Basic Framework for Scientific Data Rights Analysis

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Abstract

Research data constitutes a crucial component of scientific advancement, and as a knowledge asset, it also presents an emerging challenge for library knowledge management. Research data rights and interests are pivotal to research data management, with a fundamental framework encompassing: the rights and interests of stakeholders, management approaches across different disciplines, multi-level management policies, rights pertaining to usage and citation, rights concerning storage and dissemination, rights related to public sharing, etc. After considering the current demands for research data management and services in China, future directions for research data rights and interests management oriented toward the scientific research workflow are ultimately proposed.

Full Text

Abstract

Research data constitutes a vital component of scientific development and, as a form of knowledge asset, presents an emerging challenge for library knowledge management. Research data rights represent the key to research data management, and their basic framework encompasses: the rights of stakeholders, management approaches across different disciplines, policies at various administrative levels, rights concerning use and citation, rights regarding storage and dissemination, and rights for public sharing, among others. Based on an assessment of current needs for research data management and services in China, this article ultimately proposes future work oriented toward research workflow-based research data rights management.

Keywords: data-intensive scientific discovery, open research data, research lifecycle, data lifecycle, research data management

1. Scientific Enterprise, Research Data, and Libraries

Publishing scientific theories along with their empirical and observational data provides the foundation for others to evaluate, accept, reject, or understand a given work [1-2]. The dissemination of research findings carries several significant implications: First, scientific doctrines or theories require validation by the scientific community through expert recognition and identification of problems and solutions. Second, science serves society and continuously pursues progress for the welfare of humanity, making research results as publicly accessible and usable as possible [1-2]. This call for openness stems from deep concerns about a cultural disconnect in science and expectations for library and information services. As an important component of the scientific enterprise, academic journals originated from scientists' correspondence in the early eighteenth century. Both components of research output—argumentation and evidence—were published together in these scientific communications developed later by institutions such as the Royal Society. However, with the rapid expansion of research, much evidence (i.e., research data) has had to be omitted. Comparing the evidence for Mendel' s genetic theory with current genomic sequence data reveals how print journals cannot accommodate all data supporting a paper' s arguments. Moreover, various factors (such as commercial publishers, scientific evaluation systems, and opportunistic researchers) have enabled scientific misconduct (e.g., deliberately withholding experimental data that contradicts a paper' s thesis).

This has created a problem: the two major components of scientific theory have been separated, with intellectual arguments remaining visible while experimental data becomes difficult to access fully. This separation has caused a series of issues: (1) How can independently existing datasets prove universally applicable scientific propositions? (2) Except for a few insiders, the general public or other research communities can only choose to "believe" or "disbelieve" a scientific claim without being able to verify it themselves. (3) Even if they choose to believe, they cannot directly apply the research findings without access to the data. (4) Even when data can be obtained through various channels, much of it cannot be interpreted. (5) Even if interpretable, data may not be in reusable formats. (6) Even when people obtain interpretable and reusable data, they may not be authorized to use it. (7) While some disciplines already have system platforms for storing research data, the locations where scientific arguments are published and where research data is stored are not necessarily the same, nor do they necessarily provide convenient and reliable links. (8) Scientific data needed for potential interdisciplinary research is stored in different locations with different formats, methods, and standards. (9) Moreover, the problem of lacking research data output is currently universal, while the practice of providing research data to promote disciplinary development remains individual. (10) Due to these difficulties, new researchers can easily go astray, leading to improper handling and presentation of research data. (11) Because research data management tends too much toward information systematization and established disciplinary paradigms, it can deepen tendencies toward self-enclosure.

(12) Evaluation of research contributions becomes imbalanced: the impact of scientific ideas is amplified while the contribution of scientific verification is underestimated, yet the two are complementary.

2. Practical Review of Research Data Management Services in China

In recent years, research data services have flourished in Chinese libraries. Recent CALIS research achievements include: analyses of foreign policies and the development of research data services in China' s research and education system [3]; compilations of research data lifecycle management models from foreign universities [4]; surveys of domestic and international university data sharing platforms [5]; investigations of user needs for research data management in Chinese universities [6]; case studies of research data management implementation at Wuhan University Library [7]; and experience summaries from building research data repositories [8]. These contributions form an important foundation for developing and implementing research data management services in China' s research and education libraries.

