Challenges and opportunities for research data management in Chinese library community

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resource sharing in a disruptive ecosystem

Challenges and Opportunities for Research Data Management in the Chinese Library Community

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Abstract:

Based on the three models of research data publishing, this paper presents an investigation and analysis of Chinese research data management and sharing, including China's national research data management and sharing platforms, institutional research data repositories, Chinese data publishing journals, and data publishing practices. Based on the analysis of China's research data management and sharing environment, the paper will further examine the challenges and opportunities of research data management and sharing services offered by the Chinese library community. Finally, it will provide suggestions for how Chinese libraries can create implementation paths in order to conduct research data management services more effectively.

Keywords: research data management, research data sharing platform, data publishing, RDM

Introduction

China has witnessed a "growth spurt" in the amount of research data generated in domestic in recent years, and the quality of data has increased substantially. According to incomplete statistics, the total amount of research data effectively managed and preserved in China is approximately 80PB (1PB = 1,024 TB = 1,048,576 GB =1,125,899,906,842,624 bytes). The national research data management and service platforms based on the independent publishing mode, the universities' research data repositories constructed by university libraries jointly with other sections, and publication of data papers by data journals are three typical representatives of Chinese research data management practice.

The gap between scientific and technological innovation needs for research data management and China's research data management policies and practices in process is the main contradiction at this stage. In 2018, the State Council issued "Research Data Management Measures" at the national level to promote the high quality management and sharing of

Chinese research data. For libraries, what is the library's role in the development of the national research data management? How to find the new emerging point of appropriate service development? The library's accurate role in positioning, strategic planning, and deployment will be critical in the next stage of development.

China's research data management related policy system

China joined the Committee on Data for Science and Technology (CODATA) in 1984 and established the CODATA China Committee. [1] In 2001, the Ministry of Science and Technology proposed to the State Council the "Implementation of Research Data Sharing Projects to Enhance National Science and Technology Innovation Capabilities." In 2002, the implementation of research data sharing projects began. [2] In 2006, the State Council issued the "National Medium- and Long-Term Science and Technology (S&T) Development Plan (2006-2020)" proposing the development of digital S&T platform to promote the sharing of research data.[3-4] In 2008, the Ministry of Science and Technology issued the "Converging and Management Measures for the Data of Projects in the Resource and Environmental Fields of the National Key Basic Research and Development Program," which implemented the converging and sharing of batch data. [5] After that, the Ministry of Land and Resources and other ministries successively released management methods for data management and sharing in various disciplines and fields. [7-10] In 2015, the State Council issued the "Action Plan for the Promotion of Big Data Development" and proposed actively promoting open data and sharing of research data obtained and generated by public welfare research supported by the state's public finances. [11] Later, the Ministry of Agriculture, the Ministry of Land and Resources, and the Ministry of Transport issued implementation policy documents on the development of data applications in agriculture, land and resources, and transportation, respectively. [12-16, 17-19] In 2016, the State Council issued the Interim Measures for the Management of Government Information Resources Sharing. [17] The above-mentioned policies issued by the State Council are mostly guiding policies; the policies issued by ministries are both guiding and operational and are mostly data management methods or data norms and standards.

In 2018, the General Office of the State Council issued the "Research Data Management Measures" as the first national level policy to regulate the management and sharing of research data, the policy focused mainly on responsibility, research data collection, exchange and preservation, sharing and utilization, and confidentiality and security. [20] In February 2019, the Chinese Academy of Sciences issued the "Research Data Management and Open Sharing Method of the Chinese Academy of Sciences (Trial)," a policy which operates at the research institution level and which clarified the overall principles, responsibilities, management requirements, guarantee mechanisms, security and confidentiality of research data management and open sharing. [21]

The policies mentioned are mostly formulated by the State Council or national ministries and commissions. Compared to the data management policy systems in some other countries, the research project funding agency is responsible for formulating specific policies for funded research projects, including regulations on the responsibility of the researcher undertaking a project, research data ownership, scope and duration, sharing methods, rights and obligations, and publishing and citation mechanisms. The research institutions are responsible for the management and the creation of sharing policies for their own data, including intellectual property rights, academic norms, data confidentiality, data quality guarantees, researcher

duties and responsibilities, data preservation, and so on.[22] It can be predicted that research project funding agencies and research institutions will release data management policies and methods for the projects or institutions funded, Which will be supplementary policies to the "Research Data Management Measures" to further clarify data standards, intellectual property and ownership rights, and duration of open availability, and publishing and citation mechanisms and so on.

