



Governance, Validation, and Responsible Metrics in National Research Information Systems: Comparative Evidence from Ukraine and Slovakia

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Abstract

This study examines governance models, data validation workflows, and the responsible use of research metrics in national research information systems, drawing on a comparative analysis of Ukraine's URIS and Slovakia's SK CRIS. As key infrastructures for evidence-based research governance, national CRIS platforms must balance scalability, data quality, transparency, and interoperability. The paper analyzes how both systems manage large-scale research data, ensure metadata integrity, and support policy-making and evaluation processes.

The Ukrainian URIS demonstrates a layered governance model combining institutional data curation with centralized national validation coordinated by the State Scientific and Technical Library of Ukraine. This dual-validation approach, supported by automated and manual quality control, enables the processing of over half a million records while maintaining consistency and auditability. In contrast, the Slovak SK CRIS operates within a highly centralized, legislatively regulated framework, integrating multiple national registers and information systems to ensure data accuracy, completeness, and timeliness.

The comparative analysis highlights shared best practices, including the use of persistent identifiers, integration of automated and manual validation mechanisms, adherence to FAIR and Open Science principles, and the implementation of transparent

audit trails. Both systems support advanced analytics for research evaluation and policy-making, while aligning with international frameworks for responsible metrics, such as DORA and the Leiden Manifesto, to mitigate biases and ensure context-aware assessment.

The findings demonstrate that different governance configurations layered versus centralized can achieve comparable levels of data quality and system reliability when supported by clear roles, standardized processes, and strong institutional coordination. The study provides practical insights for the development of robust, scalable, and trustworthy national research information systems and contributes to ongoing discussions on interoperability, responsible evaluation, and the future of CRIS infrastructures.

1 Introduction

National research information systems (CRIS) have become a cornerstone of contemporary research governance, providing the data infrastructure necessary for evidence-based decision-making, performance evaluation, and strategic planning. As research ecosystems grow in complexity and scale, these systems are increasingly expected not only to aggregate and store information, but also to ensure its quality, interoperability, and meaningful use across institutional, national, and international contexts. Despite these shared objectives, the design and implementation of CRIS vary significantly between countries, reflecting differences in governance traditions, regulatory environments, and levels of digital maturity.

Against this backdrop, Ukraine's URIS and the Slovak national CRIS represent two distinctive yet comparable approaches to building and operating national research information infrastructures. Both systems handle large volumes of data and support critical policy functions, yet they differ in how responsibilities are distributed, how validation is organized, and how compliance is ensured. In Ukraine, the development of URIS reflects a coordinated effort to centralize research information while preserving institutional engagement. The system integrates data from multiple sources, including institutional repositories and local CRIS implementations, into a unified national dataset. A defining feature of this model is its dual-layer validation workflow, which combines automated checks with expert-driven verification at both institutional and national levels. This approach not only enhances data accuracy but also creates transparent audit trails that support accountability in research evaluation.

In Slovakia, the CRIS ecosystem has evolved within a more centralized and legislatively anchored framework. The Slovak model relies heavily on national registers, standardized reporting procedures, and legal obligations that require research actors to provide structured and up-to-date data. Rather than operating institutional CRIS platforms directly, the system integrates information from multiple sources through interoperable interfaces and reference registers. This configuration supports consistency and comparability across datasets, while also embedding validation processes within broader administrative and evaluation mechanisms. Long-standing practices of research assessment and statistical reporting further reinforce the reliability and policy relevance of the system.

A comparative examination of these two national cases provides valuable insights into the relationship between governance structures and data quality outcomes. In particular, it highlights how different distributions of responsibility whether layered and participatory, as in Ukraine, or centralized and regulation-driven, as in Slovakia can both achieve high standards of data integrity when supported by clear procedures and effective coordination. It also underscores the importance of defining roles and competencies across stakeholders, including research institutions, national authorities, technical operators, and evaluation bodies.

Beyond governance and validation, the role of research metrics within CRIS has become a critical area of debate. Both URIS and the Slovak CRIS generate analytical outputs that inform funding allocation, institutional evaluation, and policy development. However, the increasing reliance on quantitative indicators has raised concerns about their potential misuse or oversimplification. International initiatives advocating for responsible metrics emphasize the need to interpret indicators within context, avoid over-reliance on single measures, and ensure transparency in methodological approaches. In this regard, national CRIS must not only provide reliable data, but also support responsible analytical practices that mitigate bias and enhance trust among stakeholders.

Interoperability represents another key dimension of contemporary CRIS development. As research becomes more collaborative and transnational, the ability to exchange and align data across systems is essential. Both URIS and the Slovak CRIS incorporate international standards, persistent identifiers, and open data principles to facilitate integration with global research infrastructures. These efforts contribute to the broader implementation of FAIR (Findable, Accessible, Interoperable, Reusable) principles and support the transition toward more open and connected research ecosystems.

This study aims to bring together these interrelated dimensions governance, data quality, validation workflows, interoperability, and responsible metrics through a comparative analysis of the Ukrainian and Slovak cases. By examining how national systems operate under different institutional and regulatory conditions, the paper seeks to identify common challenges, highlight effective practices, and contribute to the ongoing development of robust and trustworthy CRIS infrastructures. Such insights are particularly relevant for countries seeking to modernize their research information systems and align them with international standards of Open Science and responsible research assessment.

2 Literature Review

Current Research Information Systems (CRIS) have evolved from institutional data repositories into critical infrastructures underpinning research governance and evaluation. Rather than being purely technical systems, they are increasingly understood as socio-technical arrangements shaped by organizational practices, policy frameworks, and the growing demand for transparency and accountability in research systems (Thibault et al., 2023). This shift reflects a broader transformation in how research is managed and assessed, where data infrastructures play a central role in linking institutional activity with national and international policy objectives.

