

Enhancing Trust, Integrity, and Efficiency in Research through Next-Level Reproducibility Impact Pathways

Deliverable D5.3 – Tools and practices for funders

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Lead Beneficiary: ARC

Author/s: Eleni Adamidi, Thanasis Vergoulis, Barbara Leitner, Joeri Tijdink, Petros Stavropoulos, Stefania Amodeo, Haris Papageorgiou

Reviewer/s: Fakhri Momeni, Jesper Schneider, Sven Arend Ulpts



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Executive Summary

Deliverable 5.3 (Tools and Practices for Funders) presents the outcomes of Task 5.3 (WP5), which developed practical solutions to help funding organizations promote and monitor reproducibility in the projects they support. Recognizing that funders play a pivotal role in shaping research culture, this work translates conceptual insights from earlier TIER2 activities into actionable mechanisms that embed reproducibility across the funding lifecycle from policy formulation to monitoring and evaluation.

Three main outputs were delivered:

- 1. The Reproducibility Promotion Plans (RPPs) which are policy templates and recommendations that help funders incorporate reproducibility principles into their calls, reviews, and internal processes.
- 2. The Reproducibility Monitoring Dashboard, a data-driven tool that tracks reproducibility and reusability indicators across funded portfolios, offering an evidence base for assessing policy impact.
- 3. The Research Artefact Extraction Tool, an automated text-mining component that identifies and classifies datasets, software, and workflows in publications, providing the underlying evidence for reproducibility metrics.

Together, these tools and practices provide funders with policy templates, monitoring infrastructure, and actionable planning tools to embed reproducibility in funding processes.

List of Abbreviations

EU - European Union

DMP - Data Management Plan

CWL - Common Workflow Language

FAIR - Findable, Accessible, Interoperable and Reusable

KIPs - Key Impact Pathways

RMP - Reproducibility Management Plan

RPOs - Research Performing Organisations

RFOs – Research Funding Organisations

SMP - Software Management Plan

UX – User Experience

WP - Work Package

1. Introduction

Funders hold a central position in shaping the culture and practices of research. Through the policies, expectations, and incentives they establish, they can influence how research is planned, conducted, and reported. Recognizing this pivotal role, Task 5.3 of Work Package 5 (WP5) focused on developing tools and practices that empower funders to actively promote and monitor reproducibility in the research they support. The objective was to move beyond general advocacy toward practical, evidence-based mechanisms that integrate reproducibility into the full funding lifecycle, from policy formulation to project evaluation and monitoring.

The work built upon community needs identified in Work Packages 3 and 4, which mapped reproducibility barriers and policy gaps across epistemic domains. Insights from these earlier

stages informed the design of interventions that address funders' dual responsibilities, ensuring that the projects they fund adhere to robust reproducibility standards, and embedding reproducibility within their own operational and evaluative frameworks.

To achieve this, Task 5.3 followed three complementary development tracks, each corresponding to one of the core outputs:

- The Reproducibility Promotion Plans (RPPs) provide customizable templates and recommendations that funding bodies can adapt to their policies, evaluation criteria, and internal processes.
- The Reproducibility Monitoring Dashboard offers a data-driven infrastructure for tracking reproducibility and reusability indicators across funded portfolios, enabling funders to assess the effectiveness of their policies and identify areas for improvement.
- The Research Artefact Extraction Tool, integrated with the Dashboard, automates the
 detection and classification of research artefacts (datasets, software, workflows) from
 publications and reports, providing the evidence base that underpins reproducibility
 metrics.

Each of these solutions was developed through co-creation workshops and iterative testing with national and international funding organizations, research-performing institutions, and publishers. This participatory approach ensures that the resulting tools and practices are adaptable to different policy contexts.

Together, the outputs of Deliverable 5.3 provide funders with a coherent framework for operationalizing reproducibility, linking policy, planning, and monitoring through integrated technical and procedural instruments.