Table 1: Policies related to research data management and sharing services

Policymaker	Policy name	Release date	Policy attributes
The Chinese Academy of Sciences	Research data management and open sharing measures for the Chinese Academy of Sciences	2019.2	Research institution policy
National Standards Committee	Information technology research data reference (GB/T 35284-2017)	2018.7	National policy
The State Council	Research data management measures	2018.3	National policy
State Oceanic Administration	Management measures of polar survey data in China	2018.3	Industry policy
National Defense Science and Technology Industry	Interim management measures for satellite remote sensing data for major projects involving a high-resolution earth observation system	2018.1	Project policy
The State Council	Interim sharing and management measures for government information resources	2016.9	National policy
Ministry of Transport	Implementation comments on promoting the open sharing of data resources in the transportation industry	2016.8	Industry policy
Ministry of Land and Resources	Notice on Printing and Distributing Implementation Opinions for Promoting the Development of Big Data Applications of Land and Resources	2016.7	Industry policy
General Office of the State Council	Notice of the implementation opinions for promoting and regulating the application of big data in health care	2016.6	Industry policy
The Ministry of Agriculture	Implementation opinions for promoting the development of big data in agriculture and rural areas	2016.6	Industry policy

National Marine Information Center	Procedures for sharing marine ecological/environmental monitoring data (trial)	2015.12	Industry policy
The State Council	Action plan for promoting big data development	2015.9	National policy
China Meteorological Administration	Administration Measures for meteorological information services	2015.3	Industry policy
Hydrographic Bureau of the Ministry of Water Resources	Management measures of research data sharing of hydrology and water resources (trial)	2011.7	Industry policy
State Oceanic Administration	Implementation Opinions for data sharing of marine environmental monitoring	2010.10	Industry policy
Ministry of Land and Resources	Interim management measures for land and resources data	2010.9	Industry policy
China Meteorological Administration	Management measures for sharing meteorological data	2008.6	Industry policy
Ministry of Science and Technology, Ministry of Finance	Interim Converging and Management Measures for the Data related to Projects in the Resource and Environmental Fields of the National Key Basic Research and Development Program	2008.3	Project policy
China Earthquake Administration	Sharing and management measures for seismic research data	2006.7	Industry policy
The State Council	Outline of the national program for medium and long-term scientific and technological developments (2006-2020)	2006.2	National policy

National research data management and sharing platform based on independent publishing mode

With the implementation of the research data sharing project by the Ministry of Science and Technology in 2002, the Ministry of Science and Technology and the Ministry of Finance have supported the establishment of national science and technology resource and sharing platforms in eight areas: Basic science, agriculture, forestry, oceanography, meteorology, seismology, earth science, and population and health. The data from the eight platforms come from long-term systematic observation and monitoring, national science and technology plan projects, scientific investigations, major research facilities, major scientific projects, and so on. On June 11, 2019, the Ministry of Science and Technology and the Ministry of Finance carried out optimization and adjustment work on the original national platforms and twenty national science data centers were established, the National High-Energy Physical Science Data Center, the National Genome Science Data Center, the National Microbial Science Data Center, and the National Space Science were formed to conduct research together with the Data Center, National Astronomical Science Data Center, National Earth Observation Data Center, National Polar Science Data Center, National Qinghai-Tibet Plateau Science Data Center, National Ecological Science Data Center, National Material Corrosion and Protection Science Data Center, National Glacial Frozen Soil Desert Research Data Center, National Meteorology Science Data Center, National Earth System Science Data Center, National Population Health Science Data Center, National Basic Science Public Science Data Center, National Agricultural Science Data Center, National Forestry and Grassland Science Data Center, National Meteorological Science Data Center, and the National Marine Science Data Center.[23] The former eight research data management and sharing platforms and twenty national science data centers belong to the data independent publishing mode. [24] The eight platforms are shown in Table 2.[25-32] The eight platforms and twenty data centers were established in order to integrate research data from various departments, localities and units, and to make full use of international research data resources, develop a series of data sets and products, and to build an intelligent and networked research data management and sharing service system for the whole society. [33]