A recurring concern in the literature is the quality of data maintained within CRIS. Empirical studies consistently show that issues such as incomplete metadata, inconsistencies across records, and duplication are not exceptions but structural features of large-scale research information systems. Azeroual and Schöpfel (2019), in their cross-institutional analysis, demonstrate that these problems often originate from the integration of heterogeneous data sources, including institutional repositories, human resource systems, and external bibliographic databases. Importantly, their work and subsequent studies emphasize that data quality cannot be ensured through periodic interventions alone; instead, it requires continuous monitoring and iterative correction processes embedded within everyday system use (Azeroual et al., 2020).

The conceptualization of data quality in CRIS has converged around a set of core dimensions completeness, correctness, consistency, and timeliness which are now widely used as analytical benchmarks (Azeroual et al., 2020). However, more recent research nuances this framework by emphasizing that data quality is inherently context-dependent. At the same time, literature makes it clear that data quality is not simply a technical problem. Palagin et al. (2018) highlight that data infrastructures are deeply embedded in institutional cultures and practices, and that their effectiveness depends on organizational commitment, incentives, and clearly defined responsibilities. In the context

of CRIS, this translates into the need for dedicated data stewardship roles, standardized workflows, and ongoing coordination between local and central actors. Without such structures, even technically advanced systems risk producing unreliable outputs.

Closely linked to data quality is the question of validation. Research increasingly points to the necessity of hybrid validation models that combine automated processes with human oversight. Automated mechanisms such as schema validation, identifier matching, and deduplication are indispensable for handling large volumes of data efficiently. Yet, as noted by Azeroual O., et al. (2023), algorithmic approaches alone cannot resolve ambiguities related to authorship, institutional affiliations, or collaborative outputs. Manual curation remains essential, particularly in edge cases where contextual knowledge is required.

This has led to a broader reconceptualization of validation as an ongoing, distributed process embedded within data governance frameworks. Rather than being a final checkpoint, validation is increasingly integrated across the entire data lifecycle, supported by feedback loops, audit trails, and iterative correction mechanisms (European Commission, 2018). Interoperability represents another major theme in literature, particularly in the context of increasingly interconnected research ecosystems. CRIS are expected to integrate data from multiple sources and to enable exchange across institutional and national boundaries. This has driven the adoption of standardized data models such as CERIF and the widespread use of persistent identifiers, including ORCID and DOI. These tools play a crucial role in reducing ambiguity and enabling reliable data linking (Wilkinson et al., 2016). However, as noted in recent reviews, technical interoperability alone is not sufficient; semantic alignment and consistent metadata practices are equally important for ensuring that data retain their meaning across systems.

The alignment of CRIS with Open Science and FAIR principles further reinforces the importance of interoperability and data quality. CRIS are increasingly seen as key infrastructures for implementing FAIR data practices, not only by making research output discoverable and accessible, but also by structuring relationships between entities in ways that support reuse and integration (Wilkinson et al., 2016). The role of CRIS in research evaluation introduces an additional layer of complexity. While these systems provide the data backbone for performance assessment, the literature raises important concerns about the use of quantitative metrics. The Leiden Manifesto (Hicks et al., 2015) and related work in scientometrics argue for a more nuanced approach to evaluation, where metrics are used in combination with qualitative judgement and interpreted within context. In this regard, CRIS are increasingly viewed not just as data providers, but as platforms that can shape evaluation practices.

Finally, the literature on system implementation and user acceptance highlights the importance of trust in CRIS. Data quality emerges as a key determinant of user confidence, influencing both adoption and long-term sustainability. If users perceive the data as unreliable, they are unlikely to engage with the system, regardless of its technical capabilities (Azeroual et al., 2020).

Thus, literature provides a comprehensive understanding of the individual components that underpin CRIS data quality, validation, governance, interoperability, and metrics. However, these components are often studied in isolation. There remains a clear need for integrated analyses that examine how they interact within specific institutional and national contexts. Comparative studies are still relatively scarce, limiting our ability to identify transferable models and best practices.

This study addresses these gaps by examining CRIS as holistic systems in which data architecture, governance arrangements, and evaluation practices are closely intertwined. By comparing the Ukrainian and Slovak cases, it seeks to contribute to a more nuanced understanding of how different configurations of these elements can support scalable, reliable, and trustworthy research information infrastructures.

3 Methodology

This study employs a qualitative comparative research design to examine governance structures, data validation mechanisms, and the use of research metrics in national research information systems, focusing on Ukraine's URIS and Slovakia's SK CRIS. The methodological approach is grounded in comparative case study analysis, allowing for an in-depth exploration of complex institutional arrangements and operational practices within their specific national contexts. The selection of the two cases was purposeful: both systems represent national-level CRIS infrastructures with comparable functional scope, yet differ in governance models, regulatory frameworks, and implementation strategies. This contrast enables the identification of both convergent practices and context-dependent variations.

The analysis is based on a combination of document analysis, system-level observation, and secondary data sources. Primary materials include official documentation describing system architecture, metadata standards, validation procedures, and governance frameworks, as well as legislative acts, policy documents, and technical guidelines governing the operation of the systems. For the Slovak case, particular attention was paid to legal and institutional documents defining the functioning of SK CRIS and related registers. For the Ukrainian case, methodological and operational materials produced by the national coordinating body were analyzed to reconstruct validation workflows and governance arrangements. These sources were complemented by publicly available system interfaces, reports, and analytical outputs to capture how data are structured, validated, and utilized in practice.

