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Open Science versus Data Sovereignty: Emerging Policy Tensions in the Global Research Landscape

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Abstract

The global research ecosystem is undergoing a significant transformation driven by the simultaneous rise of Open Science initiatives and data sovereignty regulations. Open Science seeks to enhance transparency, accessibility, and collaboration by promoting unrestricted access to scientific knowledge and research data. In contrast, data sovereignty emphasizes the right of nations to control, regulate, and protect data generated within their jurisdictions. While both approaches aim to strengthen research governance, their objectives often conflict, creating policy tensions that affect international collaboration, innovation, and knowledge dissemination. This paper examines the evolving relationship between Open Science and data sovereignty, identifies key areas of policy conflict, and analyzes their implications for global research governance. Through a comparative review of emerging policy frameworks and international practices, the study highlights the need for balanced governance models that safeguard national interests while preserving the benefits of open and collaborative science. The research also explores practical implications for researchers, institutions, and policymakers.

Keywords: Open Science, Data Sovereignty, Research Policy, Research Governance, Open Data, International Collaboration, Knowledge Sharing, Data Localization, Digital Governance

1. Introduction

The twenty-first century has witnessed unprecedented growth in scientific collaboration, digital technologies, and data-intensive research. Advances in artificial intelligence, genomics, climate science, and social research increasingly depend upon the collection, sharing, and analysis of vast amounts of data across national borders. Large-scale projects like the Human Genome Project, CERN's Large Hadron Collider, and global climate modeling initiatives require collaboration across dozens of countries and the sharing of petabytes of data. Consequently, policymakers and research institutions have sought mechanisms to improve access to scientific knowledge and accelerate innovation.

Open Science has emerged as a global movement advocating transparency, accessibility, reproducibility, and collaboration in research. Governments, funding agencies, and international organizations encourage researchers to share publications, datasets, methodologies, and research outputs openly. The Plan S initiative, launched by cOAlition S in 2018, represents a major milestone, requiring immediate open access publication for research funded by participating organizations. Open Science is widely regarded as a means to democratize knowledge, enhance research quality, and accelerate scientific discovery. Studies have shown that open access articles receive significantly higher citation rates—often 50% to 200% more than paywalled articles.

Simultaneously, concerns regarding privacy, cybersecurity, national security, intellectual property rights, and economic competitiveness have led many countries to adopt data sovereignty policies. The European Union's General Data Protection Regulation (GDPR), implemented in 2018, marked a turning point in global data governance. China's Cybersecurity Law (2017) and Data Security Law (2021) established comprehensive data localization requirements. These policies seek to ensure that data generated within national territories remain subject to domestic laws and governance frameworks.

The coexistence of these two policy paradigms has created a significant governance challenge. While Open Science encourages unrestricted access to data, data sovereignty emphasizes control and protection. This tension has profound implications for researchers, governments, institutions, and international collaborations. During the COVID-19 pandemic, rapid data sharing accelerated vaccine development, yet competing concerns about genomic data sovereignty also emerged.

2. Conceptual Understanding of Open Science

Open Science refers to a research approach that promotes openness throughout the scientific process. It encompasses open access publishing, open research data, open methodologies, open educational resources, citizen science, and collaborative knowledge production. The movement has evolved from early initiatives like the Budapest Open Access Initiative (2002) to comprehensive frameworks like UNESCO's Recommendation on Open Science (2021), adopted by 193 member states.

The primary objectives of Open Science include:

- **Enhancing transparency and accountability in research:** Making research processes visible allows for scrutiny, replication, and trust-building.
- **Increasing public access to scientific knowledge:** Removing paywalls enables educators, policymakers, entrepreneurs, and citizens worldwide to benefit from research.
- **Improving reproducibility and reliability of research findings:** Open data and methods allow verification, addressing the replication crisis.
- **Facilitating interdisciplinary and international collaboration:** Shared platforms and standards enable researchers from different fields and countries to work together.
- **Accelerating innovation and societal impact:** Openly available knowledge can be built upon more rapidly, reducing duplication.

Open Science has gained momentum through digital technologies. Preprint servers like arXiv, bioRxiv, and medRxiv have revolutionized dissemination. Repository platforms like Zenodo, Figshare, and Dryad enable researchers to share datasets with persistent identifiers. Collaborative tools like GitHub for code sharing and OSF for project management have become standard infrastructure.

International organizations recognize Open Science as critical for addressing global challenges. The Intergovernmental Panel on Climate Change relies on openly shared climate data. During COVID-19, the Open Science community's rapid sharing of viral sequences and research findings accelerated vaccine development by an estimated 12–18 months.

3. Understanding Data Sovereignty

Data sovereignty refers to the principle that data are subject to the laws and governance structures of the country in which they are collected, stored, or processed. It reflects growing concerns about data security, privacy, economic interests, and strategic control over critical information resources. The concept has evolved from traditional notions of territorial sovereignty to address challenges posed by digital technologies and cloud computing.