The system architecture of the eight research data management and sharing platforms is distributed into center- disciplinary or regional sub-centers. They integrate decentralized research data and provide "one-stop" discovery services. However, the disadvantage of integration here mostly means providing a link address instead of true data fusion with the exception of the Earth System Data Platform, which provides an "International Data Resources" search function. Furthermore, most of the platforms only index data and data sets and rarely use the uniform resource identifier (URI) to name data entities.

The eight platforms adopted discipline-specific metadata standards with high levels of specificity instead of common metadata standards such as Dublin Core (DC) or the DataCite Metadata Schema. Thus, the metadata fields for each platform are quite different. Keywords describe the subjects/themes of data housed on the platforms and these keywords are searchable. However, the data standards and regulations for each platform do not have corresponding specifications for keywords and most of them use free-word indexing.

Each platform has its own data standards and regulations. The earth science data platform even has published books about the standard specifications for the platform. Three types of regulations were developed for the platforms. The first type is regulations related to the

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operation of a platform: Platform operation management specifications, data sharing regulations, data management methods, and so on. Another type of regulations set data management standards including data collection standards, data quality control specifications, data recording specification, data classification and coding standards, metadata standards, data submission procedure specifications, and exchange format specification. The last set of regulations involves platform development and user service regulations such as data classification systems, software coding specifications, platform interface specifications, and data sharing service specifications. Approximately 18 national research data standards related to these eight fields have been formed, such as the Basic Regulations for Basic Geographic Information Standards (GB21139-2007) and Soil Science Data Metadata (GB/T 32739-2016).

When compared to the four-stage research data management life cycle suggested by the UK Data Monitoring Center (DCC)[34] and the UK Data Archive's [35] six-stage research data management life cycle he, the platforms in China provide functions for data creation and processing, data collection, data storage, data sharing and access control, as well as data analysis and data visualization but lack research data management planning functions. This is because the aforementioned Chinese policies focus primarily on the preservation and sharing of research data and do not include requirements for submitting data management plans in the early stages of a research project.

The platforms support user services such as user registration, search and browsing, downloading data, and data usage applications. However, the scope and quantity of data access by non-registered users is limited and users must submit an application and be authorized to access APIs. The data service volume for each platform is at the TB (1TB=1024GB, 1B=8bit) level, but the download volume for most platforms stays at the GB (1GB=1024MB, 1B=8bit) level. This indicates the sharing services should be improved.

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Table 2: National research data management and sharing platforms

No	Platform Name	Institution	Administration Department	URL	Amount of databases and data volume	Data service volume
1	National Population and Health Science Data Platform	Chinese Academy of Medical Sciences	Health and family planning commission	http://www.ncmi.cn	7192.38 TB	None
2	National Earth System Science Data Platform	Institute of Geoscience and Resources, Chinese Academy of Sciences	Chinese Academy of Sciences	http://www.geodata.cn	24,431,150.08 TB	Number of platform users: 115,206 Page views: 21,539,917 Total service quantity: 530.25 TB
3	National Forestry Science Data Platform	Chinese Academy of Forestry	State Forestry Aadministration	http://www.cfsdc.org	1,682.06 TB	User visits: 1,162,980 Registered users: 31,298