2. Practical Tools and Practices for Funders

This section presents the tools and practices developed under Task 5.3 to enable funders to actively promote and monitor reproducibility within the research they actively support. Each subsection details one of the core outputs, highlighting their objectives, development pathway, and final outcomes. By structuring the section around these outputs, we provide an overview on how this task has transformed co-creation activities with funding bodies into actionable frameworks and infrastructures. Together, these solutions strengthen funders' ability to set expectations, support reproducible research practices, and track their implementation across projects and programs.

2.1. Reproducibility Promotion Plans (RPP) practice

Related Pilot(s): Pilot 5

Responsible Organisation(s): AmsterdamUMC

Stakeholders Addressed: Funders

Type of tool/ practice: Policy template with recommendations and guidance for

implementation

2.1.1. Scope & objectives

Many funding organizations lack clear guidance and practical support to promote reproducibility in the projects they support. This results in inconsistent practices and challenges in ensuring

research findings can be reliably reproduced, which can ultimately affect the credibility of funded research.

The reproducibility promotion plan for funders provides a structured approach to encourage and support reproducibility practices throughout the research lifecycle. It offers practical recommendations, examples, and strategies tailored to funders of varying expertise and resources. By embedding reproducibility principles into funding policies and processes, the plan helps ensure that funded research is transparent, reliable, and can be independently verified, thereby strengthening the overall quality and trustworthiness of scientific outcomes.

2.1.2. Development process & related activities

We had two co-creation workshops with funders, and an evaluation workshop to help refine the RPP. After that we piloted the RPP in two funding institutions over a 6-month period. The RPP was further refined considering the feedback of the pilot institutions. During the piloting phase we collaborated with Pilot 2 and Pilot 6 as best practice examples for certain recommendations.

2.1.3. Final Outcomes

The outcome is a multipage policy template. All the versions can be found on OSF, including the latest <u>version</u>. We have also created a short one-pager of the <u>RPP</u> (see **Figure 1**). All documentation for Pilot 5 is available on <u>OSF</u>, these include all existing versions of the RPP, the survey used to evaluate the RPP, and the interview guide used to evaluate the pilot process.



Figure 1: The one pager of the RPP.

2.1.4. Value for Reproducibility

The RPP provides recommendations for funders on how to develop and enhance internal practices for their funding processes in relation to reproducibility, as well as inform researchers of funders' expectations towards them. The RPP has recommendations on developing policies and definitions, evaluation and monitoring, and how to incentivize reproducibility. Recommendations are intended for funders of varying sizes and levels of expertise, making them accessible to those with no reproducibility practices in place and to those who already have some practices established. Furthermore, the recommendations include guidance on implementing reproducibility practices, examples already in use from other funders, and identification of enablers, potential barriers, and strategies to overcome those barriers. The RPP is applicable across different disciplinary contexts (e.g. life sciences, qualitative research), as it provides best practices and relevant examples for different purposes. Moreover, because of the broad diversity that exists among funders, we recognize that some recommendations are not applicable in all funding settings. For this reason, the recommendations are not a 'one-size-fits-all' but rather a tool that can be used flexibly and adapted to meet funders' specific needs.

2.1.5. Stakeholder Engagement & Adoption

Funders were essential throughout the entire process. We held two co-creation workshops with funders from different international and national funding agencies. The first workshop focused on identifying the most important themes to include in an RPP, and the second workshop on developing specific recommendations for the themes. The workshops aimed at identifying the needs of funders and narrowing them down to themes and recommendations as well as collecting best practices, enablers, barriers and ways to overcome these. We also held an evaluation workshop where funders helped refine the RPP and provide their recommendations. Across the three workshops eight funders participated. Furthermore, we created a survey which was disseminated amongst the TIER2 funder community to receive feedback on the clarity of the RPP and to collect further best practices. In total two funders completed the survey. Moreover, we piloted the RPP with two funding organizations: one international and one national funding agency. Feedback from the pilot institutions indicated engagement and initiated uptake of the RPP.