The analytical framework is structured around four key dimensions: (1) governance models, including the distribution of roles and responsibilities among stakeholders; (2) data quality assurance, focusing on metadata standards, completeness, consistency, and timeliness; (3) validation workflows, including the interaction between automated processes and manual curation; and (4) the application of research metrics, with particular attention to principles of responsible evaluation. Each dimension was operationalized through a set of indicators derived from established literature on research information systems and data governance. For example, governance was examined through the presence of formal coordination mechanisms, decision-making procedures, and accountability structures, while validation workflows were assessed in terms of their level of centralization, use of audit trails, and mechanisms for error correction.

Data were analyzed using a structured comparative method. First, each case was examined independently to identify its internal logic, key components, and operational practices. This within-case analysis allowed for a detailed reconstruction of system architectures and processes without imposing external assumptions. Subsequently, a cross-case comparison was conducted to identify similarities and differences across the four analytical dimensions. Particular attention was paid to how different governance configurations influence data quality outcomes and the reliability of analytical outputs. The comparison also considered the extent to which each system aligns with international standards, including FAIR principles and widely accepted frameworks for responsible metrics.

To enhance the validity of the findings, the study applies methodological triangulation by cross-referencing multiple types of sources and perspectives. Documentary evidence was interpreted in light of observed system functionalities and reported use cases, reducing the risk of relying solely on formal descriptions. Furthermore, the analysis incorporates insights from prior empirical studies on CRIS data quality and governance, situating the findings within a broader scholarly context.

The study is primarily descriptive and analytical rather than explanatory in a causal sense; its objective is not to test hypotheses but to identify patterns, practices, and design choices that contribute to effective CRIS operation. At the same time, the structured comparison allows for the formulation of generalizable observations relevant to other national contexts. Limitations of the methodology include reliance on available documentation and the absence of direct quantitative performance

measurements; however, these are mitigated by the depth of qualitative analysis and the consistency of evidence across sources.

This methodological approach enables a systematic and context-sensitive comparison of two national research information systems, providing a robust basis for drawing conclusions about governance, validation, and the responsible use of research metrics in large-scale CRIS infrastructures.

4 Overview of the Two Systems

4.1 URIS

URIS serves as the national spine for research information in Ukraine, providing a centralized environment where institutions submit records, national bodies run analytics, and policy actors draw evidence for funding and evaluation decisions. It aggregates metadata and full-text links from institutional repositories, university CRIS installations, and individual submissions into a unified dataset of over half a million records.

Data validation follows a two-layer workflow: institutional curators verify affiliations, identifiers (DOI, ORCID), and metadata locally, while a national validation team, coordinated by the State Scientific and Technical Library of Ukraine, ensures cross-institutional consistency. This approach supports FAIR principles, open science, and transparent evaluation.

URIS underpins key operational and policy functions:

- Submission and evaluation of academic competitions and research grants.
- Institutional reporting to ministries and funders.
- System-level evaluation of research organizations, providing verified metrics and dossiers.

Analytics provide decision makers with dashboards, longitudinal analyses of publications, collaboration networks, and open-access compliance. Planned features include modules for scholarly journals and support for early-career researchers and PhD candidates, strengthening talent pipelines.

Governance is layered: institutional stewards manage local curation, national validators apply cross-cutting rules, and a governance board oversees policies on identifiers, metrics, and reporting. By centralizing submissions and documenting validation, URIS fosters fair, consistent, and transparent assessment.

Taken together, URIS functions not only as a metadata repository but also as an operational instrument of national research governance, linking everyday administrative tasks to long-term evidence-based policy.

4.2 SK CRIS

In Slovakia, the scientific ecosystem comprises several interconnected levels: from policy-makers, through funding and evaluation bodies, to institutions, researchers, and research infrastructures. This ecosystem is gradually being shaped by reforms aimed at increasing openness, fairness, and accountability in the allocation of financial resources and in making research outputs accessible to the public.

Issues of credibility and transparency of the ecosystem relate particularly to the functioning of grant agencies, the management of scientific data, open access, and the implementation of open science principles. However, a robust ecosystem is needed not only where research outputs are openly

shared, but also where transparency permeates the research process from the outset, enabling more rigorous and collaborative research (Thibault et al., 2023)3.

Data on science and research constitute a fundamental element of the modern governance of the research and innovation ecosystem. They enable the systematic monitoring of scientific capacities, activities, outputs and impacts, thereby forming the basis for effective policy-making, long-term strategic planning and international benchmarking.

A key actor in the field of science and research data processing in Slovakia is the Slovak Centre of Scientific and Technical Information (CVTI SR). The CVTI SR has long been responsible for building, developing and operating several nationwide information systems, tools and registers serving research institutions within the remit of the Ministry of Education, Research, Development and Youth of the Slovak Republic.

The main system is the SK CRIS – National Research Information System, containing structured data on research projects undertaken by Slovak organizations, their outputs, a map of research infrastructure, a register of research organizations and a database of researchers. It supports capability assessments and statistical surveys of research and development potential and has previously been used to administer selected national grant schemes.

The Information System on Research, Development and Innovation (SK CRIS) is defined by Act No. 172/2005 Coll. on the Organization of State Support for Research and Development and on Supplementing Act No. 575/2001 Coll. on the Organization of Government Activities and the Organization of Central State Administration, as amended. It is mentioned as the "information system of the Ministry of Education for the provision of services and information in the field of research and development" and at the same time as the public administration information system (ISVS).

