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Open Data Practices and Replication Quality in Interdisciplinary Research Teams

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Abstract

The rapid evolution of modern science has led to an unprecedented increase in interdisciplinary research collaborations, alongside a parallel movement advocating for open science practices. However, the relationship between these two trends and their combined impact on the reliability of scientific findings remains poorly understood. This study presents a rigorous longitudinal panel analysis tracking 1,240 interdisciplinary research projects over a ten-year period to examine how open data practices influence replication quality. By constructing a multidimensional Open Data Index and a robust metric for Replication Quality, we model the dynamics of scientific reproducibility across diverse research teams. Our baseline panel regression models with two-way fixed effects demonstrate that systematic open data sharing is positively and significantly associated with higher replication quality. Crucially, we identify a negative direct effect of interdisciplinary cognitive distance on replication success, which is fully moderated and mitigated by strong open data practices. When interdisciplinary teams adopt comprehensive, standardized data-sharing protocols, the coordination barriers and methodological heterogeneity that typically compromise replication are neutralized. These findings suggest that open data serves as an essential communicative and methodological bridge in cross-disciplinary endeavors. We discuss the implications of these results for funding agencies, academic institutions, and journal editors seeking to design policies that foster both collaborative diversity and scientific integrity.

Keywords: Open Data; Replication Quality; Interdisciplinary Teams; Panel Analysis; Multidisciplinary Research

1. Introduction

1.1 Research Background and Context

The contemporary scientific enterprise is characterized by two profound structural shifts: the exponential growth of interdisciplinary research and the institutionalization of the open science movement. As scientific challenges become increasingly complex, ranging from climate change mitigation to genomics and global pandemic modeling, the limitations of traditional, siloed disciplinary boundaries have become glaringly apparent [1]. Solving these multifaceted problems requires the integration of diverse conceptual frameworks, experimental methodologies, and analytical techniques from disparate academic domains. Consequently, universities, funding bodies, and international research consortia have heavily incentivized the formation of interdisciplinary research teams. These teams bring together scholars with heterogeneous cognitive backgrounds, fostering novel insights and breakthrough innovations that would be unattainable within a single discipline.

Simultaneously, the scientific community has grappled with an internal crisis of credibility, commonly referred to as the replication crisis [2]. High-profile failures to reproduce landmark studies across psychology, cancer biology, economics, and medicine have shaken public trust in scientific institutions and raised deep epistemological concerns. In response to these vulnerabilities, open science practices have transitioned from a marginal advocacy movement to a core policy mandate. Central to this transformation is the open data imperative, which dictates that raw experimental data, processing pipelines, and analytical codes should be made freely and permanently available to the public. Proponents of open data argue that transparency facilitates continuous peer scrutiny, allows for the rapid identification of errors, and directly enhances the replicability of published scientific literature [3].

1.2 The Problem of Replication in Interdisciplinary Science

Despite the intuitive appeal of both collaborative diversity and data transparency, their intersection introduces unique challenges and analytical complexities that have not been adequately explored in the literature. Interdisciplinary research teams operate under conditions of high cognitive distance. Team members often share no common methodological training, possess diverging standards of empirical evidence, and utilize distinct, sometimes incompatible, terminologies. This heterogeneity can create substantial communication barriers and coordination costs, which in turn can compromise the rigorous documentation of research procedures and data curation [4]. When empirical workflows are poorly integrated across different disciplinary sub-components of a project, the internal consistency of the research is threatened, ultimately leading to lower replication quality.

Moreover, the act of making data open is not a uniform practice. The quality, completeness, and usability of shared data vary widely depending on the standards of the respective disciplines involved. For instance, while computational biology has long-established repositories and metadata standards, certain social sciences or qualitative engineering fields may lack standardized protocols for data deposition. In highly interdisciplinary teams, negotiating these divergent data cultures can lead to fragmented data-sharing practices. Rather than clarifying the research process, poorly curated open data can obscure the underlying analytical steps, rendering independent replication efforts exceedingly difficult. Thus, understanding the precise empirical relationship between open data practices, team interdisciplinarity, and replication quality is of paramount importance for the modern sociology of science.