2.1.6. Sustainability & Future Use

To ensure usability and sustainability of the RPP, all documentations and versions will be available on OSF.

2.2. Reproducibility Monitoring Dashboard tool

Related Pilot(s): Pilot 6

Responsible Organisation(s): ARC

Stakeholders Addressed: Funding agencies, Research Performing Organisations

(RPOs), Publishers

Type of tool/ practice: Software tool - dashboard

2.2.1. Scope & objectives

The Reproducibility Monitoring Dashboard provides stakeholders (i.e., funding agencies, publishers, research organizations) with tracking and monitoring capabilities to evaluate the adoption and implementation of reproducible research practices.

The purpose of this tool is to enhance transparency in research by offering a systematic way to monitor reproducibility metrics, supporting both policy development and compliance assessment.

2.2.2. Development process & related Activities

The development process included design, co-creation with stakeholders for requirements gathering and feedback collection, testing and refinement phases. All development materials are publicly available on OSF: Pilot material

Further details on the methodology for the design and development of the monitoring tool and its app are provided in Deliverable D4.3. covering the general methodology underpinning the work of this Pilot (pilot 6).

2.2.3. Final Outcomes

The main outcome was a functional **Reproducibility Monitoring Dashboard** pipeline that (i) ingests and gathers data to be analysed (e.g., project portfolios, publications, RPO research outcomes), (ii) executes Al/ML processing pipelines analysing the data (see 2.5 Research Artefact Extraction tool), (iii) calculates Reproducibility/reusability indicators (FAIR Index, Reusability, Reproducibility indicators, etc), (iv) transforms and consolidates all analytics outputs in a predefined template, and (v) builds the dashboard and populates it with visualizations and reproducibility metrics across research outputs in a consistent and comprehensive way covering different perspectives (e.g., domain/field, time, geographical) that stakeholders are interested in. Stakeholders can navigate through the analytics panels examining different views related to reproducibility and reusability in their funded research, getting insightful visualizations and the data supporting them as well as the evidence – the analytics intermediate results that underpin the estimated indicators. The dashboard addresses a broad range of different questions, such as:

- What is the absolute number of artefacts produced or exploited by funded research, and how are these distributed by country, organization and research areas or discipline?
- To what extent are the produced artefacts well documented, as reflected in the FAIR Index?
- How visible and re-used (Reusability index) are these artefacts within the same field or in general?
- Which artefacts are the more outstanding?
- What is the general feedback and the perception of the research community related to those artefacts?
- What are the main reproducibility and reusability indicators per artefact category, organization or geographical region?
- How these indicators evolve over time and what are the main trends?
- In which research areas or fields should a funding agency place greater emphasis to strengthen its policies and enhance outcomes and impacts?

Several use cases were built (see the dashboard for the EU-funded Machine Learning projects from 2016 to 2021: Reproducibility Monitoring Dashboard Prototype for RPOs).

The interactive dashboard includes info boxes that define each metric index. Users can access an information page from the dashboard overview page, as well as download data and visualizations regarding reproducibility/reusability analysis of their collections. The snapshot in **Figure 2** displays the dashboard overview page.



Figure 2: Overview dashboard showing metrics and charts about research artefacts, with filters for organization, type, category, and year, and panels for counts by category and country, metric averages, and a treemap of artefacts by field of science.

Several resources are publicly accessible:

- The **Reproducibility Monitoring Dashboard prototype**, where the artefact-level evidence views are available as part of the pilot implementation: Reproducibility Dashboard prototype.
- The Reproducibility Dashboard documentation including definitions and descriptions of all reproducibility and reusability indicators.
- The SciNoBo toolkit portal, which hosts the Research Artefact Extraction Tool among other components employed by the Dashboard pipeline: SciNoBo Toolkit.
- The **GitHub repository** of the AI/ML analytics tools with source files and further details: SciNoBo GitHub repo.

