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INSTITUTIONAL DRIVERS OF RESPONSIBLE OPEN SCIENCE IN EURASIA: AN EXTENDED PLS-SEM FRAMEWORK

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Abstract: Research systems across Eurasia are being asked to improve transparency, integrity, data reuse, and international engagement while operating under uneven legal, technological, and institutional conditions. This paper develops a revised survey-based framework for explaining responsible open science at universities and research organisations, with particular relevance to Central Asia. Unlike models that treat ethics, data management, and training as the only antecedents, the proposed framework adds digital research infrastructure, incentive alignment, leadership support, and researchers' practical open-science competence. Seven latent constructs are connected through direct, mediating, and moderating relationships and can be tested using partial least squares structural equation modelling (PLS-SEM). The model assumes that ethical-regulatory governance and digital infrastructure build data stewardship capability; competence, incentives, and stewardship then shape the institutionalisation of open science; and institutionalisation improves international scientific connectivity. The study proposes a multilingual questionnaire, a cross-country sampling strategy, and an analysis procedure incorporating measurement invariance, multi-group analysis, mediation, moderation, predictive assessment, and importance-performance mapping. The framework offers universities, funding bodies, and public authorities a diagnostic instrument for moving from formal open-science declarations toward reliable, rewarded, and reusable research practices.

Keywords: open science; research integrity; FAIR data; digital infrastructure; incentives; Eurasia; Central Asia; PLS-SEM.

1. Introduction

Contemporary research quality is assessed through more than publication counts and journal rankings. Scientific communities increasingly expect research to be ethically conducted, methodologically transparent, reproducible where feasible, and supported by data and documentation that can be verified or reused. Open science is therefore best understood as a governance model for the entire research lifecycle rather than a narrow policy of free access to articles.

This agenda is especially important in Eurasia. The region combines highly internationalised institutions with universities that are still developing ethics review procedures, repositories, research-data policies, and professional support services. Central Asian research organisations also work across several languages and legal traditions, which can complicate informed consent, metadata creation, licensing, cross-border data transfer, and compliance with funder requirements. Evidence from Kazakhstan, Kyrgyzstan, and Uzbekistan indicates that human-participant research ethics education remains uneven and is often concentrated in internationally oriented institutions (Sagitova et al., 2024; Sharplin et al., 2025).

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The UNESCO Recommendation on Open Science calls for enabling policies, infrastructure, skills, incentives, and international cooperation. The European Code of Conduct for Research Integrity similarly positions reliable research practices as responsibilities shared by researchers, institutions, funders, and publishers. The ORCA project, operating from 2025 to 2029 in five Central Asian countries, provides a timely regional setting for examining how these elements can be institutionalised.

The earlier version of this study connected research ethics, data management, training, open-science implementation, and international visibility. The present paper retains that institutional logic but introduces four additional considerations: the availability of interoperable digital infrastructure; the alignment of promotion and funding incentives; visible leadership commitment; and researchers' practical competence in repositories, licensing, anonymisation, metadata, code sharing, and reproducible workflows. The central research question is: which institutional capabilities most strongly convert open-science policy into routine and internationally connected research practice in Eurasia?

2. Theoretical foundation and regional problem

Research integrity provides the normative foundation of responsible openness. Clear rules on authorship, conflicts of interest, participant protection, data fabrication, plagiarism, and misconduct investigation reduce uncertainty and strengthen trust. Yet formal codes alone do not guarantee implementation. Ethical-regulatory governance must include functioning review bodies, transparent procedures, trained reviewers, accessible guidance, and proportionate safeguards for different disciplines. In economics and social science, these safeguards are relevant to household surveys, administrative records, firm-level information, banking data, online behaviour, and interviews with vulnerable groups.

Data stewardship translates ethical commitments into operational practice. The FAIR principles require data and related outputs to be findable, accessible under defined conditions, interoperable, and reusable (Wilkinson et al., 2016). FAIR does not require unrestricted disclosure. Rather, institutions must specify access conditions, protect personal or commercially sensitive information, document decisions, and preserve data in appropriate repositories. Data management plans, persistent identifiers, metadata, version control, retention schedules, and anonymisation protocols are therefore central components of open science.