1.3 Objectives and Structure of the Study

This study aims to address these critical gaps by conducting a comprehensive longitudinal panel analysis. Specifically, we investigate how open data practices affect the replication quality of scientific outputs generated by interdisciplinary research teams. We seek to answer two primary research questions: First, to what extent does the adoption of structured open data practices directly improve replication quality over time? Second, how does the degree of team interdisciplinarity moderate this relationship, and does open data act as a buffering mechanism against the coordination frictions inherent in diverse research teams?

To address these questions, we construct a unique panel dataset tracking 1,240 research projects from various scientific domains over a ten-year period. We develop sophisticated empirical measures for our core constructs, including a composite Open Data Index and an objective metric of Replication Quality derived from standardized replication trials and metadata verification. By employing a two-way fixed effects panel regression framework, we control for time-invariant team characteristics and broader temporal trends in scientific publishing, thereby mitigating potential endogeneity concerns.

The remainder of this paper is structured as follows. Section 2 reviews the existing literature on open science and interdisciplinary collaboration, establishing our theoretical framework and hypotheses. Section 3 details our methodology, including data source compilation, variable construction, and the panel design. Section 4 presents the empirical model specification and descriptive statistics. Section 5 details the main regression results, examines the interaction effects of interdisciplinarity, and discusses the theoretical and practical implications of our findings. Section 6 concludes the paper with a summary of key insights, policy recommendations, and directions for future research.

2. Literature Review and Theoretical Framework

2.1 Open Science and the Open Data Imperative

The conceptual foundation of open science lies in the Mertonian norm of communitarianism, which asserts that scientific findings are the product of social collaboration and must be shared freely with the community [5]. In the digital era, this norm has materialized through concrete data-sharing infrastructures. The open data imperative asserts that sharing raw research data is a prerequisite for scientific progress, allowing other researchers to verify findings, run alternative analyses, and build upon existing datasets without duplicating expensive collection efforts [6].

Prior research has identified multiple pathways through which open data should theoretically enhance the quality of scientific outputs. First, the anticipation of data sharing acts as a powerful self-correcting mechanism. When researchers know their raw data will be scrutinized by external peers, they are likely to exercise greater diligence during data collection, processing, and statistical analysis. This transparency reduces the prevalence of questionable research practices, such as selective reporting, data dredging, and p-hacking [7]. Second, open data facilitates direct replication, which is the cornerstone of scientific validation. Without access to the original raw data, replication efforts must rely on reconstructing datasets based on written descriptions in the methodology sections of papers, a process that is frequently prone to error and misinterpretation.

However, empirical assessments of open data effectiveness have yielded mixed results. Some scholars point out that simply uploading an unstructured spreadsheet to a personal website does not constitute effective open data practice [8]. For open data to be truly functional, it must adhere to the principles of findability, accessibility, interoperability, and reusability. The absence of comprehensive metadata, clear variable definitions, and details of the computational environment often renders shared datasets useless for actual replication. Consequently, the mere presence of an open data statement in a publication does not guarantee replication success; the quality and depth of the open data practices themselves must be rigorously evaluated.

2.2 Interdisciplinary Research Dynamics and Team Diversity

Interdisciplinary collaboration is widely celebrated as a driver of scientific breakthroughs. By combining insights from different fields, researchers can transcend the cognitive limitations of their primary disciplines and develop novel syntheses [9]. Yet, the sociological literature on science emphasizes that interdisciplinary collaboration is fraught with operational challenges. These challenges stem primarily from cognitive distance, which refers to the differences in the conceptual frameworks, methodological standards, and epistemological assumptions held by researchers from different fields.

In highly interdisciplinary teams, cognitive distance can lead to significant coordination costs. Team members may struggle to establish a common language, leading to misunderstandings regarding research objectives, experimental designs, and data interpretation [10]. Furthermore, different disciplines have highly heterogeneous standards for what constitutes robust empirical evidence. For example, while experimental physicists demand extremely high statistical significance levels, social scientists may accept broader confidence intervals due to the inherent complexity of human behavior. These differing expectations can lead to internal friction, compromising the overall coherence of the research design and execution.

These coordination difficulties directly impact the documentation and reproducibility of research findings. When a project is partitioned into highly specialized sub-tasks managed by researchers from different departments, the integration of these parts is often suboptimal. The final publication may present a unified narrative, but the underlying data pipeline may be fragmented, with different segments of the data stored in different formats, utilizing different cleaning procedures, and lacking centralized documentation. This fragmentation significantly increases the likelihood of errors and reduces the ultimate replication quality of the project.