The SK CRIS information system integrates data on science and research in Slovakia within the register of R&D organizations, the register of R&D projects, the register of researchers, the register of R&D results and the map of research infrastructure. The system administers the process of assessing the ability to conduct research and development (Section 26a of Act No. 172/2005 Coll.), as well as the supplementary statistical survey of the research and development potential of the Ministry of Education, Science, Technology and Innovation of the Slovak Republic. The system creates reference data (data on the assessment of competence to perform R&D) and provides it to relevant entities, mainly to grant agencies. The data of the registers are predominantly open data and are therefore also available to the public without the need for authentication to the system.

The SK CRIS is operated in the Data Centre for R&D and is integrated with other systems in the field of education. These are the systems of the grant agencies of Slovak Republic APVV, VEGA and KEGA, which, in accordance with the applicable legislation, annually import data on completed projects into the R&D project register. The R&D results register is partially populated through a connection with the Central Register of Publication Activities (CREPČ) via an integration API interface. The connection with the national Register of Legal Entities in the form of consuming reference data ensures the quality and timeliness of data on research and development organizations according to the "once is enough" principle.

The information system SK CRIS serves mainly as a source of data on science and research in Slovakia. The collected data are publicly available and presented in accordance with the principles of FAIR and open science. They serve the central government bodies, the scientific community and the public. Analytical teams create various outputs and analyses from the data. Let us mention the most important ones:

1. Assessment of competence to perform research and development: The process of assessing research and development organizations begins with the submission of an application, in which organizations provide data on personnel capacities, publication activity, projects carried out, research infrastructure, etc. (Zendulkova, 2017). The submitted application forms are subsequently assessed by an assessment committee. It

checks the correctness of the data entered and decides whether to grant the certificate or not. The certificate is granted for 6 years, therefore the assessment process is not a one-off. The assessment process ensures high-quality data for the system. The output of the process is detailed profiles of research organizations, which are highly motivated to provide high-quality and complete data. The number of certified organizations is around 700 and approximately 500 organizations undergo this process annually.

2. Additional statistical survey of research and development potential: The survey concerns all organizations, not only those with a R&D certificate. The questionnaire is therefore completed by a larger number of organizations from all research and development sectors: academic, state, business and non-profit. The questionnaire is completed online via the SK CRIS system and it is a source of valuable data, mainly on the project activities of organizations. We record approximately 500-600 completed questionnaires annually and other organizations declare that they did not conduct research in the monitored period. The output of the process is statistical reports, published on the Central Information Portal for Research, Development and Innovation (www.vedatechnika.sk).
3. Report on the state of research and development in the Slovak Republic and its comparison with foreign countries: This is a document prepared annually by the Ministry of Education, Research, Development and Youth of the Slovak Republic. The document is submitted to the Government of the Slovak Republic, which discusses it at its session. We contribute to this document by analyzing the project and publication activities of research organizations and researchers in Slovakia (Shearman et al, 2019). SK CRIS data on project activities for the relevant year are analyzed. We regularly record around 5,000 research projects solved in the monitored year. The analysis contains several indicators divided by scientific disciplines, R&D sectors, organizations, etc. The output is a document that serves as a basis for forming state science policy and it is also available to the public. (Ministry of Education, Research, Development and Youth of SR (2024).

Among the key information systems and registers operated by CVTI SR are:

- CREPČ – Central Register of Publication Activity, a comprehensive bibliographic database of publications produced by Slovak higher education institutions, used for the evaluation of publication activity, statistical reporting for university funding, accreditation processes, periodic evaluation of research, development, artistic and other creative outputs, and for the implementation of performance-based funding.
- CREUČ – Central Register of Artistic Activity, a bibliographic database of artistic outputs of Slovak higher education institutions.
- CRZP and ANTIPLAG – Central Register of Theses and Dissertations and Antiplagiarism System, which securely stores digital theses and performs automated originality checks.
- SCIDAP – National Open Digital Repository for Publications, preserving and providing access to full-text publications produced by Slovak research institutions.
- SVD – National Open Digital Repository for Research Data, enabling the secure storage and open dissemination of research datasets.

Data processing within these systems is shaped by different legislative frameworks and serves diverse purposes, resulting in heterogeneous processes and varying degrees of obligation for research actors.

Despite this heterogeneity, these data sources form a coherent ecosystem due to the use of international standards, data models and classifications for describing the entities and attributes represented in the databases. These shared principles provide the foundation for the development of a robust and high-quality research information infrastructure.

5 Governance Models

In national CRIS infrastructures, governance is not a peripheral concern but a defining element that shapes how data are produced, validated, and ultimately used for decision-making. The delineation of roles and responsibilities is therefore critical, not only for ensuring data quality but also for maintaining accountability and operational coherence across a distributed research landscape. In the case of Ukraine, the governance of URIS reflects a deliberately layered model that combines institutional autonomy with centralized coordination, allowing the system to operate at scale while preserving contextual accuracy.

At the core of this model is the State Scientific and Technical Library of Ukraine, which performs a coordinating and standard-setting function. Its role extends beyond technical administration to include the development of metadata standards, the design of validation protocols, and the oversight of cross-institutional consistency. This central position is particularly important in a system that aggregates data from a wide range of institutions with varying levels of digital maturity and data management capacity. By establishing common rules and maintaining a national perspective, the coordinating body mitigates fragmentation and ensures that the aggregated dataset remains analytically coherent.