Research data rights management is the key to sustainable development of research data services. Regarding research data policies, domestic scholars have already translated and introduced Christine L. Borgman' s research [9-10]; renowned information-seeking behavior researcher Gary Marchionini introduced iSchools' research data management experience at Wuhan University [11]; prominent scholar Qin Jian delivered a special lecture at the National Science Library [12]; Huang Yongwen and colleagues introduced open scientific data policies, scientific data citation formats, and repository cases investigated by the National Science Library [13]; and Meng Xiangbao and Qian Peng systematically reviewed foreign data education practices [14]. These achievements constitute an important foundation for research data rights management.

Accordingly, this article proposes two main orientations for research data management: (1) the long-term preservation (Preservation) of digital data from published research results, and (2) the curation (Curation) of digital data during the research process. The former primarily involves describing, storing, and providing for download and use the datasets involved in data analysis from papers published in academic journals or monographs. The latter involves storing various data generated by individuals, groups, institutions, or funded research projects at different stages—from raw observational data to aggregated data, test data, verified data, data to be discarded or retained, transformed datasets ready for analysis, and finally curated data simplified for publication—along with providing metadata descriptions, analysis tool specifications, and analysis result documentation for subsequent analytical reuse. Adopting the first management mechanism requires consideration of: (1) the hierarchy of research data and (2) the representation structure of research data. Adopting the second mechanism requires consideration of these two factors plus (3) the research data lifecycle.

3. Basic Concepts of Research Data

As a knowledge asset, research data serves as both "raw material" and "finished product" in the "knowledge industry," and as an asset through which individuals can "prove" and "influence" others' evaluations of them in a knowledge-based society. Its storage and dissemination methods have already impacted the composition of knowledge-based society. The concept of human "society" is changing, with the shift from an industrial model to a knowledge model driven primarily by a qualitative change in raw materials—that is, changes in how data and information are exchanged [15]. One impact of technological development driving social change is the transformation of communication methods, not only among populations but also in how scientific research itself evolves. In the online open publication *The Fourth Paradigm: Data-Intensive Scientific Discovery*, particular attention is paid to how science itself shifted at the end of the last century from positivist research to data-intensive research: "Scientific communication, including peer review, is also undergoing fundamental change. Due to cost, timeliness, and the need to place experimental data and related documents together, digital public libraries are comprehensively replacing the role of traditional libraries in collecting publications" [16].

The hierarchy of research data [17] is shown in . In the era of positivist research, one could only extract derived and recombined data from raw data, which then formed the content of scientific literature. In the data-intensive research era, people can link from scientific literature to recombined data and discover raw data from recombined data, enabling data convergence and mining.

Under data-intensive research, we need to reconsider the relationship of knowledge structures, returning to Kant to define science [18]. As shown in , facts or data constitute the fundamental basis of research work. Without facts or lacking data evidence, scientific results and arguments cannot be validated. The information work of mining data by researchers is the main work of promoting open science and an important process for ultimately producing knowledge (here referring to human behavioral norms and natural change laws). Because the importance of research data is amplified through new scientific research technologies, research data management has become an important infrastructure.

The three ongoing and rapidly advancing changes in scientific and technological information exchange systems—open access, open knowledge, and open innovation—bring more challenges and higher demands to the library profession [19]. As social infrastructure for emerging technologies, libraries must serve as both platforms for public knowledge supply and stages for the deployment of various scientific and technological innovation investments. Research data management represents a new opportunity for library development. Libraries' capabilities in discovering, evaluating, and selecting research data, as well as describing, organizing, retrieving, or analyzing it, will be crucial in the future.

4. Stakeholders in Research Data Rights Management

Research data rights management is the key to sustainable development of research data services. In the short term, research data management can be established through large cloud facilities or small databases. However, in the long term, the operation of research data services relates to management, demand, openness, cost, and policy support under regulations, technology, finance, and organization [23]. Therefore, the purpose of a scientific data rights management framework is to provide a roadmap for continuously improving and deepening corresponding content during practice.

Data policies affect how scientists hold research data, and recommendations and enforcement from funding agencies and journals have even greater impact. Data policies require grant recipients and paper authors to ensure the accessibility of data produced as a prerequisite for publication or generated during projects [24]. Research data has three forms of storage, dissemination, citation, and publication, summarized in .

The specific measures in research data rights management policies include a series of research data management workflows: creating data, processing data, analyzing data, preserving data, accessing data, and reusing data. However, in the above research data management workflows, there are at least six types of participants and rights holders, as shown in . During implementation of research data management, the rights and interests of these different participants must be respected and protected.