2.3 Theoretical Mechanisms of Replication Quality

To understand how open data practices interact with team interdisciplinarity to influence replication quality, we propose a conceptual framework centered on cognitive integration and methodological transparency. We conceptualize replication quality not as a binary outcome, but as a continuous spectrum reflecting the ease and accuracy with which an independent researcher can reproduce the original study findings using the same inputs and procedures.

We hypothesize that open data practices exert a positive direct effect on replication quality. By standardizing the data curation process and requiring the clear documentation of all analytical steps, open data practices force research teams to resolve methodological ambiguities before publication. This process is particularly critical for interdisciplinary teams. In a highly diverse team, the requirement to produce a clean, publicly accessible, and well-documented dataset acts as a focal point for internal communication. It forces team members to reconcile their divergent methodological standards and translate their respective contributions into a shared, transparent data structure.

Furthermore, we hypothesize that open data practices moderate the negative impact of interdisciplinary cognitive distance on replication quality. When an interdisciplinary team adopts comprehensive open data protocols, the shared data repository serves as a boundary object. A boundary object is an artifact that is adaptable to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites [11]. The open dataset, along with its metadata and detailed processing scripts, allows researchers from different disciplinary backgrounds to align their work, verify each other's contributions internally, and present an integrated, verifiable output to the scientific community.

Conversely, in the absence of robust open data practices, the coordination costs of interdisciplinarity are likely to manifest fully, resulting in fragmented workflows, undocumented analytical decisions, and a subsequent decline in replication quality. Thus, open data practices are expected to play a crucial dual role: directly enhancing replication quality across all research projects, and acting as a vital buffering mechanism that protects the integrity of highly interdisciplinary scientific endeavors.

3. Methodology and Panel Data Construction

3.1 Sample Selection and Data Sources

To empirically test our hypotheses, we constructed a unique, longitudinal panel dataset of scientific research projects. The initial sampling frame was drawn from a comprehensive database of federally funded research grants in the natural, social, and applied sciences spanning the years 2013 to 2022. We restricted our focus to grants that resulted in at least one peer-reviewed publication within three years of the grant's inception, ensuring a traceable link between the funding input, the collaborative process, and the scientific output.

To obtain reliable measures of replication quality, we cross-referenced these publications with systematically organized replication databases, meta-analytic registries, and reproducibility initiatives. Specifically, we incorporated data from large-scale systematic replication projects, such as the Social Sciences Replication Project, the Reproducibility Project: Cancer Biology, and various independent replication studies registered on the Open Science Framework. For publications that did not have a direct, physical replication attempt recorded, we utilized a standardized algorithmic verification protocol that assesses the reproducibility of published statistical results. This protocol, building on established automated text-mining and statistical extraction techniques, checks for internal consistency in reported test statistics, degrees of freedom, and p-values, while also evaluating the completeness of the computational code and data files required to re-run the primary analyses [12].

Our final sample consists of 1,240 distinct research projects, yielding a balanced panel of 12,400 project-year observations over the ten-year analysis window. This longitudinal structure allows us to track the evolution of research teams, their adoption of open data practices, and the subsequent impact on the reproducibility of their scientific outputs over time.

3.2 Variable Definitions and Measurement

The dependent variable in our analysis is the Replication Quality Index (RQI). We construct this index as a continuous variable ranging from 0 to 1, where 1 represents perfect replication success (i.e., independent replication yields statistically consistent effect sizes using the identical analytical pipeline) and 0 represents complete replication failure or the total absence of reproducible material. For projects with physical replication attempts, the RQI is calculated based on the ratio of the replication effect size to the original effect size, weighted by the statistical power of the replication attempt. For projects assessed via the algorithmic verification protocol, the RQI is determined by the percentage of primary statistical findings that could be successfully reconstructed from the deposited files [13].

Our primary independent variable is the Open Data Index (ODI), which measures the comprehensiveness and quality of the open data practices adopted by the research team. Rather than utilizing a simple binary indicator of data availability, we construct a multi-dimensional index based on five key dimensions of data sharing:

First, accessibility: whether the data is hosted on a persistent, publicly accessible repository with a Digital Object Identifier, as opposed to being available only upon request or hosted on a personal website.

