Research on the Construction of China's Open Science Policy System: Postprint

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Abstract

Open science has ascended to the level of a global strategy. Open science policies will serve as an "accelerator" for the achievement of the United Nations Sustainable Development Goals. Currently, China still exhibits notable insufficiencies in the formulation and support of policies related to open access, open science infrastructure, and similar domains. The immediate demand for China's open science policies derives from the emerging open innovation research scenarios within the country, while the long-term demand originates from the construction of an open innovation ecosystem. This study proposes an open science policy system that aligns with the framework of China's scientific and technological innovation policy system, and presents policy action recommendations that conform to UNESCO's "Recommendation on Open Science."

Full Text

Preamble

At the opening ceremony of the Top Scientists Forum, the *Initiative on International Cooperation in Research Conduct* was released, actively advocating for globally recognized research values including open science. This initiative aims to work alongside international peers to address global challenges, representing an important practice for Chinese scientists and technologists to accelerate implementation of the UN 2030 Agenda for Sustainable Development and integrate into global scientific and technological cooperation. Currently, China has not yet introduced policies explicitly named "open science." This study employs policy content analysis to construct China's open science policy system, providing a foundation for top-level design and overall planning.

Value of Open Science Policies

The UNESCO Recommendation on Open Science, officially released in November 2021, has become a guiding framework for global open science policies, attracting widespread attention in academic circles worldwide. The Recommendation defines open science and proposes its main pillars: open scientific knowledge, open science infrastructure, science communication, open engagement of societal actors, and open dialogue with other knowledge systems. It emphasizes that the core values of open science are quality and integrity, collective benefit, fairness and equity, and diversity and inclusion. It recommends that member states take simultaneous action in seven areas: common understanding, policy environment, infrastructure, capacity building, incentives, innovative approaches, and global cooperation. For the first time, it proposes characterizing open science topology through two dimensions—openness and inclusiveness—across four scientific research quadrants, where openness governance targets open knowledge and inclusiveness governance targets diverse actors.

The Recommendation provides solutions for key global scientific issues and serves as an "accelerator" for achieving the UN Sustainable Development Goals (SDGs), consistent with the "research accelerator" concept proposed in 2019. In 2022, the Open Science Policy Working Group focused on three aspects: guiding the establishment of open science policies, creating a global repository of research tools for international cooperation, and discussing key steps and challenges in open science policy development to formulate policy guidelines. Working group discussions addressed: primary policy needs for open science; main challenges in creating and implementing open science policies; highlights of existing successful open science policies; and challenges including awareness among key open science stakeholders, strengthening policy design diversity for access, openness, participation, and collaboration, and providing financial support for opening publications and research data, as well as necessary infrastructure and human resource training. These are also elements that need clarification in China's open science policy development.

Open science policies enhance the openness and inclusive governance connotation of China's scientific and technological innovation policy system. China's S&T innovation policy framework consists of four dimensions—innovation elements, innovation subjects, innovation environment, and innovation links—working synergistically to advance innovation. Policy content analysis of the Recommendation reveals that it acts upon all dimensions of China's S&T innovation system, primarily affecting: platform infrastructure, talent management, and knowledge utilization within innovation elements; international cooperation, research integrity, and financial support within innovation environment; S&T investors within innovation subjects; and information technology within innovation links [Figure 1: see original paper]. Therefore, open science policies can be considered a category of S&T innovation policy.

Global Trends in Open Science Policies

(1) International open science policy releases are increasing annually. Based on international open science policy texts collected by our research team, analysis shows that the number of open science policies released internationally has been rising yearly [Figure 2a: see original paper]. Policies on open science governance are the most numerous, peaking in 2021 [Figure 2b: see original paper]. Governments are the primary issuing institutions, followed by research institutions [Figure 2c: see original paper]. The United States has released the most open science policies, followed by the European Union [Figure 2d: see original paper], consistent with recent survey results from the Open Science Policy Working Group on policy releases across countries.

(2) Open science policies focus on promoting innovation. Analysis of international policy texts shows continuous releases of open access and open data policies by nations, research institutions, funding agencies, and international organizations, all aiming to drive national innovation. In national open science roadmaps or plans released by Finland, France, Canada, the Netherlands, the EU, and others, Finland aims to enhance essential scientific exploration and deepen the relationship between research and society; the EU expects to lead globally in research data management and ensure European scientists fully benefit from data-driven science; Canada hopes to open science to all and maximize benefits for national wellbeing and health.