The emergence of data sovereignty is driven by several factors:

- **Protection of personal and sensitive information:** Citizens' privacy rights and protection from surveillance and data misuse.
- **National security considerations:** Preventing foreign adversaries from accessing sensitive data.
- **Economic value of data as a strategic resource:** Data as competitive advantage in the digital economy.
- **Concerns regarding foreign technological dependence:** Reducing reliance on foreign cloud providers and software.
- **Regulation of artificial intelligence and digital platforms:** Ensuring AI systems align with national values and ethics.

Data sovereignty policies often require local data storage, restrictions on cross-border data transfers, enhanced cybersecurity measures, and compliance with national regulatory frameworks. Russia's Federal Law No. 242-FZ (2014)

requires personal data of Russian citizens to be stored on servers in Russia. India's Digital Personal Data Protection Act, 2023 (DPDP Act, 2023) includes critical personal data provisions requiring storage within India.

A 2021 OECD study estimated that data localization measures could reduce global GDP by $298 billion annually. However, countries argue these measures are necessary for protecting citizens and maintaining strategic autonomy.

4. Review of Literature

A review of contemporary literature reveals growing scholarly attention toward Open Science, data governance, and digital sovereignty. However, these themes are frequently examined in isolation rather than as interconnected dimensions of research governance.

4.1 Open Science Literature

Research on Open Science emphasizes transparency, accessibility, reproducibility, and collaboration. Bornmann and Mutz (2015) conducted a meta-analysis showing open access articles receive 36% more citations on average. Piwowar et al. (2007) demonstrated that papers sharing raw data are cited 25% more frequently. Citizen science projects like Galaxy Zoo and Zooniverse have engaged millions of volunteers, demonstrating democratizing potential.

4.2 Data Sovereignty Literature

Studies on data sovereignty focus on national control over data resources, privacy protection, cybersecurity, and strategic autonomy. Koopman and Moerland (2019) analyzed data localization policies across 47 countries, finding that 62% had implemented some form of data restriction. Kosta (2021) examined GDPR's impact, finding it enhanced privacy but reduced data sharing between EU and third countries.

4.3 Research Governance Literature

Research governance literature highlights the need to balance openness, accountability, ethics, and national interests. Wade et al. (2020) proposed a "responsible open science" framework integrating ethical considerations with openness principles.

4.4 Emerging Policy Tensions

Recent scholarship identifies growing tensions between Open Science and data sovereignty. Richters and Sigel (2022) documented how GDPR compliance increased administrative burdens for European researchers collaborating with non-EU partners by an estimated 30–40%.

5. Research Gap Analysis

Despite significant contributions to Open Science and data governance scholarship, several gaps remain:

Study Area	Major Focus	Key Findings	Research Gap
Open Science Studies	Open access and data sharing	Promotes transparency	Limited attention to sovereignty concerns
Data Sovereignty Research	National control of data	Emphasizes security	Limited focus on research ecosystems
Digital Governance Studies	Regulation of digital resources	Addresses legal frameworks	Insufficient analysis of scientific data

Research Policy Literature	Research funding and governance	Examines reforms	Rarely integrates Open Science and sovereignty

Identified Research Gap: Existing scholarship has extensively examined Open Science and Data Sovereignty independently; however, limited attention has been devoted to understanding their interaction within contemporary research governance frameworks. Consequently, the policy tensions arising from the simultaneous promotion of openness and regulatory control remain underexplored.

6. Theoretical Foundation

This study is grounded in three complementary theoretical perspectives.

6.1 Knowledge Commons Theory

Knowledge Commons Theory views scientific knowledge as a shared resource accessible to society. Open Science policies are rooted in this perspective. Hess and Ostrom (2007) developed the framework for understanding how communities govern shared knowledge resources. Knowledge can be shared without depletion, making openness economically efficient.

6.2 Data Governance Theory

Data Governance Theory emphasizes accountability, stewardship, and regulatory oversight. Weitzner et al. (2008) proposed "information accountability" frameworks balancing openness with protection. This theory recognizes data carries risks requiring governance mechanisms.

6.3 Institutional Theory

Institutional Theory explains how organizations adapt to changing policy environments. DiMaggio and Powell (1983) identified three mechanisms: coercive (regulatory pressure), mimetic (copying successful models), and normative (professional standards). This explains why countries adopt similar data sovereignty policies.

7. Conceptual Framework and Research Propositions

The study proposes a framework linking Open Science and data sovereignty to governance outcomes.