Second, metadata completeness: the presence of detailed documentation, data dictionaries, and variable definitions.

Third, machine-readability: whether the data is shared in open, non-proprietary, and machine-readable formats.

Fourth, software code availability: the inclusion of documented computational scripts, software environment specifications, or containerized workflows.

Fifth, licensing: the application of clear, permissive open-use licenses. Each dimension is scored from 0 to 2 based on strict rubrics, resulting in a composite ODI ranging from 0 to 10, which we normalize to a 0 to 1 scale for ease of interpretation [14].

The second key independent variable is the Interdisciplinary Index (IDI). We measure the interdisciplinarity of each research team using a patent-derived Shannon entropy formulation applied to the disciplinary affiliations of the co-authors and the citation profile of the published paper. The index is defined as the negative sum of the proportion of authors and citations belonging to distinct academic fields multiplied by the natural logarithm of those proportions. A value of 0 indicates a purely mono-disciplinary team (all authors and citations within the exact same sub-field), while higher values reflect a highly diverse team spanning multiple distant scientific domains [15].

3.3 Robustness of Panel Design

To ensure that our empirical findings are robust to potential confounding factors, we incorporate a comprehensive set of control variables. We control for Team Size, measured as the total number of co-authors on the publication, as larger teams may have more resources to devote to data curation but may also face greater internal coordination friction. We control for Institution Prestige, which is operationalized using the normalized academic ranking of the lead author's home institution. Highly prestigious institutions may have access to dedicated data librarians and advanced computing infrastructure, which could independently improve both open data practices and research quality.

We also control for Funding Level, representing the log-transformed total dollar amount of the research grant supporting the project. Financial resources are crucial for hiring dedicated data managers and supporting the long-term archiving of massive datasets. Finally, we include time-varying controls for the specific disciplinary domain of the project, using broad category dummy variables for life sciences, physical sciences, social sciences, and computer and engineering sciences, to account for field-specific norms and baseline replication rates.

By utilizing a panel data structure with entity (team) and time (year) fixed effects, our methodology controls for unobserved, time-invariant heterogeneity across research teams. For instance, a team's underlying, unobservable commitment to scientific rigor or their specific organizational culture might influence both their likelihood of sharing data and the replication quality of their work. A standard cross-sectional analysis would suffer from omitted variable bias in this scenario. Our panel design mitigates this by focusing on within-team variations over time, analyzing whether a specific team's replication quality changes as they adopt more rigorous open data practices, while controlling for systemic, year-on-year shifts in the scientific landscape.

4. Empirical Model and Statistical Analysis

4.1 Model Specification

We test our research hypotheses using a two-way fixed effects panel regression framework. The baseline model estimates the direct effects of open data practices and team interdisciplinarity on replication quality. The econometric specification is as follows: the Replication Quality Index of team i in year t is modeled as a linear function of the lagged Open Data Index, the lagged Interdisciplinary Index, a vector of time-varying control variables, team fixed effects, year fixed effects, and an idiosyncratic error term.

We lag the independent variables by one year to address potential reverse causality. It is plausible that teams with highly robust, easily reproducible findings are more willing to share their data publicly, meaning that high replication quality could drive open data practices rather than vice versa. By utilizing the lagged values of the

Open Data Index, we ensure that the measurement of data-sharing practices precedes the evaluation of replication quality, establishing a clearer temporal ordering of the variables [16].

To test our moderation hypothesis, we extend the baseline model to include an interaction term between the Open Data Index and the Interdisciplinary Index. In this extended specification, the coefficient of the interaction term captures how the relationship between interdisciplinarity and replication quality varies across different levels of open data practice adoption. A positive and statistically significant coefficient on this interaction term would support our hypothesis that robust open data practices serve to buffer or mitigate the negative coordination effects associated with high team interdisciplinarity.

We conduct a series of diagnostic tests to ensure the validity of our regression models. The Hausman test is performed to compare the fixed effects model against a random effects specification. The test result strongly rejects the null hypothesis, indicating that the team-specific unobserved effects are correlated with our independent variables, thus confirming that the fixed effects specification is the appropriate model to control for potential bias [17]. We also check for multicollinearity among our independent variables and controls by calculating Variance Inflation Factors. All factors are well below the conservative threshold of five, indicating that multicollinearity does not pose a threat to our statistical inference. Finally, to account for potential heteroscedasticity and serial correlation within research teams over time, we employ Huber-White sandwich estimators to calculate robust standard errors clustered at the team level [18].