Digital research infrastructure is introduced as a separate explanatory factor because researchers cannot implement open practices without dependable technical systems. Secure storage, institutional repositories, persistent identifiers, research information systems, licensed analysis tools, high-speed connectivity, and technical support reduce the cost and perceived risk of sharing. The European Open Science Cloud agenda illustrates the importance of trusted, interoperable environments for FAIR data and services. In less-resourced institutions, infrastructure may exist in fragmented form, leaving researchers dependent on personal devices or informal cloud accounts.

Incentive alignment and leadership are also decisive. Open practices require additional time for documentation, curation, licensing, and communication. International evidence shows that many organisations have open-science policies but provide little formal credit for related work; researchers prefer recognition in evaluation and career progression, dedicated funding, and visible rewards (Grattarola et al., 2024). When promotion systems continue to reward only publication volume or journal prestige, open-science expectations may be treated as unfunded administrative duties. Leaders can change this by including data, software, protocols, replication, peer review, and community engagement in research assessment.

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Finally, competence is distinct from general awareness. Researchers may support openness while lacking the skills to select a repository, assign a licence, prepare machine-readable metadata, anonymise a dataset, write reusable code, or determine when data should remain restricted. Training must therefore be practical, discipline-sensitive, and available in relevant regional languages. The interaction of competence with institutional incentives is important: skills are more likely to become routine behaviour when the organisation recognises and rewards their use.

3. Conceptual model and hypotheses

The proposed model contains seven reflective latent constructs. Ethical-Regulatory Governance (ERG) captures institutional rules and oversight. Digital Research Infrastructure (DRI) measures the availability and usability of technical systems. Data Stewardship Capability (DSC) reflects planning, documentation, protection, preservation, and FAIR-aligned management. Open Science Competence (OSC) represents researchers' applied skills. Incentive Alignment and Leadership (IAL) captures rewards, managerial commitment, and workload recognition. Open Science Institutionalisation (OSI) measures the extent to which transparent and open practices are embedded across the research lifecycle. International Scientific Connectivity (ISC) represents participation in cross-border networks, co-authorship, trust, visibility, and access to collaborative opportunities.

The model advances eight hypotheses. H1: stronger ERG increases DSC because ethical clarity and oversight improve decisions about consent, confidentiality, ownership, and access. H2: DRI positively affects DSC by providing secure and interoperable tools. H3: DSC positively affects OSI because well-documented and governed data can be shared or accessed responsibly. H4: OSC positively affects OSI. H5: IAL positively affects OSI by reducing the conflict between open practices and conventional performance pressures. H6: ERG has an additional direct effect on OSI because transparent procedures and research-integrity norms shape behaviour beyond data management. H7: OSI increases ISC by making outputs easier to discover, evaluate, reproduce, and combine with international work. H8: IAL positively moderates the OSC–OSI relationship, meaning that competence is translated into practice more strongly where leaders recognise open-science contributions.