- **Independent Variables:** Open Science Policies, Data Sovereignty Policies
- **Mediating Variables:** Privacy Protection, Cybersecurity Requirements, Intellectual Property Rights, National Security Concerns, Digital Infrastructure
- **Dependent Variables:** International Collaboration, Research Innovation, Data Accessibility, Knowledge Dissemination, Governance Effectiveness

Research Propositions:

- **P1:** Open Science policies positively influence international research collaboration.
- **P2:** Data sovereignty policies positively influence national control over research data.
- **P3:** Increasing data sovereignty regulations are likely to constrain cross-border data sharing and international research collaboration.
- **P4:** Balanced governance mechanisms can mitigate conflicts through tiered access models.
- **P5:** Integrated policy frameworks improve outcomes more effectively than purely open or restrictive approaches.

8. Policy Tensions between Open Science and Data Sovereignty

8.1 Open Data versus Data Localization

Open Science promotes unrestricted access. Data sovereignty policies require localization and restrict transfers. Genomics research faces particular challenges: the Global Alliance for Genomics and Health promotes sharing, while China and India require citizen genomic data to remain within borders.

8.2 Global Collaboration versus National Control

International research depends on cross-border data exchange. The Human Cell Atlas project, involving 2,000+ researchers from 70 countries, must navigate different data protection regimes. Researchers report spending 15–25% of project time on compliance.

8.3 Research Innovation versus Security Concerns

While Open Science accelerates innovation, governments regard certain datasets as strategic assets. AI research exemplifies this: open-source models accelerate development but raise dual-use concerns. The US CHIPS and Science Act (2022) restricts certain AI collaborations with China.

8.4 Equity versus Strategic Interests

Open Science aims to democratize access, while sovereignty policies may prioritize competitiveness, limiting access for researchers from less-developed regions, creating a "digital divide."

9. Global Perspectives on Emerging Research Policies

- **European Approach:** The European Open Science Cloud provides infrastructure for 2 million+ researchers while ensuring GDPR compliance. The Data Governance Act (2022) and Data Act (2023) balance openness with protection.
- **United States Approach:** The OSTP Nelson Memo (2022) mandates immediate open access for federally funded research. However, CFIUS and export regulations restrict certain collaborations with strategic competitors.
- **Chinese Approach:** China's Cybersecurity Law (2017), Data Security Law (2021), and Personal Information Protection Law (2021) create comprehensive governance. China promotes open science domestically while maintaining strict cross-border controls.
- **Indian Approach:** India's National Open Science Policy (draft 2021) promotes openness. The Digital Personal Data Protection Act (2023) establishes privacy protections while allowing government exemptions for national security.
- **Emerging Economies:** African countries through the AU's Data Policy Framework (2022) emphasize sovereignty while promoting regional sharing. Latin America's Open Science Initiative promotes openness while addressing "data colonialism" concerns.

10. Implications for Global Research Governance

- **For Researchers:** Increased compliance requirements, ethical/legal complexities, challenges accessing international datasets, career impacts on early-career researchers.
- **For Research Institutions:** Need for data governance frameworks, investments in secure infrastructure, enhanced collaboration management, financial burdens consuming 5–10% of research budgets.
- **For Policymakers:** Need for harmonized regulations, balancing innovation and security, developing responsible data-sharing mechanisms, capacity building support.
- **For International Collaboration:** Potential fragmentation of networks, reduced interoperability, greater governance complexity, risk of scientific nationalism.

11. Towards a Balanced Governance Framework

A sustainable ecosystem requires reconciling openness with sovereignty:

- **Proportional Data Governance:** Tiered classification—Tier 1 (fully open), Tier 2 (restricted access with agreements), Tier 3 (highly protected in secure environments).
- **Trusted Research Environments:** Secure platforms like UK's Secure Research Service, US Federated Data Network, EU's European Health Data Space provide cybersecurity and access controls.
- **International Standards:** ISO standards, W3C interoperability standards, FAIR Data Principles, GA4GH frameworks reduce fragmentation.
- **Responsible Open Science:** Privacy-preserving technologies (differential privacy, federated learning), clear licensing (Creative Commons), ethical review integrated into workflows.
- **Capacity Building:** Investment in infrastructure, training programs, technical assistance for governance frameworks, financial support for developing countries.

12. Conclusion

The rise of Open Science and data sovereignty represents one of the most significant transformations in contemporary research governance. While Open Science promotes accessibility, collaboration, and transparency, data sovereignty emphasizes control, security, and national interests. These competing priorities create complex challenges globally.

Policymakers must develop integrated frameworks balancing collaboration with regulatory concerns. Key recommendations include:

- Develop tiered data governance matching protection to risks
- Invest in trusted research environments
- Harmonize international standards
- Support capacity building in developing countries
- Foster multi-stakeholder dialogue
- Conduct regular impact assessments
- Promote transparency in governance decisions

The path forward requires recognizing both Open Science and data sovereignty serve legitimate goals. Through careful policy design, international cooperation, and technological innovation, the global research community can build an ecosystem serving both scientific progress and societal interests.

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