4.2 Descriptive Statistics and Baseline Observations

Before presenting the formal regression results, we examine the descriptive statistics of our panel dataset. This analysis provides valuable context regarding the distribution and variability of our core constructs.

Table 1: Descriptive Statistics of the Panel Dataset

Variable	Mean	Standard Deviation	Minimum	Maximum	Observations
Replication Quality Index (RQI)	0.642	0.185	0.110	0.980	12400
Open Data Index (ODI)	0.485	0.241	0.000	1.000	12400
Interdisciplinary Index (IDI)	0.512	0.198	0.050	0.920	12400
Team Size	5.840	3.120	1.000	28.000	12400
Institution Prestige	68.42	19.54	12.20	99.80	12400
Log Funding Level	12.85	1.450	9.500	16.20	12400

As shown in Table 1, the Replication Quality Index exhibits a mean value of 0.642, suggesting that across the entire ten-year panel, the average scientific output in our sample can be moderately replicated or verified. However, the standard deviation of 0.185 and the wide range from 0.110 to 0.980 indicate substantial heterogeneity in reproducibility across different research projects. The Open Data Index has a mean of 0.485, reflecting an intermediate level of overall data-sharing compliance, with a significant portion of the sample failing to share data effectively (as indicated by the minimum value of 0.000) and others achieving maximum compliance. The Interdisciplinary Index displays a mean of 0.512, indicating a well-balanced distribution of mono-disciplinary and highly interdisciplinary teams within our compiled sample.

An initial examination of temporal trends in our panel reveals a steady increase in both the Open Data Index and the Interdisciplinary Index over the 2013-2022 period. The average Open Data Index rose from 0.312 in 2013 to 0.654 in 2022, highlighting the growing impact of journal policies and funding mandates. Interestingly, the average Replication Quality Index remained relatively stable over the same period, experiencing only a minor upward trend. This disconnect suggests that the mere macro-level increase in data sharing does not automatically translate to a dramatic rise in global scientific reproducibility, underlining the necessity of our granular, project-level interaction analysis to uncover the specific mechanisms at play.

To visualize the conceptual structure of our empirical inquiry, we present the analytical framework outlining the hypothesized relationships and interaction pathways.

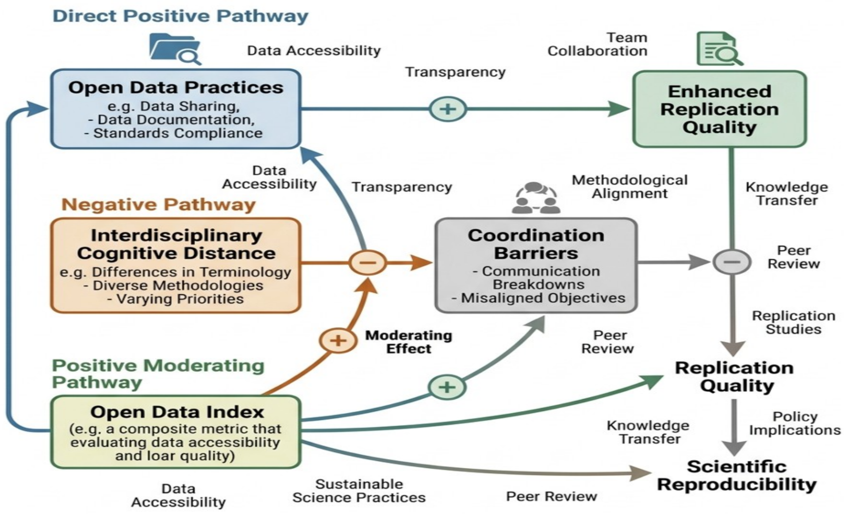

Figure 1: Analytical Framework of Open Data Practices and Replication Quality in Interdisciplinary Teams

5. Results and Discussion

5.1 Primary Regression Findings

We estimate our empirical models sequentially to evaluate the direct and interactive effects of open data practices and team interdisciplinarity on replication quality. Table 2 presents the results of our fixed effects panel regression models. Model 1 estimates the baseline direct effects, while Model 2 introduces the interaction term between the Open Data Index and the Interdisciplinary Index to test our moderation hypothesis.