2.2.4. Value for Reproducibility

The dashboard provides monitoring capabilities that allow stakeholders (i.e., funding agencies, RPOs and publishers) to track compliance with reproducibility requirements and assess policy effectiveness.

The prototype has been applied to machine learning-related projects across diverse scientific domains. The "Artefacts by FoS" graphic (see Fig 2.2) illustrates classifications spanning multiple fields including biology, astronomy and astrophysics, neurology, environmental sciences, and psychology, to name a few. This broad applicability demonstrates its effectiveness as a cross-disciplinary monitoring tool.

2.2.5. Stakeholder Engagement & Adoption

Our multi-phase process centered on stakeholder engagement. In October 2024, we hosted our first workshop with RFO representatives to gather initial requirements, introduce key concepts, and collect baseline needs (check <u>Pilot workshop material</u>). This phase established the core metrics and features desired by our primary stakeholders.

From November 2024 to May 2025, we conducted intensive prototype development. During this phase, we transformed stakeholder feedback into a functional dashboard prototype, integrating SciNoBo algorithms for automated research artifact annotation and creating visualizations tailored to various organizational contexts.

In June 2025, we entered the prototype refinement phase, highlighted by our second workshop with an expanded group of participants from both RFOs and RPOs. This session allowed us to demonstrate the functional prototype, gather detailed usability feedback, and identify improvement areas (check Pilot workshop material).

Our final implementation phase (July–October 2025) focused on refining the dashboard based on cumulative feedback. We optimized visualizations, enhanced the user interface, and developed a representative dashboard example for EU-funded Machine Learning projects from 2016–2021.

2.2.6. Sustainability & Future Use

The **Reproducibility Monitoring Dashboard** will remain an integral component of SciNoBo toolkit maintained by ARC. It can also be deployed as a service feeding analytics data in external stakeholder's applications. Trustworthiness, transparency and robustness are deemed as the most critical aspects underpinning the dashboard findings and emphasis should be placed in the evidence and the way it is presented and provided to the stakeholders.

Although the dashboard pipeline keeps track of the evolving dynamics of stakeholders' research outcomes, pilots raised the need of a more flexible and interactive way with stakeholders, facilitating and streamlining different angles and views on reproducibility and reusability instead of a fixed order dashboard. In that respect, dashboard components will be integrated into the SciNoBo Al assistant where different stakeholders can interact with the assistant, thus, conducting their own research on reproducibility/reusability across different dimensions.

2.2.7. Editorial Integration & Applicability

From the publishers' standpoint, Dashboard results can be incorporated at various stages of the editorial workflow. It can serve as a screening method to identify whether journals include adequately documented artefacts (such as essential metadata like name, version, license, and URL), or act as a policy enforcement tool that encourages authors to supply more comprehensive details before acceptance or during the proofing stage. On a broader scale, publishers can utilize aggregated data for portfolio analysis, helping them monitor how policies are adopted across different journals, fields, and over time.

By generating machine-readable outputs linked to evidence, the Dashboard tool enables publishers to play a more active role in promoting reproducibility while minimizing manual effort and maintaining consistency throughout their editorial activities.

2.3. Research Artefact Extraction tool

Related Pilot(s): Pilot 6

Responsible Organisation(s): ARC

Stakeholders Addressed: Funding Agencies, Publishers, RPOs

Type of tool/ practice: software tool

2.3.1. Scope & objectives

Stakeholders increasingly need ways to verify whether research outputs (e.g., Data management plans [DMPs], reports, deliverables, manuscripts and published articles) **name, document, and make accessible** the research artefacts (e.g., datasets, software) that underpin results. However, manual checks are time-consuming and inconsistent across documents and disciplines. Within Pilot 6, the **Research Artefact Extraction Tool,** which is part of ARC's SciNoBo toolkit¹, was **operationalised to power the Reproducibility Monitoring Dashboard ingestion layer** (cf 2.2), automatically identifying and aggregating artefact mentions and their metadata from publications relevant to funded projects. These structured outputs feed the Dashboard indicators and the evidence views behind them, thereby supporting funders, RPOs and publishers in assessing **transparency, reusability and reproducibility readiness** at scale.