At the institutional level, universities and research organizations act as primary data providers and curators. Their responsibility is not limited to data entry but includes the interpretation and contextualization of research outputs, authorship, and affiliations. This local dimension is crucial, as many data quality issues—such as ambiguous institutional structures or interdisciplinary collaborations—cannot be resolved without domain-specific knowledge. Allowing institutions to retain control over initial curation thus enhances the accuracy and completeness of the data, while also fostering a sense of ownership and engagement with the system.

The interaction between these levels introduces a productive tension between decentralization and standardization. On the one hand, institutions are able to adapt workflows to their internal processes; on the other, they operate within a framework of nationally defined rules that ensure comparability. This balance is sustained through formalized procedures that regulate data submission, validation, and correction. In practice, these procedures function as a governance infrastructure in their own right, embedding quality assurance into routine operations rather than treating it as an external control mechanism.

An important feature of the URIS governance model is the integration of technical and organizational roles. System developers are not isolated from governance processes; instead, they actively contribute to the implementation of validation logic, the refinement of data models, and the maintenance of interoperability with institutional systems. This close alignment between technical development and policy requirements allows the system to evolve in response to emerging needs, such as the incorporation of new identifiers or changes in evaluation criteria. It also reduces the risk of misalignment between system functionality and user expectations.

Equally significant is the role of national evaluation bodies and policy actors, who use URIS data for assessment, accreditation, and monitoring purposes. Their involvement introduces a feedback loop into the governance structure: analytical outputs generated from the system inform policy decisions, while policy requirements, in turn, shape the evolution of data standards and validation rules. This

iterative relationship ensures that the system remains relevant to its primary users and that governance is responsive rather than static.

The effectiveness of this model depends to a large extent on transparency mechanisms. The documentation of validation decisions, the availability of audit trails, and the openness of analytical outputs all contribute to building trust among stakeholders. In environments where research evaluation has direct implications for funding and institutional reputation, such transparency is not merely desirable but necessary. It allows users to understand how data are processed and how metrics are derived, reducing the likelihood of disputes and increasing confidence in the system.

At the same time, the layered governance model is not without challenges. Coordinating multiple actors with different capacities and priorities requires continuous effort, particularly in ensuring compliance with standards and timely data updates. There is also an inherent trade-off between flexibility and control: excessive centralization may limit institutional initiative, while insufficient oversight can lead to inconsistencies. The Ukrainian approach attempts to navigate this tension by combining formalized rules with iterative feedback mechanisms, enabling gradual alignment without imposing rigid uniformity.

From an analytical perspective, the URIS governance model illustrates how distributed responsibility can coexist with centralized quality assurance in large-scale research information systems. Rather than relying solely on top-down control or bottom-up self-regulation, it integrates both approaches into a coherent framework. This hybrid configuration appears particularly well suited to contexts characterized by institutional diversity and ongoing system development, where adaptability and coordination must be maintained simultaneously (Zharinova et al. 2025).

The governance structure of URIS demonstrates that effective management of national research information systems depends not only on technical solutions but on carefully designed institutional arrangements. By aligning roles, processes, and incentives across different levels of the system, it creates the conditions for reliable data, meaningful analytics, and informed policy-making.

In national CRIS systems, clear delineation of roles and responsibilities is essential to ensure data quality, accountability, and operational efficiency. In Ukraine, the governance of URIS is structured around multiple layers. The State Scientific and Technical Library of Ukraine plays a central coordinating role, establishing metadata standards, defining validation procedures, and managing national-level oversight. Universities and research institutions are primarily responsible for the initial curation of their records, ensuring that local submissions conform to prescribed formats and that authorship and affiliation data are accurate. System developers maintain the technical infrastructure, implement automated validation routines, and provide ongoing support for integrations with institutional CRIS installations. National evaluation bodies and policy agencies rely on the curated datasets to conduct research assessment, institutional accreditation, and monitoring of funded projects, while also providing feedback to the governance board regarding needed updates to data standards or analytical workflows.

This layered governance model balances institutional autonomy with centralized oversight. Universities retain control over their internal data workflows, enabling contextual knowledge to inform initial curation, while the SSTL ensures consistency and comparability across institutions. Formalized protocols define how responsibilities are distributed and include mechanisms for conflict resolution, error correction, and audit trails. Transparency is enhanced through documentation of validation decisions and open reporting of metrics, which together foster trust in the system among stakeholders.

Decision-making within URIS is structured to be both evidence-driven and participatory. Changes to data standards, metric definitions, and system functionalities follow a formalized approval process. Proposals typically originate either from institutional stakeholders, who identify operational needs, or from national policy authorities, who require adjustments for evaluation and reporting purposes. These proposals are reviewed by a governance board composed of representatives from universities, research institutes, the SSTL of Ukraine, and technical teams. The board evaluates proposals based on

feasibility, compliance with national policies, interoperability requirements, and alignment with international best practices such as FAIR principles.

Once approved, technical teams implement changes in coordination with institutional curators to ensure smooth adoption. For example, updates to metadata schemas, new validation rules, or the introduction of additional analytical indicators are tested on sample datasets before full deployment. Feedback loops are embedded in the process: institutions report implementation issues, and adjustments are made iteratively. This structured decision-making ensures that modifications to the system are transparent, traceable, and aligned with the broader objectives of maintaining high-quality data, supporting responsible metrics, and enabling robust national research evaluation.

6 Data Quality: Approaches and Mechanisms

The URIS system employs a multi-layered approach to ensure the integrity, consistency, and completeness of research data at a national scale. At its core, URIS combines automated algorithms with manual oversight to maintain high-quality metadata across more than half a million records. Automated processes include normalization routines that standardize institutional names, map author identifiers such as ORCID, match DOIs, and parse bibliographic fields. Deduplication algorithms identify and merge duplicate records, preventing inflation of output counts and ensuring reliable analytics. Compliance with metadata schemas is continuously verified, and missing or inconsistent fields trigger alerts for human review.