Among them, researchers are particularly concerned about the degree of recognition of research data as a scientific contribution and the methods for citing research data. Academic communities typically focus on quality assurance of research data and whether it can be widely used, reused, and used to test scientific theories by others. Research institutions generally emphasize the preservation and management mechanisms of research data as an institutional knowledge asset, considering open sharing to enhance institutional reputation. Funding agencies often value research data as part of research project outcomes, which must not be appropriated for private use under any circumstances, or prefer open sharing to increase the credibility of funding agencies within their industries. Publishers are often concerned with what means can be used to obtain reasonable commercial profits to develop better research data services. The public is concerned with whether they have the right to access and use research data and whether research results are reliable.

5. Data Rights Issues in Research Activities

Social capital (here referring to expected reciprocity) relates to how research communities behave regarding open sharing of research data. Competition among researchers is only a moderate influencing factor; the key factor determining researchers' attitudes toward research data processing is their social networks

and industry competition systems [34]. Different disciplines have varying needs, cultures, and problems regarding research data sharing, summarized in .

Research data rights issues across different disciplines revolve around two main threads: first, the balance between "maximizing data utilization" and "maximizing security and privacy protection," a challenge that requires developing alternative electronic information management solutions across different disciplines [36]; second, the rights and obligations relationship between "data sharing" and "data acquisition" [37]. The former involves basic rights protection mechanisms between researchers and the general population, while the latter involves cooperative coordination and policy norms between researchers.

Currently, such debates are increasingly reaching consensus, with the basic principle being open sharing of research data, though specific implementation depends on research data management policies at different research levels. These policies include important but often overlooked rights definitions and handling guidelines that involve the rights of all parties and guide stakeholders in following common principles when preserving, publishing, using, and disseminating research data.

6. Management Levels for Research Data Rights

The management levels for research data rights are divided into international, national, institutional, and individual levels. As shown in [1-2], different levels concern and can implement different content.

Currently, various data policies have emerged at different rights management levels for different purposes. For example, the open data movement initiated by the European Parliament and European Council primarily provides access methods for government data based on W3C data description recommendations, including open data structure and formats, reusable data, and provision of new services for citizens and enterprises [45], which is framework in nature. The UK Ordnance Survey' s OS OpenData online map portal allows users to browse, download, or develop simple data applications, encouraging more geographic information data injection [46] and strengthening governance of fragmented geographic locations (especially marginal islands and maritime territories) [47-48], which is national policy. The U.S. Health Insurance Portability and Accountability Act (HIPAA) Privacy Rule requires that open data management technology must adopt risk identification through simulated attacks and matching tests, achieving open data establishment principles [49] after verification, which is technical detail within industries. Chemical informatics tools for analyzing chemistry, biochemistry, pharmacology, and drug discovery [50] belong to project work of research teams.

7. Use Rights and Citation Issues in Research Data Rights Management

Data resource usability includes: reflecting specific questions, becoming understandable and operable data, having sufficient transparency and clarity, and supporting user interaction and access [54]. Research data rights management must address these issues in terms of technology, finance, regulations, and organizational capacity.

First, forty years ago publishing a paper required including complete data to enable replication; however, few journals could do this because the vast amount of data required for new scientific research far exceeds what journals can publish. This has separated the two main components of scientific achievements—ideas and evidence—creating a data-gap that is detrimental to science' s self-correcting mechanism. If research data cannot be accessed and reviewed, how can scientific theories be challenged and revised?

To solve this problem and generate benefits from scientific acceleration in data-intensive research, open sharing of research data is needed. shows the degree of open sharing of research data. Only when accessibility, assessability, intelligibility, and usability are all satisfied can research data be replicated and verified, thereby forming new knowledge from scientific exploration and discovery.

Recently, international research management policies have shown a trend toward open sharing of research data. For example, EU member states have policies implementing "public access, use, and reuse of research data from publicly funded research results through electronic infrastructure" [51]. The U.S. White House Office of Science and Technology Policy (OSTP) executive order states: "Digital research data produced by research projects funded in whole or in part by the federal government should be stored and provided for searchable, retrievable, and usable public access" [52]. The EU plans to include similar requirements in its eighth HORIZON 2020 framework [53]. These policies largely establish the international trend toward open sharing of research data; however, implementation involves a series of issues such as use rights and citation, storage rights and collection, dissemination rights and publication, and sharing rights and policies.