					Downloads: 52GB
4	National Agricultural Science Data sharing Service Platform	Institute of Agricultural Information, Chinese Academy of Agricultural Sciences	The Ministry of Agriculture	http://www.agridata.cn	686,362.15 TB	Total downloads: 1,685 GB Total visits: 2,342,005 times Registered users: 26,010
5	National Seismic Science Data Platform	China Earthquake Network Center	China Earthquake Administration	http://data.earthquake.cn	11,912 TB	Registered user: 94,212 Service quantity: 93.53TB; Service projects: 2,453
6	National Meteorology Science Data Platform	National Meteorological Information Center	China Meteorological Administration	http://data.cma.cn	1,051,116 TB	None
7	National Basic Science Data Platform	Computer Network Information Center, Chinese Academy of Sciences	Chinese Academy of Sciences	http://www.nsdata.cn	77,546.83 TB Relational data volume: 7.28GB File data volume: 46.83TB	Total number of visitors: 25,814,832 Cumulative visits: 702,267,722 Cumulative downloads: 795,761.95 GB
8	National Marine Science Data Platform	National Marine Information Center	Oceanic Administration	http://mds.nmdis.org.cn	1,580.75 TB	Page views: 197,396 times

University data repositories based on the independent data publishing model

Beside the platforms mentioned above, university libraries have practices related to institutional data repositories (data management and sharing platforms), including Peking University, Fudan University, Wuhan University, and the Shanghai Foreign Studies University[36-39] (see Table 3). The data repository of Fudan University is not led by the library, but the library provides data management related consulting and training services. The other three repositories are mainly led by the library. For its repository, Wuhan University uses DSpace and the other three libraries use Dataverse. In terms of the volume of data, the digital scholarship research platform at the Shanghai Foreign Studies University Library has the largest data space and data set, with 5,108 data sets. The Wuhan University repository is a demonstration project of research data management platforms for colleges and

universities and has only 9 data sets The number of data sets in the other two data repositories is under 1,000. The Peking University, Fudan University, and Wuhan University data repositories support both social science and natural science data management; the Shanghai Foreign Studies University Library digital scholarship platform mainly supports social science data management. These four repositories (with the exception of the Wuhan University repository, which only supports data storage and preservation), support data creation and management, data collection, data storage, access control, and data analysis and visualization. All four repositories support retrieving, browsing, and download services. The Fudan University and Shanghai Foreign Studies University repositories have data standards, data utilization and sharing specifications, data access and citation specifications, and so on., but the other two repositories do not. All four provide data management-related consulting and training services.

In addition to the research data repositories supported by these four libraries, some universities also have other databases or data management platforms such as the China Economic and Social Data Center at Tsinghua University, the Academic Research Database Sharing Program at Zhongshan University, and the China National Survey Database at the Renmin University of China. [40] However, the data on these platforms is mainly social science data and survey data, so the data structure is relatively simple and will not be discussed further here.

Table 3: University data repositories (research data management and sharing platforms)

Data management platform	Implementing institution	Resources	Data services	Data policy	Technology
Peking University's Open Research Platform	Peking University Library, Natural Science Foundation of China, Peking University Management Science Data Center, Peking University Research Department, Peking University Social Science	39 data spaces, 241 data sets including social sciences, life sciences, geographic information, software and microelectronics	Data storage, publishing, storage, DOI identifier, digital fingerprint, data correlation, online analysis, data retrieval and download, data citation, consulting and training	User guide: data specification, data utilization, data sharing, data access	Dataverse

Social Science Data Platform at Fudan University	Data Research Center of Social Sciences, Fudan University	152 data spaces, 645 data sets in social sciences, earth and environmental sciences, pharmaceutical health and life sciences	Data collection and integration, data storage, data publication, data verification and transformation, online analysis, data exchange and harvesting, data retrieval and download, data-related paper publishing, consulting and training services	None	Dataverse
Wuhan University Research Data Management Platform	Wuhan University Library	9 data sets in life sciences, social sciences	Data submission, preservation, data retrieval and access	Specifications of data submission, organization, preservation, sharing and use, general and discipline metadata standards, and indexing system	DSpace
Shanghai International Studies University Digital Academic Research Platform	Shanghai International Studies University Library	1,042 data spaces, 5,108 data sets in social sciences	Specifications of data storage, handle identifier, data sharing, online analysis, data cite, data retrieval and download, training guide	None	Dataverse