2.3.2. Development process & related activities

Work in the TIER2 project focused on integration, adaptation, and validation-in-use of the tool:

- **Design & scoping (Q1–Q2 2024):** Defined the artefact fields and evidence needed by publishers/funders, and mapped tool outputs to the Dashboard's data model (e.g., artefact category, name; ownership/reuse; URL, license, version for FAIRness checks).
- Co-creation (Q3–Q4 2024): Presented methodology and data needs to funders; gathered
 priorities on which artefacts and proxies matter most. Feedback shaped which metadata
 the tool should surface to the Dashboard and how evidence should be displayed (check
 Pilot material).

¹ scinobo.ilsp.gr

 Testing & refinement (Q1–Q2 2025): Ran batch analyses on publications linked to CORDIS/OpenAIRE projects; iteratively refined artefact aggregation and metadata fields to support indicators (e.g. FWRI, FAIR Index, Reusability Index) and evidence-backed views. Live demo and additional feedback were collected in June 2025 (check 2nd Pilot workshop material).

2.3.3. Final Outcomes

The main outcome was the operational integration of the Research Artefact Extraction Tool into the Reproducibility Monitoring Dashboard pipeline. As a result, the tool now automatically populates artefact-level fields within the pilot dataset used for the Dashboard. These fields capture unique artefact identifiers (deduplicated mentions), metadata elements such as name, version, license, and URL, and an ownership/reuse classification that distinguishes between artefacts created within a project and those re-used within a project but built elsewhere. These outputs underpin key reproducibility indicators and provide evidence views where users can drill down into the artefact-level information extracted from publications.

In addition, the project produced a **structured pilot dataset** in which artefact-level information is aggregated for monitoring purposes, as well as **documentation** describing how the tool outputs map to the Dashboard indicators. Evidence and methodological explanations were also shared through **public webinars and reports** (see section 2.2), ensuring transparency of approach and stakeholder alignment.

Several resources are publicly accessible:

- The **SciNoBo toolkit portal** (see **Figure 3**), which hosts the Research Artefact Extraction Tool among other components: SciNoBo Toolkit.
- The **GitHub repository** of the Research Artefact Analysis (RAA) tool, with source files and further details: <u>SciNoBo RAA Github repo</u>.
- The **Reproducibility Monitoring Dashboard prototype**, where the artefact-level evidence views are available as part of the pilot implementation: Reproducibility Monitoring Dashboard prototype.



Figure 3: The SciNoBo toolkit and its tools.

2.3.4. Value for Reproducibility

The Research Artefact Extraction Tool contributes to reproducibility by making it easier to identify and describe the research artefacts that underpin scientific results. Instead of relying on manual checks, which are often inconsistent and resource-intensive, the tool automatically extracts mentions of datasets, software, and other key artefacts from publications and records basic information about them, such as name, version, license, or URL. This creates a more reliable basis for monitoring whether essential elements of reproducibility are present and adequately documented.

In the context of the Reproducibility Monitoring Dashboard, the tool supports the calculation of several indicators. For example, it helps capture **reusability signals** (through the FWRI), assess the **completeness of artefact documentation** (through the FAIR Index), and combine this information with citation analysis to provide a broader **reproducibility confidence measure**. While first applied to computer science and AI publications, the approach is not tied to a specific discipline. The same principles can be extended to other domains, such as life sciences or social sciences, making the tool relevant across different publishing contexts.

2.3.5. Stakeholder Engagement & Adoption

Stakeholders were engaged primarily through the **funder-focused webinars** in late 2024 and mid-2025. During these sessions, participants emphasised that funders and publishers value not only the presence of artefact mentions but also their **documentation quality** and clear evidence of **reusability practices**. This feedback informed the prioritisation of metadata fields and the design of the Dashboard's evidence panels.

