Data, Power, and the Scientific Silk Road: China's Earth Observation Infrastructures and the Global Politics of Knowledge

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Research Proposal

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1 Object, Problem, and Central Research Question

This research project examines the political and scientific consequences of the Digital Belt and Road Programme (DBAR), which is the flagship international scientific initiative launched in May 2016 by the Chinese Academy of Sciences (Guo et al. 2018). The programme is designed as a ten-year mandate to mobilise Big Earth Data to support the United Nations 2030 Agenda and the implementation of the Sustainable Development Goals (SDGs) (Guo 2017). DBAR operates through a Secretariat based at the International Research Centre of Big Data for Sustainable Development Goals (CBAS)[1] and coordinates an international network comprising fifty-nine countries and various international organisations (Big Data for Sustainable Development Goals 2024). Unlike purely technical Chinese infrastructures such as the China High-resolution Earth Observation System (CHEOS) and its Gaofen satellites, DBAR is organised as a collaborative scientific platform structured around nine International Centres of Excellence (ICoEs) and nine specialised Working Groups (China National Space Administration 2022; Big Data for Sustainable Development Goals 2024). To ensure empirical specificity, this study focuses on the European interface sites located at the ICoE-Helsinki in Finland and the ICoE-Potenza in Italy (Big Data for Sustainable Development Goals 2024).

The central analytical problem is that while DBAR is presented in international discourse as a neutral instrument of science diplomacy providing global public goods, its deeper governance effects remain under-theorised (Rungius and Flink 2020). Traditional International Relations scholarship often focuses on the stated intentions of states, thereby neglecting how infrastructures themselves encode specific governance choices (Rungius and Flink 2020). Following Science and Technology Studies, Earth Observation infrastructures are understood here as integrated sociotechnical systems that organise the collection, processing, and governance of environmental data (Bowker and Star 1999). By treating DBAR as a knowledge infrastructure, this project investigates how technical standards and collaboration networks redistribute scientific authority and generate structural vulnerabilities[2] (Jasanoff 2004).

To avoid treating authority as a static trait, this study constructs a genealogy of power using classic International Relations theory. It adopts Susan Strange's concept of structural power within the knowledge structure, where authority is derived from the ability to determine the validity of and access to essential data (Strange 1994). It further integrates Michael Mann's

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[1]The International Research Centre of Big Data for Sustainable Development Goals (CBAS), based in Beijing, serves as the administrative and scientific headquarters (Secretariat) for DBAR. It coordinates the programme's international network of fifty-nine countries and provides the cloud infrastructure supporting DBAR's capabilities.

[2]Drawing on Farrell and Newman (2019), structural vulnerability is defined as the functional insecurity that arises when an actor's reliance on a centralised network for essential data or services makes the cost of exiting that network prohibitively high. In this context, it describes the dependency generated by DBAR-specific technical standards.

definition of infrastructural power to adapt the concept from its domestic origins to the transnational domain. It operationalises this as the capacity of the state to penetrate and coordinate cross-border scientific networks, effectively extending state capacity extra-territorially (Mann 1984). Finally, it critiques the static assumption of neo-liberal institutionalism. It argues that while DBAR initially reduces transaction costs to attract participation (Keohane 1984), mechanisms of path dependence subsequently increase switching costs, thus transforming cooperation into functional dependency over time.

Central Research Question: How and why does the Digital Belt and Road Programme (DBAR) reshape global collaboration and redistribute authority within international scientific networks and governance venues?

In the end, this project seeks to understand the trade-offs inherent in modern science diplomacy: how the pursuit of infrastructural efficiency through DBAR affects the long-term scientific autonomy of participating European institutions.

2 Article 1: Structural Power in the Knowledge Structure

The first article examines structural authority by moving beyond materialist conceptions of state power to adopt the framework of the knowledge structure. Drawing on the work of Susan Strange, this study argues that authority is derived from the ability to determine the validity of and access to essential data (Strange 1994). This lens allows for an investigation into how scientific capacity structures power relations through the control of unique data flows (such as exclusive coverage of Belt and Road regions) and the definition of technical benchmarks.