8. Storage Rights and Collection Issues in Research Data

Data management workflows [60-61], research workflows [62-63], research data management workflows [64-65], and research data rights management workflows have different connotations, as shown in .

Accordingly, we can analyze the two main orientations of research data management: (1) the long-term preservation (Preservation) of digital data from published research results, and (2) the curation (Curation) of digital data during the research process. The former primarily involves describing, storing, and providing for download and use the datasets involved in data analysis from papers published in academic journals or monographs. The latter involves storing

various data generated by individuals, groups, institutions, or funded research projects at different stages—from raw observational data to aggregated data, test data, verified data, data to be discarded or retained, transformed datasets ready for analysis, and finally curated data simplified for publication—along with providing metadata descriptions, analysis tool specifications, and analysis result documentation for subsequent analytical reuse.

Referencing the lifecycle of data archive management [66] and the content of Tables 7-9, presents the research data rights management process, divided into three dimensions: scientific data flow, stakeholders, and rights management.

9. Dissemination Rights and Publication Issues in Research Data

If scientific papers are tightly integrated with the actual data and metadata supporting their results, this implies the ability to effectively and long-term maintain papers, data, metadata (describing papers and data), and links. As shown in , this includes a series of rights management policies. Future research data publication systems should first conduct policy formulation work before planning platform storage requirements, permission management, and dissemination licenses.

There are two major technical routes for research data publication and linking services: Linked Open Data and Knowledge Bases. Although the technology is mature, the key factor determining implementation is data rights management.

(1) Linked Open Data differs from traditional search in that it can cross different data sources and perform complex queries based on standards like RDF format and SPARQL query language. It is more similar to distributed or federated databases, but the data sources cooperating with it maintain and update their respective data independently [70]. Converting open information into computable open knowledge involves work including: (1) supporting the reusability of open information; (2) supporting the structuring of reusable information; (3) supporting the semanticization of structured information; and (4) supporting the linking of semanticized information [71]. The Linked Open Data process includes: collecting data, publishing linked data, normalizing "connection points" in links, obtaining data from individual datasets, and client application data [72]. However, Linked Open Data includes two parts [73]: openness (standards, access, licensing) and linking (identifiers, data models, ontologies, query languages).

(2) Knowledge Base (KB): A massive database compiled, distributed, and maintained by knowledge base developers, containing information about electronic resources such as title lists, coverage dates, and seamless links. Early designs were for "dynamic update links" [74-76] and "multi-party linking" [77], later solving the "appropriate copy" problem [78]. Based on the same principle, knowledge bases for data-intensive science within disciplines can be developed, such as "Biological Expression Language"

[79], and intelligently linking various research data center databases to provide search, access, download, and computing functions, as shown in for Altmetric [80-84] and other data usage methods. Currently, the knowledge base supply chain consists of a series of complex roles: publishers, other content holders, subscription agents, link resolver vendors, libraries, etc. [85-86]. The U.S. NISO is promoting new standards to solve data quality and licensing issues [85]. These issues also occur in the dissemination of research data in the academic communication system.

If professional technology vendors are sought to quickly build platforms, research shows that general (other industries') professional technology vendors, if willing to provide open platforms, will defend their intellectual property more vigorously [87]. This is because currently widely used software-intensive systems are components of open architecture (OA) plus multiple open APIs as open source software (OSS) components. Their advantage is realizing many benefits of openness; however, the challenge is that each component is constrained by different copyrights or intellectual property licenses [88]. Therefore, whether building a platform or not, it is recommended to prepare research data rights management policy content in advance. shows key rights issues involved in research data publication.

10. Sharing Rights and Policy Issues in Research Data

Research data management is not merely a matter of distributed network systems and personalized permission management. Unlike past distributed heterogeneous data, it requires simpler, more flexible, and more effective technology, and more importantly, a need for technical and cultural adaptation [98].

In the life sciences, technical issues with Linked Open Data (LOD) are not sufficient to affect the construction of a data-centric "big biology" discipline; however, there is a lack of understanding in the culture of heterogeneous data [99]: (1) following a data standard; (2) scientists sharing data; (3) incentive measures. These issues create invisible obstacles to related work. To enable full utilization of research data, bioscience communities have begun advocating for technical and reward mechanisms to support interoperability and promote the growth of open science and culture.