Journal data publishing based on the data paper publishing mode

In recent years, China's pioneers in data paper publishing are three data journals. *China Science Data* (Chinese and English Online Edition) is sponsored by the Computer Network Information Center of the Chinese Academy of Sciences. In 2015[41], it became China's first academic journal for the publication of research data in multidisciplinary fields. The *Journal of Global Change Data*, hosted by the Institute of Geographical Resources of the Chinese Academy of Sciences started in 2017[42], relies on the "Global Changes Research Data

Publishing System" and together, the journal and the system conduct correlative publication of metadata, entity data, and data papers. In 2018, the International Digital Earth Society, the Institute of Remote Sensing and Digital Earth of the Chinese Academy of Sciences, and the British Taylor & Francis Publishing Group jointly began publishing an international academic journal, *Big Earth Data*[43], an open access journal that relies on the strategic pilot science project at the Chinese Academy of Sciences entitled "Earth Big Data Science Engineering." There are some other journals setting up special articles or columns for data papers or publishing paper data but these are beyond the scope of this article.

The National Standard for Information Technology Research Data Citation [44] was issued in 2018 by The National Standardization Management Committee, which mandates that research data should be cited in a standardized manner by peers in academic papers.

SWOT analysis and recommendations for data management and sharing services in the Chinese library community

The data service paths of domestic libraries are mainly five types: (1) research data management platform based on data curation life cycle, such as the data management platforms at Peking University, Fudan University, and Wuhan University introduced above; (2) data resource discovery system such as the "Shuimu Search" discovery system based on Primo at Tsinghua University Library[45] (in addition to traditional resource types, it integrates data sources such as research datasets, statistical datasets, maps, audiovisual materials, and so on); (3) data management-related consulting and training services (Peking University Library, for example, provides data management consulting services)[46]; (4) data visualization services such as the data analysis software and data analysis services[47] provided by the Chinese University of Hong Kong; (5) open access data navigation services (the Library of Chinese Academy of Sciences, for example, provides integrated navigation for a large number of data platforms, journals, official statistics, and open access data of international organizations)[48].

Compared with the data management and sharing service paths of some foreign libraries, the research data management platform service of Chinese libraries emphasize platform-based data management and utilization more, while foreign library platform such as the Data Conservancy at the Johns Hopkins University (JHU) Library [49] emphasize its function as a data curation and management infrastructure. The JHU platform has software for metadata capture, data organization and description, and data visualization such as Rmap, Fedora API-X, and packaging, specifications. Consulting and training services of domestic libraries are more focused on data policies, open data access, data rights, data intellectual property, data licensing, instead of data management plans and data curation infrastructure. Some data service practices, like the data management services for the pre-research, middle and post-research stages provided by York University;[50] the DOI registration service provided by the German National Science and Technology Library;[51] and the German National Library of Medicine data storing service in the Dryad data knowledge base, [52] are rarely carried out the same good by Chinese libraries.

Based on summary of research data publishing and sharing in China presented above, external opportunities and challenges for data management and sharing services in the Chinese library community are analyzed. Opportunities include: (1) Research and innovation

needs: Scientific and technological innovation is increasingly dependent on the comprehensive analysis of research data. (2) The demand for China's research today: China's research data growth spurt, But China has only started shortly in the managing and sharing of research data, compared with the management and sharing of research data in developed countries such as those in Europe and in the United States. (3) China attaches importance to data management and the release of the "Research Data Management Measures" reflects the importance China attaches to the development of research data management and sharing capabilities. (4) Developing opportunity: The research data repository of research institutions affiliated with libraries has not been implemented widely; the management of research data at many universities and research institutions has not yet started or has only just started in a short time and there is an urgent need to establish or further improve institutional data repositories.