The research question for this article asks whether Chinese-led collaborations are shifting from bilateral partnerships (as seen with the ESA-MOST Dragon Programme)[3] to hub and spoke network centrality (DBAR). The central hypothesis is that given increased network centrality and brokerage, participation in DBAR makes the acquisition of structural authority more likely. The motivation for this shift is the pursuit of structural power, which allows the infrastructure provider to define the terms of data validation and access (Strange 1994; Mann 1984). This is tested through bibliometrics (Scopus and Web of Science databases) by mining "Acknowledgements" sections to distinguish DBAR output from general bilateral ties. Inferential network analysis will then calculate "betweenness centrality" to test if DBAR positions the Secretariat as a structural bridge compared to the Dragon Programme baseline (Hafner-Burton

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[3]The ESA-MOST Dragon Programme is a long-standing joint initiative established in 2004 between the European Space Agency and the Ministry of Science and Technology of the People's Republic of China. For this research, it provides a twenty-year comparative corpus of scientific publications, which is essential for distinguishing whether the DBAR is introducing new trajectories of authority or simply reinforcing established patterns of Chinese-European scientific interaction.

et al. 2009).

3 Article 2: Normative Authority and Multilateral Legitimation

The second article examines whether the discourse of "Open Science" serves as a legitimising narrative that aligns Chinese geopolitical interests with the European value of scientific autonomy, therefore lowering the perceived political cost of integration. This investigation is grounded in the literature on international norm dynamics and the rational design of international institutions (Finnemore and Sikkink 1998; Koremenos et al. 2001). It asks why and how DBAR's governance claims are articulated and institutionalised within multilateral venues such as the Group on Earth Observations (GEO) and the Committee on Earth Observation Satellites (CEOS)[4].

Building on scholarship regarding the international norm behaviour of rising powers and the management of international order, this article tests three specific hypotheses (Finnemore and Sikkink 1998; Adler-Nissen 2014). First, the normative alignment hypothesis suggests that DBAR legitimises its role by embedding governance claims within accepted multilateral norms rather than proposing alternative principles, a strategy consistent with the desire to act through formal international organisations to reduce transaction costs (Abbott and Snidal 1998; Finnemore and Sikkink 1998). Second, the relational legitimation hypothesis posits that authority is constructed through partnership principles and reciprocity rather than through binding rules, reflecting a strategic choice for flexible institutional design (Koremenos et al. 2001). Third, the technocratic legitimation hypothesis argues that DBAR legitimises its role by framing governance in technical and scientific terms to downplay political contestation over data control (Finnemore and Sikkink 1998). These hypotheses are evaluated through qualitative discourse analysis of programme documents, white papers, and memoranda of understanding to reveal how these framings embody specific data governance choices.

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[4]The Group on Earth Observations (GEO) and the Committee on Earth Observation Satellites (CEOS) are the primary international coordination bodies for global Earth Observation. These venues serve as the central sites where data standards, metadata schemas, and principles such as open data access are negotiated and institutionalised at a multilateral level.

4 Article 3: Mechanisms of Infrastructural Path Dependence (IPD)

The final article addresses the causal pathways of functional lock-in by critiquing the efficiency-based models of neo-liberal institutionalism. Building on neo-liberal institutionalism, this study argues that while DBAR serves to reduce transaction costs at the point of entry (Keohane 1984), this efficiency facilitates the emergence of three mechanisms of IPD that instead generate high switching costs (Pierson 2000; Star and Ruhleder 1996).

The research question asks how collaborating actors at ICoEs navigate DBAR standards: do they fully comply or do they develop "hedging" strategies to maintain autonomy despite the potential for structural vulnerability? The article hypothesises that even in early adoption phases, technical standardisation and sunk costs create an "emerging path dependence". The sequential accumulation of commitments is expected to exponentially increase switching costs, making future exit functionally prohibitive.

We highlight three specific causal mechanisms derived from the literature. First, platform-specific standardisation creates increasing returns: while data formats may be theoretically open, the volume of Big Earth Data requires cloud-side processing. Once algorithms are calibrated to the specific architecture of the International Research Centre of Big Data for Sustainable Development Goals cloud, moving them to alternative platforms incurs significant "re-tooling" costs (Edwards 2003). Second, infrastructures generate sunk institutional and cognitive costs as organisations invest in specialised training and routines that are difficult to reverse (Edwards 2003). Third, network dependencies arise as access to essential upstream data inputs produces structural vulnerability and makes exit costly (Star and Ruhleder 1996). This dependency compels compliance because the initial transaction cost advantages are eventually eclipsed by the prohibitive costs of exit. The cost of disrupting essential environmental data flows exceeds the benefit of migrating to alternative infrastructures (Pierson 2000).