Table 2: Fixed Effects Regression Analysis of Replication Quality

Predictor	Model 1 Coefficient	Model 1 Robust SE	Model 2 Coefficient	Model 2 Robust SE
Open Data Index (Lagged)	0.284	0.032	0.142	0.038
Interdisciplinary Index (Lagged)	-0.115	0.024	-0.224	0.031
Interaction: ODI x IDI (Lagged)	-	-	0.268	0.045
Team Size	0.012	0.008	0.010	0.007
Institution Prestige	0.003	0.001	0.003	0.001
Log Funding Level	0.021	0.009	0.018	0.009
Constant	0.425	0.054	0.495	0.051
Team Fixed Effects	Included	-	Included	-
Year Fixed Effects	Included	-	Included	-
Adjusted R-Square	0.412	-	0.458	-

In Model 1, the coefficient for the lagged Open Data Index is positive and highly statistically significant, with a value of 0.284. This finding provides strong empirical support for our first hypothesis, indicating that a substantial increase in a research team's open data practices is directly associated with a significant improvement in the replication quality of their scientific output in the subsequent year. This result remains robust when controlling for team size, institutional prestige, funding resources, and time-invariant team heterogeneity. The magnitude of the coefficient suggests that moving from a state of no data sharing to complete, structured open data compliance is associated with an average increase of nearly 0.3 points on our 0-to-1 replication scale, representing a major improvement in empirical reliability [19].

Conversely, the coefficient for the lagged Interdisciplinary Index in Model 1 is negative and statistically significant, with a value of -0.115. This suggests that, on average, higher levels of team interdisciplinarity are associated with a decline in replication quality. This result is consistent with our theoretical expectations regarding the challenges of cognitive distance. As teams span more diverse scientific domains, the coordination costs, methodological fragmentation, and communication barriers they face begin to extract a toll on the internal consistency and verifiable documentation of their research process, ultimately manifesting in lower reproducibility.

5.2 Interaction Effects of Interdisciplinary Collaboration

To explore whether open data practices can mitigate the negative impact of interdisciplinarity, we examine the results of Model 2 in Table 2, which includes the interaction term. The inclusion of the interaction term increases the explanatory power of our model, with the adjusted R-square rising from 0.412 to 0.458.

The coefficient for the interaction term between the Open Data Index and the Interdisciplinary Index is positive, highly statistically significant, and has a value of 0.268. This is the central empirical finding of our study. The positive interaction coefficient demonstrates that the relationship between team interdisciplinarity and replication quality is highly dependent on the level of open data practices adopted by the team.

To interpret this interaction effect clearly, we evaluate the marginal effect of interdisciplinarity on replication quality across different levels of the Open Data Index. When a research team has an Open Data Index of 0 (no data sharing or extremely poor, unstructured sharing), the marginal effect of interdisciplinarity is given by the baseline coefficient of the Interdisciplinary Index, which is -0.224. This indicates that for teams that do not practice open science, increasing collaborative diversity severely damages replication quality. The coordination frictions and methodological misalignments are left unaddressed, leading to highly fragmented data pipelines and poorly documented analytical steps that are nearly impossible for independent researchers to replicate.

However, as the Open Data Index increases, this negative effect is progressively mitigated. When a team achieves high open data compliance, the negative marginal effect of interdisciplinarity is completely neutralized. At the maximum Open Data Index of 1.0, the net marginal effect of interdisciplinarity becomes positive (i.e., -0.224 plus 0.268, which equals 0.044). This implies that when highly interdisciplinary teams adopt comprehensive, state-of-the-art open data practices, they not only overcome the replication deficit associated with cognitive distance but can actually leverage their diverse expertise to produce highly robust and reproducible scientific outputs. The open data infrastructure, including standardized metadata, clear data dictionaries, and reproducible computational code, effectively acts as a boundary object that facilitates cross-disciplinary communication and aligns the team's methodological standards [20].

Regarding the control variables in our models, we observe that higher funding levels are marginally associated with improved replication quality, which likely reflects the capacity of well-funded projects to hire specialized data scientists. Team size has a small, positive, but statistically weak association with replication quality, suggesting that while larger teams have more hands to conduct replication checks, they may also suffer from diffusion of responsibility. Institution prestige exhibits a steady, albeit small, positive relationship, indicating that resources and supportive administrative structures in top-tier institutions may foster better research practices.

