



PROGRAMA DE DOCTORADO

FORMACIÓN EN LA SOCIEDAD DEL CONOCIMIENTO

Towards the Development of a Multidimensional Approach to Evaluating the Social Impact of Science: Integrating Alternative Metrics, Novel Indicators, and Artificial Intelligence

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INTRODUCTION

Scientific research is widely recognised as a catalyst for societal progress, yet its broader impact remains debated. As research assessment evolves, measuring “impact has become an integral part of scientific practice at all levels” (Smit & Hessels, 2021). However, translating scientific knowledge into real-world change is not always straightforward, as its influence on policy, industry, and public discourse follows complex and multifaceted pathways.

The COVID-19 pandemic demonstrated science's responsiveness to societal needs, triggering an unprecedented surge in research. Within months, “we witnessed an unprecedented mobilisation of scientific resources dedicated to addressing a single problem” (Torres-Salinas, 2020), shaping public health policies, accelerating vaccine development, and guiding governmental responses. However, the sheer volume of publications, the widespread use of preprints— “widely used outside of specific communities to communicate during the epidemic” (Fraser et al., 2021)—and the rapid dissemination of findings through non-traditional channels challenged conventional impact assessment, raising questions about how research influence is measured in a context of heightened public and policy engagement.

Research assessment has traditionally relied on citation-based metrics, such as journal impact factors and h-index scores, which reflect how outputs “are strategically positioned in the global publishing landscape” (Torres-Salinas, 2024). However, concerns about their limitations have led to a shift towards more comprehensive evaluation frameworks. Initiatives like DORA and COARA promote qualitative, impact-oriented approaches, emphasising Citizen Science and societal engagement. As recent discussions suggest, “social impact from research often occurs when researchers and stakeholders work together throughout the research process, framing questions and solving problems together” (Hill, 2016). Recognising this, evaluation agencies increasingly prioritise “the delivery of societal benefit from research” (Hill, 2016), reinforcing the need for assessment frameworks that move beyond academic influence.

In view of the “inability of academic citations to reflect societal impacts” (Thelwall, 2024), research evaluation frameworks have increasingly incorporated alternative metrics. Altmetrics, which track research engagement across social media, news, or policy documents (Priem et al., 2011), and patent citations (Hammarfelt, 2021) offer a broader view of how scientific knowledge translates into societal influence. However, altmetrics “cover only a fraction (...) of the phenomenon that they are used as an indicator of” and are “especially



given the possibility of manipulation" (Thelwall, 2024). Thus, it is essential to examine alternative parameters that may serve as impact metrics within these dimensions.

One emerging approach to enhancing research evaluation is the integration of artificial intelligence (AI). Generative AI refers to "the production of previously unseen synthetic content, in any form and to support any task, through generative modelling" (García-Peñalvo & Vázquez-Ingelmo, 2023), which opens new possibilities for assessing how research reaches and influences different sectors of society. AI can rapidly analyse vast amounts of information, identifying patterns in how research is discussed in media, referenced in policy, or engaged with by the public, offering a more nuanced view of societal impact. Additionally, preliminary studies (Liang et al., 2023) suggest that since large language models (LLMs) are pre-trained, extensive new training datasets may not be necessary, requiring instead only "appropriate prompts" (Thelwall, 2024) to refine their outputs.

However, concerns about bias, inaccuracies, and the challenge of verifying AI-generated insights persist. While LLMs may not significantly reduce workload, they can support decision-making when critically assessed. Their integration into research evaluation demands careful oversight, continuous refinement, and robust ethical frameworks. In this regard, the Safe AI in Education Manifesto outlines key principles—such as human oversight, transparency, explainability, and alignment with educational values—that should guide the adoption of AI technologies in educational and research environments (Alier Forment et al., 2024). In line with this, the European Commission (2024) emphasises that "one of the goals of these guidelines is that the scientific community uses this technology in a responsible manner" (p. 4). These principles will guide the approach to AI throughout this study, ensuring that its use complements human judgement and contributes to a fair and reflective assessment of societal impact. As highlighted in recent literature, "it is essential to promote a transparent, secure, ethical, and explainable artificial intelligence that fosters user trust and can be effectively used in educational context" (García Peñalvo, 2024).

In this context, engagement on social platforms is not only about dissemination, but also interaction. As García-Peñalvo (2016) note, genuine socialisation requires active peer participation, beyond passively observing or consuming shared content. This is key to distinguishing superficial visibility from meaningful interaction when assessing societal impact through altmetrics.



This thesis aims to explore emerging methodologies, metrics, parameters, and indicators for assessing the societal impact of research, addressing the limitations of traditional evaluation frameworks. As science policy increasingly emphasises accountability, transparency, and public engagement, the development of holistic assessment models becomes imperative. By examining evolving approaches—including the integration of AI—this thesis aims to contribute to the advancement of multidimensional frameworks that more accurately capture the societal relevance of research. These insights are crucial for informing funding allocation, institutional strategies, and policy development, ensuring that research serves as a catalyst for effective societal progress.