In the second webinar, a live demonstration of the tool integration within the Dashboard received positive feedback, with stakeholders highlighting the utility of artefact-level evidence

views and the ability to access the underlying data generated by the tool. These early engagements represent initial signals of adoption, laying the groundwork for further piloting within OpenAIRE-hosted deployments and publisher workflows.

2.3.6. Sustainability & Future Use

The Research Artefact Extraction Tool will remain a core component of **SciNoBo**, maintained by ARC, and can be deployed as an extraction service in monitoring or editorial contexts. The tool surfaces key metadata fields commonly used in FAIR assessments (e.g., name, version, license, URL), which makes its outputs directly usable in publisher workflows and complementary monitoring tools that rely on similar documentation checks.

Lessons from the pilot underscore that **transparent evidence** (i.e. showing which artefacts were extracted and how they were classified) is critical to building trust and facilitating adoption. Looking ahead, the Research Artefact Extraction Tool can be extended to cover additional domains beyond computer science, and to identify a wider range of artefact categories, such as tools, methods, and protocols. Broadening this scope would increase its relevance for different disciplines and strengthen its value as a general-purpose service for monitoring research artefacts across the scholarly publishing landscape.

2.3.7. Editorial Integration & Applicability

From the perspective of publishers, the tool outputs can be integrated at multiple points in the editorial process. It can be used as a **screening mechanism** to flag whether manuscripts contain sufficiently documented artefacts (including key metadata such as name, version, license, URL), or as a **policy reinforcement tool** that prompts authors to provide more complete information before acceptance or during proofing.

At a higher level, publishers can also use aggregated artefact data for **portfolio analytics**, enabling them to track policy uptake across journals, disciplines, and time. Because the artefact extraction operates automatically on article texts, it can be implemented **without disrupting existing peer-review workflows**, with adjustments made to thresholds or metadata requirements depending on disciplinary norms.

By providing machine-readable, evidence-linked outputs, the Research Artefact Extraction Tool allows publishers to take a more proactive role in supporting reproducibility, while also reducing manual workload and ensuring consistency across their editorial operations.

3. Synthesis

Deliverable 5.3 brings together three outputs, the Reproducibility Promotion Plans (RPPs), the Reproducibility Monitoring Dashboard, and the Research Artefact Extraction Tool, that collectively strengthen funders' capacity to steer research toward transparency and reproducibility. These outputs represent a framework that connects policy design, implementation, and monitoring. Together, they provide funders with both the conceptual guidance and the technical means to ensure that reproducibility expectations are not only defined but also measurable and actionable.

D5.3 Tools and practices for funders

The RPPs help funders articulate and operationalize their commitments to reproducibility through structured templates and adaptable recommendations. The Dashboard translates these commitments into measurable indicators, offering funders and other stakeholders an evidence base for evaluating progress. Meanwhile, the Artefact Extraction Tool provides the analytical foundation for these metrics, automatically identifying datasets, software, and workflows to make reproducibility traceable across funded portfolios.

Beyond the individual contributions of each tool, Deliverable 5.3 demonstrates how policy interventions and technical infrastructures reinforce one another. It operationalizes reproducibility as an interconnected cycle: funders define expectations (RPPs), researchers integrate them into project-level planning (via RMPs from D5.1), and monitoring mechanisms (Dashboard and Artefact Extraction Tool) close the loop through evidence-based evaluation. This alignment across levels, policy, research, and monitoring, embodies the broader TIER2 vision of a systemic, end-to-end approach to improving research quality.

Overall, this deliverable report contributes to making reproducibility a more tangible and trackable element of research funding. Through its policy templates and monitoring tools, it offers funders practical means to encourage, observe, and strengthen reproducibility within their funding processes.