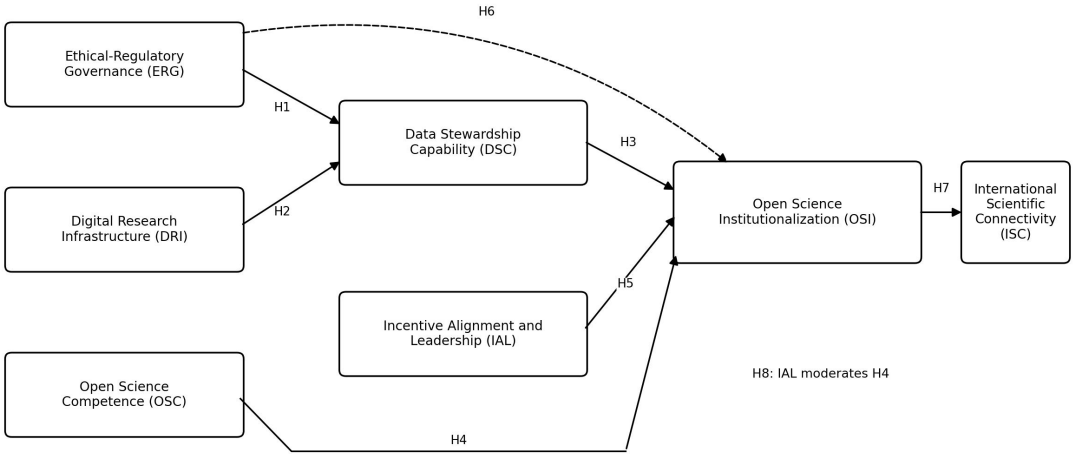


Figure 1. Extended institutional-capability model of responsible open science.

Code	Hypothesis

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Code	Hypothesis
H1	Ethical-Regulatory Governance positively influences Data Stewardship Capability.
H2	Digital Research Infrastructure positively influences Data Stewardship Capability.
H3	Data Stewardship Capability positively influences Open Science Institutionalisation.
H4	Open Science Competence positively influences Open Science Institutionalisation.
H5	Incentive Alignment and Leadership positively influences Open Science Institutionalisation.
H6	Ethical-Regulatory Governance directly and positively influences Open Science Institutionalisation.
H7	Open Science Institutionalisation positively influences International Scientific Connectivity.
H8	Incentive Alignment and Leadership strengthens the positive OSC → OSI relationship.

Table 1. Proposed hypotheses.

Two indirect effects should also be tested. First, DSC is expected to mediate the effects of ERG and DRI on OSI. Second, OSI is expected to mediate the effects of institutional capabilities on ISC. These pathways distinguish symbolic policy adoption from the operational capabilities through which international benefits are created.

4. Research design

A quantitative, cross-sectional survey is proposed. The target population comprises researchers, doctoral candidates, supervisors, research managers, librarians, ethics committee members, journal editors, and policy specialists in universities and research organisations across Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, and selected Eurasian comparator institutions. Respondents should have direct experience with research, supervision, data handling, publishing, or research administration.

A minimum usable sample of 350 is recommended, with a preferred range of 450–600 to support country and institutional comparisons. Purposive stratified recruitment can ensure representation by country, discipline, career stage, and institution type; snowball distribution may supplement access to specialised groups. The questionnaire should be available in English, Russian, and relevant national languages. Translation and back-translation, expert review, and a pilot test of 30–50 respondents are required before full deployment. Participation must be voluntary, anonymous, and based on informed consent.

All construct items may be measured on a five- or seven-point Likert scale. The measurement instrument below is intentionally concise and can be expanded after expert validation. Control variables should include country, discipline, career stage, research experience, institution type,

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participation in international projects, prior open-access publishing, repository experience, and the sensitivity of data normally used by the respondent.

Construct	Code	Indicative survey item
ERG	ERG1	My institution has clear and accessible rules for ethical research and integrity.
ERG	ERG2	Ethics review and misconduct procedures operate transparently and consistently.
ERG	ERG3	Researchers receive usable guidance on consent, confidentiality, authorship, and conflicts.
DRI	DRI1	Secure storage and backup are available for research data and code.
DRI	DRI2	The institution provides trusted repositories or supported deposit services.
DRI	DRI3	Research systems support persistent identifiers, metadata, and interoperable formats.
DSC	DSC1	Research projects use data management plans when appropriate.
DSC	DSC2	Data, code, and methods are documented sufficiently for verification and reuse.
DSC	DSC3	Sensitive data are protected through controlled access, anonymisation, or other safeguards.
OSC	OSC1	I can select suitable repositories, licences, and access conditions.
OSC	OSC2	I can prepare metadata and documentation for reusable research outputs.
OSC	OSC3	I understand how to make workflows more transparent and reproducible.
IAL	IAL1	Open-science contributions are considered in evaluation or career progression.

