooperation with multiple functions, multiple services and various companies' businesses, including the cross-platform push service of TrendMD, the scientific English translation service of Cactus Communications

(Shanghai) Company, the author academic portrait function service of Beijing Zhipu Huazhang, the journal's cover and leaflet design of Chengdu EYE SEE Medical Technology Company. Users can apply for the service appointment with all these service suppliers on the Light rich media platform simultaneously. If new technologies are beneficial to scientific publishing, we will make efforts to make a deal with service providers and strive for diversified integration in cooperation mode. Of course, in the integration process, various frictions and imperfections occur from time to time. We believe that with the continuous progress of technology, with the stick to a good wish, and with a sharing and coexisting vision to optimize services to readers, we will do better and better.

3.3.6.3 A Clear Pathway for Journal-Level Indigenous Innovation

In the past decade, successful English-language academic journals in China always cooperated with large-scale international publishers, namely "borrowing a ship to go to sea". After nearly a decade of learning and innovation, China has become a leader or a parallel to its international counterparts, especially in artificial intelligence and 5G technology areas. From the viewpoint of open science, timing is ripe for building up journals independently, namely to "build a ship and go to sea". The biggest advantage of self-run journals over those journals cooperating with international publishers is that they can take advantage of the latest technologies and expand multiple paths to serve readers. We can clarify these points by comparing the two English-language journals of the Light Publishing Group. The strength of *Light* developing on the Nature platform is *Nature*'s undeniable brand effects from a century-old institution. The influence *Light* has gained today is mainly due to *Nature* and its platform's brand effects. However, the downside is also stark. It is paramount for *Nature* to maintain its century-old reputation. Although *Nature* understands new technologies will bring more convenience and progress, soundness is their primary consideration. Therefore, every update and change to the submission and review system and its website requires a long period of examination and trial before a final decision can be taken, which cannot adapt to the ever-changing technology. As a sister journal of *Light*, *Light: Advanced Manufacturing* (LAM) has decided to develop with complete independence and control from the very beginning. For a new journal with little influence, LAM's biggest advantage is using all the latest technologies for trial and adopting them as soon as they prove effective. For example, after a week trial of the author portrait function on LAM, we found that Professor Hongbo Sun's paper of Tsinghua University was read by 1281 times, and his author portrait was 1049, which shows that readers are very interested in this information, so we immediately adopted this function. Our goal is to meet readers' needs. As a self-branded new journal of Light-derived, LAM is still in the experimentation and exploration process. However, we are confident that we can develop an independent innovation path for Chinese academic journals in the open science environment.

In short, what open science means to scientific journals is nothing but to provide precise knowledge services for users and facilitate journal transformation towards science and technology media, which adds value in various aspects, processes, and dimensions, and thus maximizes the journals' impact and promotes the innovative convergence development of scientific journals.

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