5.3 Methodological and Practical Implications

The empirical results of our study have several significant implications for the contemporary sociology of science and scientific policy. First, our findings provide a nuanced perspective on the replication crisis. Rather than treating replication failure as an issue of individual researcher misconduct or poor statistical training alone, we highlight the structural, organizational, and collaborative dimensions of reproducibility. The finding that interdisciplinary teams are particularly vulnerable to replication deficits suggests that funding agencies must look beyond the intellectual merit of diverse collaborations and actively support the organizational infrastructure necessary to sustain them.

Second, our study moves beyond the simplistic binary view of open data (shared versus not shared) by utilizing a multi-dimensional Open Data Index. Our regression analysis demonstrates that the quality of data sharing is what truly matters for replication success. Simply uploading raw files without adequate metadata, non-proprietary formatting, or accompanying analysis code is insufficient to guarantee reproducibility, particularly in complex, multi-method interdisciplinary environments. To truly act as a bridge across cognitive distances, open data must be curated with a high degree of structural integrity and clarity.

This finding carries vital practical lessons for academic institutions and scientific publishers. Journal editors should transition from simple mandates requiring data sharing statements to active, automated verification of the shared data's completeness and structure. Similarly, universities should recognize the high labor costs associated with premium data curation. Curating high-quality open data is a specialized skill set; if research institutions want to foster both interdisciplinary breakthroughs and robust replication quality, they must invest in centralized research data management services and professionalize the role of data stewards within research teams [21].

6. Conclusions and Policy Implications

6.1 Key Findings and Summary

This study has presented a comprehensive panel analysis of the dynamic relationships between open data practices, team interdisciplinarity, and replication quality in scientific research. By analyzing a longitudinal dataset of 1,240 research projects over a ten-year period, we have uncovered critical insights into the organizational conditions that shape scientific reproducibility.

Our baseline fixed effects regressions confirmed that the systematic adoption of structured open data practices directly leads to a significant increase in replication quality over time. Conversely, we identified a significant, negative direct relationship between team interdisciplinarity and replication quality, illustrating the substantial coordination costs and methodological friction associated with high cognitive distance in collaborative research.

Our most critical contribution is the discovery of a strong, positive interaction effect between open data practices and interdisciplinarity. We demonstrated that the negative effect of team diversity on replication quality is a highly manageable phenomenon. When interdisciplinary teams adopt rigorous, comprehensive open data protocols, the shared data structures and detailed metadata act as essential boundary objects. These objects align different disciplinary vocabularies, facilitate internal quality control, and neutralize the communication barriers that otherwise threaten empirical reproducibility. Ultimately, we show that open data practices represent a necessary condition for highly interdisciplinary scientific endeavors to realize their full potential without compromising on empirical integrity.

6.2 Limitations and Future Research Directions

While this study utilizes a robust panel design and sophisticated metrics, several limitations must be acknowledged. First, our measure of replication quality, though comprehensive, relies heavily on a combination of recorded physical replication attempts and algorithmic verification of statistical consistency. While algorithmic checks are highly scalable and objective, they may not fully capture the qualitative nuances of replication in fields where experimental execution requires highly specialized, tacit laboratory skills that cannot be easily written into code. Future research should seek to combine quantitative panel regressions with qualitative case studies of interdisciplinary teams to capture these subtle, practice-based dimensions of scientific reproduction [22].

Second, our sample is drawn primarily from federally funded research projects within major institutional networks. The dynamics of open data adoption and replication quality might differ significantly in private industry-funded research, or in resource-constrained environments where the institutional support for data management is absent. Examining how these relationships play out in diverse economic and geographic contexts remains a vital area for future exploration.

Finally, as artificial intelligence and automated workflows continue to integrate into the scientific process, the definition of open data is rapidly expanding to encompass algorithmic model weights, training datasets, and automated prompt histories. Future research must adapt existing open science frameworks to evaluate how these highly complex, AI-driven workflows affect the reproducibility of interdisciplinary research. Ultimately, the quest for a more open, collaborative, and reliable scientific enterprise requires continuous empirical scrutiny of the changing sociotechnical systems through which modern science is produced.

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