WORKING HYPOTHESIS AND PRINCIPAL OBJECTIVES SOUGHT

This thesis hypothesizes that evaluating societal impact in scientific research requires a multidimensional approach, integrating bibliometrics, altmetrics, AI analysis, and emerging parameters to capture a broader range of influences, including policy engagement, public discourse, community involvement, and knowledge transfer. It is further hypothesized that publicly funded research should generate tangible societal benefits, address social needs, and contribute to the public good. High academic impact outputs should also demonstrate relevance beyond academia. This study aims to develop strategies to maximise both academic and societal impact, considering how social trends and external factors shape research agendas and funding.

To verify this hypothesis, the following research questions will be addressed:

Q.1. How is societal impact conceptualised and assessed within research evaluation frameworks, both in Spain and internationally, and to what extent are current scientific outputs aligned with identified societal needs?

Q.2. What role do researchers and institutions play in fostering societal impact, and how should their contributions be recognised and integrated into formal research assessment processes?

Q.3. Which indicators, including altmetrics and alternative metrics, most effectively capture societal engagement, and how might these measures be refined to enhance both academic visibility and societal relevance?



Q.4. How can a multidimensional framework be developed to assess societal impact with greater precision, particularly in relation to outputs that demonstrate high academic significance yet aim for broader societal dissemination?

Q.5. What potential does artificial intelligence hold for supporting the evaluation of societal impact, particularly through the analysis and integration of diverse indicator sets?

Q.6. To what extent does publicly funded research contribute to addressing regional social and economic challenges, and how can such contributions be effectively measured within research evaluation exercises?

General Objective:

To develop a multidimensional framework for assessing the societal impact of scientific research, integrating altmetrics, new evaluation parameters, and AI analysis to enhance existing practices. This framework will capture the complexity of social impact, ensuring that high academic impact outputs and publicly funded research demonstrate societal relevance and practical application.

Specific Objectives:

S.O.1. To analyse current criteria and frameworks for evaluating societal impact, both in Spain and internationally, identifying best practices, existing gaps—particularly in knowledge transfer and responsiveness to socio-political trends—and establishing practical guidelines to enhance evaluation processes and clarify researchers' responsibilities.

S.O.2. To critically assess altmetrics and alternative indicators as measures of societal engagement, exploring their strengths, limitations, and potential for broader and more effective application.

S.O.3. To develop a comprehensive set of multidimensional indicators aimed at improving the assessment of societal impact across diverse research outputs and contexts.

S.O.4. To formulate strategic approaches for maximising both academic and societal impact, including effective communication practices and dissemination pathways aligned with evolving social needs.



S.O.5. To investigate the role of artificial intelligence in supporting the evaluation of societal impact, identifying potential applications, challenges, and future avenues for integration within research assessment frameworks.

METHODOLOGY

This study will adopt a mixed-methods approach to develop a multidimensional framework for assessing the societal impact of scientific research. The methodology will integrate bibliometrics, altmetrics, AI analysis, and emerging parameters to capture diverse dimensions of impact, including policy engagement, public discourse, community involvement, and knowledge transfer. The methodological framework comprises the following stages:

1. **Systematic Literature Review (SLR):** A SLR will be conducted to examine current approaches to evaluating societal impact, including traditional bibliometric methods, altmetric indicators, and emerging frameworks. Special attention will be given to identifying gaps and opportunities for integrating multidimensional assessment strategies. Following the methodological framework proposed by García-Peñalvo and García-Holgado (2022), the review will ensure rigour, transparency, and reproducibility throughout the selection, screening, and analysis phases. Based on the insights progressively obtained, additional reviews will be planned and conducted as needed.

2. **DMP and Open Access:** The research will adhere to the FAIR principles (Findability, Accessibility, Interoperability, Reusability) to ensure proper data management throughout the project. Data will be securely stored on institutional and cloud platforms, with metadata for traceability and long-term preservation. The results and outputs will be openly accessible through the University of Salamanca Institutional Repository (GREDOS), promoting transparency and compliance with open science practices.

3. **Data Collection and Indicator Selection:** Relevant data will be gathered from academic databases and altmetric aggregators (e.g., Altmetric.com, PlumX, etc.). Selection criteria will include research outputs with significant digital engagement and citation impact. Bibliographic management tools will be used for data organisation and export. The selection of indicators will prioritise metrics reflecting social engagement, academic recognition, and policy relevance. In this initial phase, additional data sources and resources may be



incorporated as identified through the SLR or as new analytical needs emerge, allowing for adaptive refinement of the methodological framework.

4. Exploration of a Multidimensional Assessment Approach: The viability and relevance of developing a composite indicator will be explored, with the aim of integrating metrics related to social engagement, academic impact, and policy or community involvement. The potential weighting of these dimensions would be informed by statistical analysis, sensitivity testing, and expert consultation, ensuring methodological soundness if pursued. Particular attention will be paid to the alignment of societal contribution with broader frameworks, such as the Sustainable Development Goals (SDGs), drawing on the practical approach outlined by Mangas Vega (2023).