(3) National policies remain key to advancing open science comprehensively. In 2013, the U.S. White House Office of Science and Technology Policy (OSTP) issued the *Memorandum on Increasing Access to the Results of Federally Funded Scientific Research*, making the U.S. the country with the most institutional repositories globally. As of 2022, according to the Directory of Open Access Repositories (OpenDOAR), the U.S. had 1,168 institutional repositories. In 2022, OSTP issued a new open access memorandum, requiring immediate public access to federally funded research results upon publication (with institutional repositories playing a key role) and designating 2023 as the "Year of Open Science." In 2020, CERN's open science policy mandated that data, software, and hardware from major facility-based research must comply with the FAIR principles. The EU's Horizon Europe program and the *Global Code of Conduct for Research in Resource-Poor Settings* support establishing long-term equitable research relationships between low-income and high-income regions based on fairness, respect, care, and honesty.

(4) Open science policies promote standardized, legalized, and internationalized scientific governance. In 2022, the Committee on Publication Ethics (COPE), Directory of Open Access Journals (DOAJ), Open Access Scholarly Publishing Association (OASPA), and World Association of Medical Editors (WAME) released the first version of the *Principles of Transparency and Best Practice in Scholarly Publishing*. In 2021, Serbia incorporated open science into national law, mandating open access for all publications from research funded

by the Ministry of Education, Science and Technological Development.

Insufficient Release of China's Open Science Policies

Comparing domestic and international policy release patterns reveals significant differences in open access policies [Figure 3a: see original paper]. While China's "open science infrastructure" policies started early, releases have slowed markedly in recent years [Figure 3b: see original paper]. China has not yet formulated policies explicitly named "open science." Based on the Recommendation's definition and using our research team's "Science and Technology Policy Database," we retrieved policy texts containing measures like "openness," "sharing," and "cooperation," tagging them with themes of "open access," "open data," and "science infrastructure." As of October 2022, our team collected 217 Chinese policies from the past 20 years, covering outlines, plans, and management measures, plus over 100 policies from the U.S., UK, France, Germany, Netherlands, Japan, Canada, and EU for comparative analysis.

To compare with the Recommendation's action areas and adapt to China's legal framework and policy system realities, we designed China's policy action advancement indicators : (1) Institution building, from national policy formulation to participant implementation, establishing hierarchical advancement; (2) Practice promotion, from national to research institution multi-actor actions; (3) Support guarantee, establishing innovative mechanisms for implementation.

Coding China's 217 policy texts using these indicators yielded 1,243 measures. Overall [Figure 4: see original paper], China's policies already align with the Recommendation's action content but are scattered and repetitive across different policies with varying implementation strength. In institution building, multi-agency coordination systems are the main measure, while national-level regulation formulation is weak. In practice promotion, public engagement and multi-science actor collaboration are strong, while knowledge co-production is weak. In support guarantee, improving S&T investment systems and research evaluation/incentive mechanisms are strong, while optimizing the S&T business environment is weak.

China's Innovation-Driven Development Model Based on Open Science

Evolution of the Open Science Knowledge Chain Drives New Paradigms. The Recommendation proposes governance of openness and inclusiveness across different research quadrants and a value enhancement model centered on the knowledge innovation chain. Open science advocates for openness and inclusiveness to promote positive evolution of the knowledge innovation chain while reducing negative influences, aligning with the "new paradigm" proposed in the Recommendation's open science definition.

The open science innovation paradigm complements the currently popular fourth paradigm characterized by data-driven research, while demonstrating greater

openness and inclusiveness across all disciplines and research stages. This gives open science distinct features compared to other paradigms.

Current Status of Open Science Practices in China's Scientific Community. Analysis of over 100 open science practice cases from China's scientific community reveals that Chinese researchers have adopted open research models across different research stages. These models share similarities with data-intensive research paradigms (fourth paradigm), eScience, convergent research, and intelligent research, but exhibit greater openness and inclusiveness, covering all disciplines and research stages.