The methodology utilises qualitative fieldwork and process tracing at the ICoEs in Helsinki and Potenza to observe the sequential accumulation of these commitments. The fieldwork will also probe technical "hedging" behaviours rather than stated political preferences. Interviews will aim to quantify friction by estimating specific metrics such as man-hours and recoding required to port algorithms out of the Chinese cloud, thus measuring the material reality of exit options.

5 Relevance and Contribution

This dissertation advances International Relations and Science & Technology Studies by analysing DBAR as a knowledge infrastructure that redistributes authority through path dependence (Bowker and Star 1999; Jasanoff 2004). The innovation of the project lies in operationalising structural vulnerability as the bridge between technical standards and political order (Farrell and Newman 2019). By centring DBAR while using the Dragon Programme as a baseline, the study provides a unique test of whether Chinese-led initiatives are creating new authority structures or reinforcing established scientific networks. This approach ensures that the analysis does not simply describe correlation but demonstrates how functional lock-in compels compliance through the specific mechanisms of path dependence.
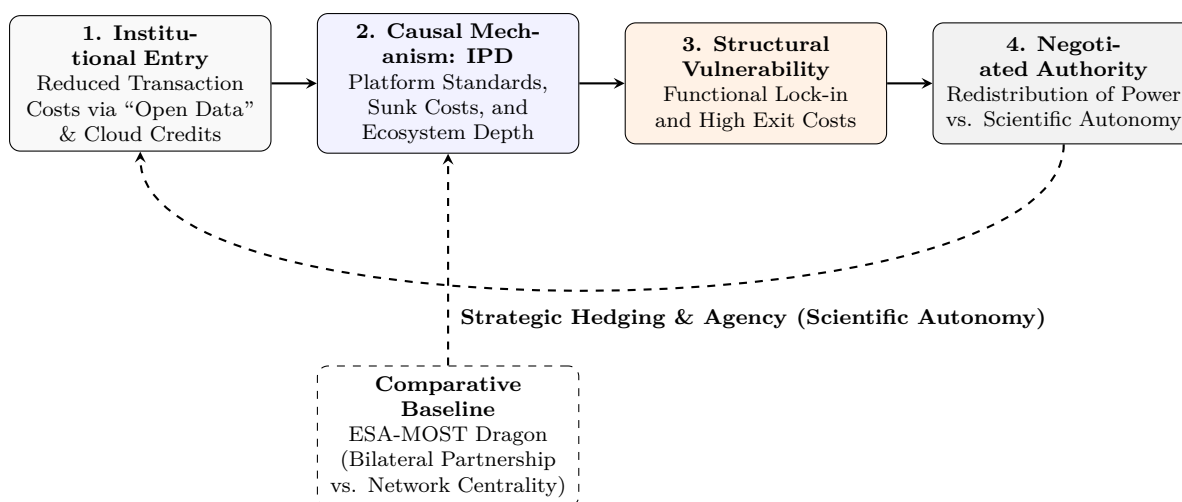
Figure 1: Conceptual Design: The Temporal Shift from Transactional Efficiency to Infrastructural Dependency

Article	Key Concepts	Analytical Objective	Methodology
1: Structural Power	Structural power; Knowledge structure; Network centrality	Comparative Test: Distinguishing DBAR's "hub and spoke" model from bilateral partnerships (e.g., Dragon).	Bibliometrics; Social Network Analysis
2: Legitimacy & Discourse	Science diplomacy; open data; narrative framing	Deconstruction: Analysing how "open data" discourse reduces initial transaction costs to build international legitimacy.	Critical Discourse Analysis
3: Platform Dependence	Platform standards; Switching costs; structural vulnerability	Causal Mapping: Identifying how initial efficiency (entry) leads to functional lock-in and "hedging" strategies (exit costs)	Qualitative fieldwork; process tracing

List of Abbreviations

CBAS: International Research Centre of Big Data for Sustainable Development Goals

CEOS: Committee on Earth Observation Satellites

CHEOS: China High-resolution Earth Observation System

DBAR: Digital Belt and Road Programme

ESA-MOST: European Space Agency-Ministry of Science and Technology

GEO: Group on Earth Observations

ICoE: International Centre of Excellence

IPD: Infrastructural Path Dependence

SDGs: Sustainable Development Goals

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