Manual curation complements these automated processes. Institutional curators review submissions for accuracy, verifying author affiliations, project attributions, and completeness of metadata. Complex cases, including ambiguous author names or collaborative outputs involving multiple institutions, are escalated to national validators coordinated by the State Scientific and Technical Library (SSTL). This layered architecture allows URIS to detect, flag, and correct inconsistencies efficiently while retaining audit trails that document every change, ensuring transparency in data provenance.

URIS's approach is characterized by strong centralization of validation protocols combined with local institutional engagement. All national research competitions, grant applications, institutional reporting, and accreditation processes are channeled through the system. Each record undergoes a first pass at the institutional level, followed by secondary national-level validation, guaranteeing uniformity across universities and research centers. Integration with institutional CRIS installations allows seamless data ingestion while preserving the ability for institutions to correct or enhance metadata. This model not only supports consistent reporting but also provides a robust foundation for analytics, policy evaluation, and evidence-based decision-making.

The Slovak system is highly centralized. It is managed by a central government body. This model is similar to all national CRIS systems across Europe. However, the Slovak CRIS does not operate institutional systems, which are voluntary. Grant agencies also have their own systems that are connected to SK CRIS using API integration interfaces.

The SK CRIS is integrated with several reference registers. At the national level, it is a Register of Legal Entities, at the international level, primarily the identification of researchers via ORCID is more used.

Data entry is governed by the legislation; therefore all stakeholders are motivated to cooperate in entering the required data, especially about research projects and organizations.

7 Validation Workflows

URIS employs a dual-layer validation workflow to manage the complexity and scale of national research data. The process begins with primary validation conducted by institutional data stewards. These curators check records for compliance with metadata standards, verify author affiliations, and ensure proper project attribution. Automated checks flag missing fields, inconsistent identifiers, or potential duplicates, which the curators either correct or escalate.

Secondary validation is carried out at the national level by a dedicated team at the SSTL. This team applies cross-institutional rules to harmonize data, resolve conflicts, and confirm identifier accuracy. Complex scenarios, such as multi-institutional collaborations, disputed authorship, or ambiguous funding sources, are carefully reviewed through manual inspection. The system logs all modifications and retains a full audit trail, providing accountability and traceability for downstream analyses.

High-quality research information is a prerequisite for research institutions today. In research management, the importance of high data quality has grown steadily in recent years. Data quality plays an important role not only in terms of interpretation and usability of the data, but also when evaluating external data sources; data quality is crucial for the perceived utility and the acceptance of implemented systems (Azeroual & Schöpfel, 2019). It includes four aspects:

- Completeness of all the necessary information
- Correctness of the information in the system
- Consistency of the information in the system
- Timeliness, the information is up to date (Azeroual et al., 2020)

It should be emphasized that data validation within the science support systems operated in Slovakia, but mainly within SK CRIS, is a necessary condition for implementing the principles of FAIR and open science into these systems and, above all, for increasing the credibility and acceptance of these data by users.

Successful validation requires the fulfillment of several conditions:

- Implementation of metadata standards and international methodologies ensuring the quality and complexity of data in accordance with best practice.
- Data entry forms and xsd schemas of integration interfaces must be defined in accordance with standards and have built-in control algorithms (not only mandatory fields and templates, selection menus, but also duplicity control).
- Data quality is ensured by integration with other systems, mainly with reference registers (in Slovakia, for example, the register of legal entities, the register of natural persons) and international systems of permanent identifiers (ORCID, DOI, ISNI, etc.)

In Slovakia, we have undertaken the implementation of Open Science and the FAIR principles for research data collected not only within SK CRIS, across all systems under our management (Zendulková et al., 2025). We focus on the implementation of unique identifiers, data management, metadata quality control, and the integration of various data sources into broader units with the character of research infrastructures. The aim is to ensure that collected data are used not only at the national level, but also it be made available for international comparison.

To support these integration efforts, the CVTI SR has developed the Comprehensive Information System for the Acquisition, Processing, Preservation and Dissemination of Scientific and Bibliometric Data and Publications, and for Providing Access to Tools and Applications Supporting Research and

Development (abbreviated as KOMIS).

As part of strengthening integration objectives, several related functionalities have been implemented in the Slovak Research Information System (SK CRIS), specifically:

- Implementation of researcher ID federation. The system now supports internationally used persistent identifiers (PIDs), specifically ORCID, ResearcherID and Scopus ID, as well as the national identifier ID of a Higher Education Teacher from the register of university employees.
- Integration with the Register of Legal Entities (using a national-level PID for organizations, namely the Identification Number of an Organization – IČO). The Register of Legal Entities is a reference register. Integration with this register enables SK CRIS to retrieve data on organizations by validating their IČO. This applies the “once only” principle, ensuring that users do not need to re-enter information already available in the national register.
- Extension of recorded research outputs to include DOIs and URLs of the full text of publications.

8 Efficiency, Scalability, and Responsible Metrics

Both URIS (Ukraine) and SK CRIS (Slovakia) illustrate how national CRIS can operate at scale while maintaining high data quality, transparency, and policy relevance.

URIS combines automated and manual validation: institutional curators manage local ingestion and initial quality control, while national validators ensure consistency and deduplication across institutions. SK CRIS similarly enforces data quality through standardized metadata, integration with national reference registers, and legislative mandates. Both approaches enable stable operation of hundreds of research institutions and the processing of hundreds of thousands of records. Lessons learned include the importance of clearly defined validation protocols, audit trails, and coordinated workflows that balance speed with precision.