Four patterns emerge: (1) **Research organization innovation at the initial stage** (GCM 2.0 phase). The National Microbiology Data Center launched the Global Catalogue of Microorganism Genome Sequencing Program, establishing the first ISO-level data standard in international microbiology, contributing Chinese wisdom to the Convention on Biological Diversity and Nagoya Protocol implementation. Beijing Normal University led the establishment of the international Credibility and Reproducibility Consortium (CRECO), the first Chinese-led international neuroimaging big data sharing initiative, demonstrating significant international influence. (2) **Data platform cooperation in global research** (DDE phase). The Earth Big Data Science Engineering project established a geoscience big data sharing platform, while the Deep-time Digital Earth (DDE) program, based on global geological big data and advanced computing methods, involves geographers, biologists, meteorologists, and data scientists collaborating on data platforms. (3) **Open sharing of research outputs** (open publishing, preprints). The ChinaXiv preprint platform enables rapid open communication, while the new journal *iMeta* integrates video, reproducible analysis, and social media promotion. The Agricultural Sciences Institutional Repository Alliance provides access to papers, patents, data, and resources from Chinese Academy of Agricultural Sciences institutes. (4) **Public monitoring and user evaluation of innovation outputs** (open influence building). Tsinghua University's open access paper management system interconnects with internal research management and scholar databases. The National Science Library annually releases global APC monitoring reports. iFLYTEK's Translator 4.0, launched in 2018, added offline translation based on user demand for simpler operation.

Fitting China's Open Science Innovation Scenarios. Based on open science jurisprudence and Chinese practice cases, we model China's open science innovation scenarios: Open access innovation models evolving from open papers to diverse research outputs (papers, preprints, patents, data, software, products), influencing researcher/collective impact building; Data reuse efficiency, from scientific data sharing to one-stop infrastructure platforms for multi-level, multi-source data; Global open innovation product governance, focusing on enhancing open academic exchange and international inclusive cooperation to generate collective innovation products for societal and global wellbeing and achieve global impact.

Short-term and Long-term Policy Needs for China's Open Innovation Scenarios

(1) Current problems and policy needs in China's open science innovation scenario development. Specific issues include: **Research output open sharing.** Open knowledge is a cornerstone supporting open science-era S&T innovation. While the Chinese Academy of Sciences and NSFC have issued open access policy statements encouraging open access for funded project papers, China has not yet formulated national-level open access policies, leaving key participants, costs, and pathways unclear. Adaptive policy changes are urgently needed. **Open data platform efficiency.** Open data is the knowledge reuse cornerstone. China has advanced open data management with layouts, platforms, and principles, but faces issues like low sharing rates, fragmented platform development, and insufficient value-added utilization. National open science infrastructure policies are needed to integrate publication data, research data, large scientific instrument data, analysis tools, and even enterprise patent data. **Global influence and competitiveness evaluation.** In open science scenarios, individual academic evaluation based on publications will shift to science communication focused on group (cross-team, cross-field, cross-region) global S&T innovation product application, creating new demands for open academic incentives, open research promotion, and international cooperation. **National support.** Chinese libraries currently pay database procurement fees for global publication access, but this only partially solves limited-range data acquisition. Coordinated national open science fund calculations are needed to promote global research output open access and Chinese scientist participation.

(2) China's open innovation scenario still has distance from the global open innovation ecosystem, requiring long-term planning. From an innovation process perspective, open science and open innovation share consistent connotations, with open science functioning across innovation stages. Explicit and tacit knowledge flows openly across stages, accelerating open science innovation, open innovation, public innovation, and user innovation. Solutions to societal open innovation and global major issues will advance in an open and inclusive ecosystem, with different participants conducting open innovation practices across research stages to provide high-quality innovation products (new theories, methods, products) for societal needs. Using open science jurisprudence as the engine and based on the open innovation ecosystem model, we map the ideal global open innovation ecosystem framework [Figure 7: see original paper], encompassing diverse actors, resource sharing, process reengineering, collective innovation product production, and knowledge spillovers. To evolve from current status to this ideal state, China needs continuous policy development to promote greater stakeholder openness, inclusivity and symbiosis in resource sharing, key actor interests in innovation process reengineering, and more globally influential innovation products.

Framework and Action Recommendations for China's Open Science Policy System

Key Policy Recommendations for Advancing China's Open Science Development. Current primary policy needs center on open access, data infrastructure, S&T innovation product dissemination and application, and how China integrates into the global open science framework and strengthens policy tool diversity. Main challenges include achieving consensus among key Chinese participants and securing government financial support to implement global open science actions. China's existing open science policies are primarily science governance policies—an inherent advantage of its national system. Therefore, we recommend prioritizing the establishment of key open science policies and governance strategies.

(1) Formulate national open access policies with proactive, mandatory, and global-thinking strategies. **From knowledge funding source:** Require open access for government-funded results, mandating deposit in national and institutional repositories. **From knowledge communication source:** Establish preprint policies advocating pre-publication on national preprint platforms to shorten open access timelines. **From knowledge dissemination source:** Accelerate Chinese S&T journals' open publishing transformation, establishing global-adapted open publishing norms, data policies, and reasonable policies. **From knowledge application benefits:** Establish public welfare platforms for open educational and S&T resources, aggregating open courseware, lectures, and academic reports for equitable education and knowledge access. Based on these actions, launch a global open access initiative to promote open sharing and cooperation of global S&T resources.