The challenges include: (1) the library playing a central role in the implementation of research data management has not been recognized at the top administrative level. For example, the implementation unit of the eight research data management and service sharing platforms mentioned above are the IT departments at the research institutions. As another non-library example, the "Research data Management and Open Sharing Measures of the Chinese Academy of Sciences (Trial)" indicates that the designated legal entities, the research institutions, are the responsible units for data collection, processing and sorting, and regular publication of catalogues. The Academy Science Data Center is a professional unit specializing in research data management and open sharing and is responsible for integration of data, research data classification, data processing and analysis, and establishing a technical platform and service system for open data sharing. (2) Libraries are not adequately prepared for transforming their service models for the new research paradigm: Chinese librarians have published a large number of papers about digital humanities, digital scholarship, and research data management in recent years, but there is not a strong voice or agile implementation plan for data services emerging from the domestic library community and few libraries have responded quickly by making great pilot cases for data services.

The internal advantages and disadvantages of data management and sharing services in the Chinese library community are analyzed. The advantages include: (1) the library community realizes that research data management is a new area of service growth, and some libraries are actively carrying out data research and data services practices. (2) Libraries have proven experience in information organization, management and service development. For example, academic libraries have experience in establishing institutional repositories, and research data is only one more type of information resource which could be managed in a repository. (3) Libraries have experience in information infrastructure development, management, and operation. Most libraries already have a large amount of local data, systems, and applications to be maintained. (4) There are many commercial platforms available for data sharing services, such as the Ex Libris Esploro research repository, Dataverse, or DSpace. The disadvantages include: (1) The domestic library community has no corresponding strategic deployment and implementation steps for data services to support the new research or new learning paradigms. (2) Libraries have not yet identified their role and positioning within the existing research data management system. (3) Lack of research data management talent in domestic libraries: Data literacy has just started in recent years and most of research data management staffs have a background in library science, information management, or computer science and qualified top talent refuse to enter the low-paying library profession.

Based on the status of Chinese research data publishing and the current data management service environment, the following recommendations are proposed for the implementation of data management services by the Chinese library community:

(1) Strengthen dialogue with stakeholders: Library alliances, such as the China Academic Library and Information System (CALIS), the Chinese National Science and Technology Library (NSTL), provincial and municipal library alliances, should actively engage in dialogues with top administrators to make them aware of the library's professional advantages in data management. Meanwhile, they should develop a convincing strategic deployment and implementation plan for data management and sharing services.

(2) Research priorities: Continue with research and analysis in multiple areas such as data management policies and measures undertaken by research funding institutions and research institutions as well as domestic and foreign research data management mechanisms and systems, domestic and international research data management platforms, data repositories, and implementation paths for library research data management.

(3) Priority to consulting and training services: Based on existing conditions, establish a virtual part-time or full-time data management and service team to provide corresponding services for data policies, data intellectual property, data publishing, data standard specifications, data usage and citation, or improving instructions for existing data repositories and research data centers.

(4) Data discovery and access services priority: Establish open data navigation, integrate data management and analysis tools, make efforts to become a service node for the large research data centers, and provide users with one-stop data discovery, correlation, and access services by making data localized and by authorizing data services.

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(5) Establish data repository: According to the current policy, entities such as research institutions are the main bodies for data management implementation and are responsible for data collection, production, processing, and long-term preservation. Chinese libraries should actively seek cooperation with institutional research projects, receive tasks as collaborators with researchers, to begin playing a core role in development of data repositories, and provide consultation services for project data management plans, data processing, publishing, data preservation, and data rights scenarios.

(6) Establish domain subject digital scholarship platforms: Building on existing data repositories, libraries should establish digital scholarship platforms or develop digital research ecosystems in specific areas. Such platforms should support data discovery and data correlation, provide data analysis tools and software, support online data analysis, and have interactive functions such as supporting collaborative research processes and sharing of data.

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