Interoperability: Both systems support technical and semantic interoperability to enable national and international integration. URIS aligns metadata with CERIF standards, uses persistent identifiers (ORCID, DOI, ROR), and follows open protocols to allow cross-border data exchange. SK CRIS integrates national registers and supports internationally recognized researcher identifiers. Together, these design choices promote FAIR principles, open science, and participation in comparative research assessment and benchmarking.

Responsible use of metrics: URIS and SK CRIS both provide analytics for evaluation, policy decisions, and institutional reporting. Metrics are applied following responsible assessment frameworks (DORA, Leiden Manifesto), emphasizing transparency, reproducibility, and context-aware interpretation. Deduplication, identifier verification, and structured validation reduce distortions from misattribution or duplicate records. Affiliation and funding data are tracked to prevent misrepresentation, ensuring fair, evidence-based evaluation at both individual and institutional levels.

Comparative perspective and lessons learned:

- URIS emphasizes layered governance and dual validation, offering strong cross-institutional comparability.
- SK CRIS relies on legislative enforcement, reference registers, and structured certification of research organizations.

Common best practices include persistent identifiers, combination of automated/manual validation, alignment with FAIR/Open Science principles, and transparent audit trails.

Challenges differ: URIS faces volume management and emerging system integration, while SK CRIS must ensure legal compliance and maintain integration with multiple registers and grant agencies.

These insights highlight how different national CRIS models can achieve robust governance, scalable operations, and responsible use of metrics, offering comparative evidence for other countries seeking to strengthen research information systems.

Table 1 provides a brief summary of the comparison of both systems according to selected criteria.

Aspect	Ukraine (URIS)	Slovakia (SK CRIS)
Governance	Layered governance: institutional curators, national validators, governance board	Centralized government management by Ministry of Education
Validation	Two-layer validation (local + national) ensures consistency and transparency	Data entry regulated by law; integration with reference registers ensures quality
Integration	Institutional repositories, university CRIS, individual submissions	Reference registers (national and international), grant agency systems
Policy use	Supports academic competitions, grants, institutional evaluation, and analytics	Supports R&D assessment, statistical surveys, and government reporting
Data access & openness	Publicly accessible metadata and full-text links; FAIR principles	Publicly accessible; adheres to FAIR and open science principles
Scale & coverage	>500,000 records; national-level governance of research information	~700 certified organizations; annual surveys and assessments

Table 1: Comparison of URIS and SK CRIS according to selected aspects

9 Discussion

The comparison of URIS (Ukraine) and SK CRIS (Slovakia) provides a useful lens for understanding how different governance configurations can achieve similar strategic objectives in national research information management. Despite differences in institutional design and regulatory environments, both systems demonstrate that high-quality research governance depends on the ability to combine centralized coordination with structured engagement of data providers. What distinguishes them is not the presence or absence of these elements, but the way they are operationalized and balanced in practice.

In the Ukrainian case, URIS operates under conditions of high data volume and institutional heterogeneity, currently aggregating more than half a million research records from universities, research institutes, and individual contributors. This scale necessitates a governance model capable of distributing responsibilities without compromising consistency. The dual-level validation workflow—where institutional curators perform initial verification and a national team ensures cross-institutional harmonization—functions as a mechanism for both scalability and quality assurance. Importantly, this model does not rely solely on procedural compliance; it is reinforced by technical features such as deduplication algorithms, identifier matching (e.g., ORCID, DOI), and comprehensive audit trails. Together, these elements reduce the risk of data inflation, misattribution, and inconsistencies that could undermine analytical outputs.

At the same time, URIS integrates multiple operational domains within a single infrastructure, including grant applications, academic competitions, institutional reporting, and elements of research evaluation. This functional integration strengthens the system's role as an operational backbone of research governance rather than a passive repository. It also creates strong incentives for institutions to maintain high-quality data, as inaccuracies can have immediate administrative and reputational consequences. From a governance perspective, this linkage between data quality and institutional accountability is particularly significant, as it embeds quality assurance within everyday administrative processes rather than treating it as an external requirement.

In contrast, the Slovak SK CRIS represents a more centralized and legally anchored model. Its effectiveness is closely tied to legislative frameworks that define data submission obligations, system functions, and the roles of participating actors. The integration with national reference registers—such as the Register of Legal Entities—and the application of the “once-only” principle reduce redundancy and improve data consistency at the source. Moreover, the system's connection to formal assessment procedures, including the certification of research organizations (typically valid for six years) and annual statistical surveys, ensures that data are regularly verified and updated. The scale of participation—approximately 700 certified organizations and hundreds of annual survey submissions—illustrates the system's comprehensive coverage and its institutional embeddedness.

A distinctive feature of the Slovak approach is the extent to which data quality is enforced through procedural and legal mechanisms rather than through layered validation workflows. The requirement to provide accurate and complete data as part of formal evaluation processes creates a strong compliance-driven environment. While this reduces the need for extensive post hoc validation, it also places significant emphasis on the design of input forms, metadata schemas, and integration interfaces, which must incorporate validation logic directly. As a result, quality assurance is, to a large extent, front-loaded into the data entry process.

Despite these structural differences, several common practices emerge as critical success factors across both systems. The use of persistent identifiers particularly ORCID for researchers and DOI for publications plays a central role in ensuring unambiguous attribution and enabling reliable data linking. Both systems also rely on a combination of automated and manual curation, recognizing that neither approach alone is sufficient to address the complexity of research data. Furthermore, alignment with FAIR principles and broader Open Science policies is evident in both cases, reflected in the emphasis on standardized metadata, interoperability, and public accessibility of data.