(2) Formulate open data policies prioritizing global value, appropriate mandates, and infrastructure. Building upon China's *National Security Law* (2015), *Cybersecurity Law* (2016), and *Data Security Law* (2021), China urgently needs to construct national scientific data infrastructure systems with proactive, higher-effectiveness policies. Led by the state, these should clarify requirements, principles, and involved fields/industries for open data infrastructure, mandating stakeholder implementation and detailed measures, including compulsory data sharing in key fields. Establish a national open data sharing center to enhance data value-added and international cooperation innovation capabilities through top-level design and coordinated management.

(3) Construct an open science maturity evaluation system with continuous global monitoring. Accelerate innovation in research output evaluation systems, extending evaluation to scientific data, open communication capacity, and innovation products, with evaluation objects being both individuals and research groups. Based on key links in open innovation scenarios, establish open science maturity evaluation indicators and kinetic development models for monitoring China's open science advancement and global trends.

Building an Open Science Policy System Aligned with China's S&T Innovation Laws. Focusing on the goal of "forming a globally competitive open innovation ecosystem," we propose integrating open science policies into China's S&T innovation policy framework. Centered on the three policy directions identified earlier, we present a framework covering four dimensions—innovation elements, innovation subjects, innovation environment, and innovation links [Figure 8: see original paper]. This framework will continue strengthening talent cultivation/management, facilities/equipment, international cooperation, and public funders (investors) while addressing weaknesses: in innovation elements, clarifying priorities and national policies; in innovation subjects, promoting participation of currently weak key actors like research institutes and universities; in innovation links, reshaping open science innovation processes to increase value for high-quality S&T industry development and new ecosystem formation; in innovation environment, shifting industry-academia-research collaboration to joint S&T tackling, directly achieving innovation product application and integration into smart cities and regional innovation development like the Yangtze River Delta.

Action Recommendations for China's Open Science Policies Adapted to the Recommendation

We recommend China actively participate in global open science governance, establishing an adaptive open science policy action framework based on our advancement indicators and policy system . The framework includes: (1) **National-level policies** like national open access policy, national open data infrastructure policy, and preprint policy; (2) **Institutional policies** from funding agencies, research institutions, and universities; (3) **Inclusive policies** covering open science investors, enterprises, and international data centers; (4) **Practice promotion** through institutional repositories, data platforms, and open labs; (5) **Evaluation incentives** including researcher evaluation reform and open science governance evaluation; (6) **Business environment optimization** protecting equal access and fair competition; (7) **Investment policy systems** innovating funding support and management methods.

Example: National Open Access Policy Development. Using a "national system, phased advancement, academia-led, key institutions pilot-first" approach: Launch the *Open Access Initiative for Publicly Funded Research Results*, jointly with funding agencies, research institutions, and academic groups to call for public-funded research to provide public welfare services and global open access. Release China's open access policy outline with relevant ministries issuing statements and policies. Subordinate research institutions, universities, and teams propose implementation details. Major funders like NSFC and CAS pilot first, updating their 2014 open access statements with ratio targets and specific actions for publicly funded outputs, developing implementation details for preprints and paper deposit services, supporting public S&T resource and open access platform construction, and establishing open innovation reward

mechanisms.

Summary and Outlook

Open science is a global endeavor and scientific project. China's open science development will follow scientific laws, aiming to "form a globally competitive open innovation ecosystem" as proposed in the 20th Party Congress report. It will advance Chinese open science and participate in global governance according to Chinese laws and public will. This study shows open science policies belong to China's S&T innovation policy category, with particular emphasis on openness and inclusiveness governance.

China has set 2035 goals for becoming a world S&T power, with its national system advantages in talent, investment, and platform facilities already playing major roles. Combined with current open science practices, China can likely achieve global open innovation ecosystem formation through overall planning, multi-actor participation, open science process reconstruction, global open data infrastructure, and global influence enhancement for high-quality S&T industry development and new ecosystem formation.

Future research should focus on: analyzing the symbiotic relationship and evolution mechanisms between open science and innovation ecosystems; constructing specific policy content for China's open science policy system; and conducting long-term evolutionary studies of the policy system.

Abstract

Keywords: open science; open access; open data; open science infrastructure; open science governance; policy system

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