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Construct	Code	Indicative survey item
IAL	IAL2	Leaders visibly support and resource responsible open-science practices.
IAL	IAL3	Workload or funding arrangements recognise the effort required for data curation and sharing.
OSI	OSI1	Open access, data sharing, and transparent methods are embedded in routine research practice.
OSI	OSI2	Research outputs are deposited in trusted systems when legal and ethical conditions permit.
OSI	OSI3	Open science is applied across planning, analysis, publication, and preservation.
ISC	ISC1	Our research outputs are easier for international partners to discover and assess.
ISC	ISC2	Responsible openness improves participation in international projects and networks.
ISC	ISC3	Transparent practices strengthen external trust and scientific visibility.

Table 2. Concise measurement instrument for the revised PLS-SEM model.

5. Data analysis strategy

PLS-SEM is appropriate because the study is prediction-oriented, includes several latent variables, tests mediation and moderation, and may involve non-normal survey data. Data screening should assess missingness, straight-lining, response time, outliers, and non-response bias. Common-method risk can be reduced procedurally through anonymity, clear item wording, separation of predictor and outcome blocks, and mixed item ordering; statistical checks may include full-collinearity VIF and a marker-variable sensitivity test.

For the measurement model, indicator loadings should generally exceed 0.708, although theoretically important items between 0.40 and 0.70 may be retained when reliability and validity remain adequate. Cronbach's alpha, rho_A, and composite reliability should normally fall between 0.70 and 0.95. Average variance extracted should exceed 0.50, and discriminant validity should be assessed primarily with HTMT confidence intervals.

The structural model should report collinearity diagnostics, standardised path coefficients, bootstrapped confidence intervals, R^2, f^2, Q^2, and out-of-sample predictive performance using PLSpredict. The mediation paths and the IAL moderation term should be estimated with at least 5,000

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bootstrap samples. Before comparing countries or institution types, measurement invariance should be assessed through the MICOM procedure; where invariance is supported, PLS multi-group analysis can identify whether institutional drivers differ across regional settings. Importance-performance map analysis can then translate the results into priorities by identifying constructs that are both influential and underperforming.

No numerical findings are reported in this conceptual paper because primary survey data have not yet been collected. The expected pattern is that infrastructure and ethical governance will influence OSI largely through data stewardship, while incentive alignment will have both a direct effect and a reinforcing effect on competence. If confirmed, this would show that training without systems and rewards is insufficient, and that repositories without ethical and managerial capacity may remain underused.

6. Expected contribution and policy implications

The theoretical contribution is an extended institutional-capability model of open science. It integrates normative governance, technical capacity, individual competence, and organisational incentives rather than treating open science as a single attitude or publication choice. The mediation structure explains how policies and infrastructure become usable data practices, while moderation captures the organisational conditions under which training produces behaviour.

The practical contribution is a diagnostic framework for universities and ministries. Low ERG scores would justify stronger ethics review, misconduct procedures, authorship rules, and data-protection guidance. Low DRI or DSC scores would indicate a need for repositories, secure storage, metadata support, data stewards, and standard data-management plans. Low OSC scores would support multilingual, discipline-specific training. Low IAL scores would point to reform of workload, promotion, grant, and recognition systems. Finally, low ISC despite high OSI may reveal language, networking, funding, or geopolitical barriers that require separate intervention.

For Central Asia, reform should be gradual and context-sensitive. Institutions should avoid copying external templates without adapting them to national law, institutional resources, and disciplinary risk. Regional cooperation can reduce costs through shared training materials, compatible metadata standards, repository partnerships, and networks of ethics and data professionals. ORCA provides a suitable platform for testing these mechanisms and comparing institutional development across the five participating countries.

7. Conclusion

Responsible open science in Eurasia depends on more than declarations of openness. Ethical governance establishes legitimacy; digital infrastructure enables secure action; data stewardship makes research outputs understandable and reusable; competence equips researchers to apply the rules; and aligned incentives turn occasional compliance into institutional routine. The extended PLS-SEM model proposed here offers a systematic way to test these relationships and to identify where reform will have the greatest effect.

The framework also avoids the assumption that every dataset must be public. Responsible openness requires transparent decisions about what can be shared, under which conditions, and with which safeguards. By measuring policy, infrastructure, capability, incentives, practice, and international connectivity together, the study can support evidence-based reforms that improve research quality, trust, and cooperation across Eurasia.

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