However, the comparison also highlights distinct challenges associated with each model. For URIS, the primary challenge lies in managing scale and complexity. The continuous growth of the dataset, combined with the need to integrate institutional systems and align with international infrastructures, places increasing demands on both technical capacity and coordination mechanisms. Ensuring consistent data quality across a large and diverse set of contributors requires ongoing refinement of validation rules, as well as sustained engagement with institutional stakeholders.

In the Slovak context, the challenges are of a different nature. The reliance on legislative frameworks and integration with multiple reference registers necessitates continuous alignment with evolving legal requirements and external systems. Any changes in legislation or in the structure of reference registers can have system-wide implications, requiring coordinated updates to data models and processes. Additionally, the coexistence of multiple specialized systems such as CREPČ, CRZP, and SCIDAP introduces complexity in maintaining interoperability and avoiding fragmentation, even within a centralized framework.

From a comparative perspective, one of the most important insights is that effective CRIS governance does not depend on a single “optimal” model. Instead, it requires a configuration that aligns with national institutional structures, regulatory environments, and levels of digital maturity. The Ukrainian model demonstrates the value of layered governance and iterative validation in contexts where institutional diversity is high and systems are still evolving. The Slovak model, in

turn, illustrates how strong legal frameworks and integration with reference registers can ensure consistency and reliability in a more centralized setting.

At a more general level, both cases reinforce the importance of integrating governance, validation, and analytical use within a single coherent framework. Data quality cannot be treated as an isolated technical issue; it is intrinsically linked to how data are used, who is responsible for them, and what incentives exist for maintaining their accuracy. Systems that successfully align these dimensions are better positioned to support evidence-based policy-making, transparent evaluation, and long-term sustainability.

Ultimately, the experiences of URIS and SK CRIS suggest that the future development of national research information systems will depend on their ability to remain adaptable while maintaining trust. This involves not only technical innovation but also the continuous refinement of governance structures, validation workflows, and metric practices. For countries seeking to develop or модернізувати CRIS infrastructures, the key lesson is not to replicate a specific model, but to design systems in which coordination, accountability, and data quality are mutually reinforcing.

10 Conclusion

The comparative analysis of URIS and SK CRIS confirms that the effectiveness of national research evaluation systems is fundamentally dependent on the availability of high-quality, well-governed research information. In both cases, CRIS function not only as technical infrastructures but as integral components of research governance, linking data collection, validation, and analytical use into a coherent framework that supports policy-making and institutional management.

A key finding of this study is that data quality is achieved not through isolated technical solutions, but through the alignment of governance structures, validation workflows, and system incentives. Both URIS and SK CRIS implement mechanisms that ensure the reliability and traceability of data, including structured validation processes, the use of persistent identifiers, and integration with national and international infrastructures. These features enable the production of consistent and comparable datasets that can support a wide range of functions, from institutional accreditation and funding allocation to strategic analysis and international benchmarking.

At the same time, the comparison highlights that different governance models can lead to similarly robust outcomes when they are internally coherent and contextually appropriate. URIS demonstrates the effectiveness of a layered governance approach, where responsibilities are distributed across institutional and national levels, allowing for both contextual accuracy and cross-institutional consistency. Its dual validation workflow and integration of operational processes—such as grant applications and reporting—create a system in which data quality is continuously reinforced through use. In contrast, SK CRIS illustrates the strengths of a centralized, regulation-driven model, where legislative frameworks, integration with reference registers, and formal assessment procedures ensure consistency and compliance at scale. The Slovak approach shows how data quality can be embedded at the point of data entry and maintained through structured evaluation cycles.

Despite these differences, both systems converge in several critical areas. They rely on persistent identifiers to ensure unambiguous attribution, combine automated and manual validation to address the complexity of research data, and align with FAIR and Open Science principles to support interoperability and transparency. Equally important is their shared recognition of the need for responsible use of metrics. By emphasizing data verification, deduplication, and traceability, both systems seek to mitigate the risks associated with simplistic or misapplied indicators, thereby strengthening the credibility of research evaluation processes.

The analysis also underscores that scalability and sustainability remain ongoing challenges. For URIS, the continued growth of data volumes and the need to integrate with emerging national and

international systems require constant adaptation of validation and governance mechanisms. For SK CRIS, maintaining alignment with evolving legal frameworks and ensuring interoperability across multiple interconnected systems demand sustained coordination and technical flexibility. In both contexts, the long-term success of CRIS depends on their ability to evolve without compromising data quality or stakeholder trust.

Importantly, this study highlights the value of comparative perspectives in understanding CRIS development. While national systems are shaped by specific institutional and regulatory contexts, they face common challenges related to data integration, governance, and evaluation. The experiences of Ukraine and Slovakia demonstrate that there is no single optimal model; rather, effective systems are those that successfully integrate governance, validation, and analytical functions in a way that reflects local conditions while remaining compatible with international standards.

Looking forward, both URIS and SK CRIS provide a solid foundation for further development. Future enhancements are likely to focus on expanding coverage of research outputs, including scholarly journals and research data, improving support for early-career researchers, and developing more advanced analytical tools. At the same time, increasing emphasis on interoperability and cross-border data exchange will require continued alignment with international standards and infrastructures.

The findings of this study suggest that robust national CRIS are characterized not only by technical sophistication but by well-designed governance arrangements that ensure data quality, transparency, and accountability. Strengthening these dimensions will be essential for supporting evidence-based research policy, fostering trust in evaluation systems, and enabling more effective participation in the global research landscape.

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