On the other hand, "Open Science" emerging in the scientific community means that researchers share every element of their research process, in addition to final research products, to promote collaboration among researchers. It can encourage researchers to spontaneously create new virtual collaborative research [102]. However, in high-cost research where only a few results can be profitable, the intellectual property (IP) system in biomedical research continues to expand into academic circles [103], and knowledge commodification is significant [104]. Researchers currently operate within a hybrid system of "open science" and "patent system" [105]. The scientific community often has different understandings of open science, such as what constitutes reproducibility, computing

resources, scientific honor, data sharing, achievement sharing, peer review, and effectiveness evaluation. These meanings are often ambiguous, requiring extensive opinion and motivation surveys and different forms of outreach to achieve consensus and agreement [105]. These tasks rely on professional scientific and technological information policy research and consulting working groups to promote them, enabling researchers to more easily obtain convenient services for academic information exchange and benefit optimally from them. Research data rights and policies are shown in .

11. China' s Needs for Implementing Research Data Rights Management

Digital research data has different data types, varying degrees of integration, and data formats due to disciplines and methods. For the purpose of accessing and reusing research data, digital research data has no value at all if metadata and appropriate documentation describing how content and tools are created, stored, adjusted, and analyzed are lacking [106].

Currently, China has implemented many measures for research data management, research data management services, and research data management service education. Learning from the past to understand the future, we can identify policy service needs when implementing research data management from the outlines of China' s three stages of research data management () and the development stages of Chinese libraries ().

Currently, China' s research data management is in the second stage, with a considerable foundation in research data repository construction and some norms for data quality control, developing toward a balance of rights and interests in open sharing of research data. Libraries, in terms of service development for research data management, are in a transition period between the first and second stages. Having recognized the service needs of research teams for library assistance in data management and, from the perspective of library development strategy, the necessity of libraries as mechanisms for research data repository construction and quality control.

Based on global research data policy research, a policy map for research data rights management is drawn, as shown in [Figure 1: see original paper].

Policy documents provided by global academic communities and national governments mainly offer principled guidance; however, specific implementation details are found in policies and manuals of funding agencies, research institutions, project teams, and researchers. Further searches for comprehensive reports from institutions that have implemented policies for some time and have certain credibility, with their content subdivided into main content frameworks, are organized in .

Therefore, to support libraries in educating researchers on data management and serving as knowledge management infrastructure for innovative society, the de-

mand for research data rights management policy services is increasingly prominent. To this end, policy research consulting teams need to be organized to provide phased support for libraries to smoothly carry out this emerging business.

12. Future Outlook: Policy Services Supporting Research Data Rights Management Across the Research Lifecycle

The research data lifecycle includes backup, collection, selection, curation, and sharing. At each different stage, there are various participants and stakeholders concerned with different issues, including researchers, academic communities, institutions, research funders, publishers, and the public, each with different rights and interests. These pose complex requirements and challenges for research data rights management, which need to be gradually sorted out and presented in practice. The policy research framework formed in this article has reference significance for general recording, storage, preservation, and publishing measures, such as: managers need to consider data reuse capabilities, data licensing, openness, and prerequisites for research data management.

In summary, there are also some universal issues that need consideration when implementing research data management and rights policy formulation, organized in .

The policy levels in [Figure 1: see original paper] should all emphasize the content of , but they should have different focuses. Global academic communities and government regulatory agencies need to fully emphasize data rights scope: public right to know, legitimate commercial benefit, national security secrets, personal privacy, and informed consent. Funding agencies and research institutions need to fully emphasize data control means: anonymization, limited access, and closure. Project teams and researchers need to fully emphasize data openness degree: accessibility, assessability, intelligibility, usability, and executability.

According to this cooperation model and the policy level framework described in [Figure 1: see original paper], as well as the aforementioned research data use, citation, storage, dissemination, sharing, and other scientific data rights analysis basic frameworks, various policy guidelines formed through research and practice will be released one by one. Currently, at the National Science Library' s Science and Technology Information Policy Center, a series of policy documents have been fully translated, including the *G8 Open Data Charter and Technical Annex* [111], *Open Data Executive Order and Implementation Details* [112-113], *Publishers and Universities' Response to OSTP Mandate* [114], *Principles for Research Data Processing* [115], *Data Management Plan Checklist* [116], and *Creative Commons Guide for Authors* [117], with a special issue of *Library Copyright Dynamics: Research Data Rights Management* forthcoming. More advanced research will follow. This article serves as a modest spur to induce more valuable contributions.

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Note: Figure translations are in progress. See original paper for figures.