5. Validation through Case Studies: The feasibility and effectiveness of the proposed elements or assessment solutions will be examined through case studies of high-impact research outputs. These cases will help explore the extent to which the selected approaches capture broader societal relevance. Where applicable, statistical analyses will be conducted to assess their performance across diverse contexts and to refine the proposed framework.

6. Integration of Artificial Intelligence (AI): AI will be explored as a cross-cutting tool to support and enhance various phases of the study, particularly those susceptible to automation or improved efficiency. Techniques such as machine learning and natural language processing will facilitate the analysis of large datasets, helping to identify patterns in societal engagement and policy references. Generative AI models will also be tested for their potential to extract insights from online discourse, while ensuring methodological transparency and addressing potential biases. In alignment with the ethical recommendations of the Heredia Declaration, the use of AI will be reported with clear references to the model, version, and purpose, following best practices for responsible integration of AI in scientific research and communication (Penabad-Camacho et al., 2024).

7. Network Analysis and Visualisation: The potential of network analysis will be explored to map relationships between academic outputs, societal engagement, and policy influence. Tools such as VOSviewer may be used to visualise connections among research outputs, citations, social media interactions, and policy references, with the aim of identifying influential nodes and clusters within both academic and social networks.



8. Automation and Implementation: The possibility of developing a prototype tool for automated impact assessment will be explored, with the aim of integrating the proposed elements into an accessible web-based environment. Feasibility studies will consider its potential application across different devices, including desktop and mobile platforms.

9. Expert Consultation and Qualitative Validation: Structured interviews and surveys will be conducted with key stakeholders (e.g., researchers, policymakers) to evaluate the usability and accuracy of the proposed indicator. Qualitative data analysis will be performed using tools like NVivo.

10. Ethical Considerations: The methodology will address potential biases and ethical challenges, including data privacy concerns and the reliability of social engagement metrics.

This methodological approach ensures a rigorous, multidimensional assessment of social impact by combining quantitative data analysis with qualitative validation.

MATERIAL MEANS AND RESOURCES AVAILABLE

The development of this thesis takes place within the framework of the Doctoral Programme "Training in the Knowledge Society" at the University of Salamanca. The doctoral portal will serve as the primary management tool for monitoring the research progress.

Additionally, the thesis will be carried out within the GRIAL Research Group (GIR), allowing access to the resources and infrastructure provided by the group.

This study will utilise a combination of technological, bibliographic, and institutional resources to ensure the successful execution of the research. The key resources include:

1. Access to Bibliographic Databases: Access to bibliographic databases is ensured through institutional subscriptions managed by the Library Service of the University of Salamanca. This includes access to major academic databases such as Web of Science, Scopus, and Google Scholar, which will be utilised to retrieve scholarly articles and citation data. Additionally, the University of Salamanca is part of the Castilla y León University Library Consortium (BUCLE),



which facilitates access to shared bibliographic resources among regional universities. Furthermore, altmetric aggregators such as Altmetric.com, PlumX, and Dimensions will be employed to collect and analyse social media engagement metrics, enhancing the comprehensive assessment of research impact.

2. Computational and Analytical Tools: The research will employ a range of computational and analytical tools to ensure rigorous data processing and analysis. Statistical analysis will be performed using GraphPad to process quantitative data and conduct correlation analysis. Data visualisation will be supported by tools like Tableau and Power BI to effectively represent trends in altmetrics and bibliometric indicators, enabling clear and comprehensive interpretation of results. Additionally, bibliometric mapping will be conducted using VOSviewer to visualise research networks and patterns. Institutional

3. Infrastructure and Support: The research will benefit from access to university libraries and digital repositories, facilitating comprehensive literature review and efficient reference management. Collaboration with offices dedicated to research impact and policy advisory will ensure methodological rigour and alignment with practical applications. Additionally, support from international research networks and participation in Open Science initiatives will enhance data availability and enable expert validation, reinforcing the reliability and relevance of the study.

4. Technical and IT Resources: The research will utilise secure data storage and cloud computing platforms, such as Google Drive, OneDrive, and institutional repositories, to ensure the safe handling and management of large datasets. If necessary, high-performance computing resources will be employed to facilitate large-scale data processing and advanced analysis, particularly in the context of research impact modelling.

5. Survey and Interview Instruments: Structured surveys and interviews will be developed to collect qualitative insights from key stakeholders, including researchers, policymakers, and science communicators. To streamline data collection and enhance stakeholder engagement, online platforms such as Qualtrics, Google Forms, and Microsoft Teams will be employed, ensuring efficient and secure management of responses.



6. Ethical and Data Management Considerations: To ensure compliance with data privacy regulations, including GDPR, secure and ethical handling of altmetric and bibliometric data will be prioritised. Institutional ethics committee approval will be sought for any qualitative data collection involving human participants. Furthermore, a comprehensive Data Management Plan (DMP) will be implemented to guide data storage, processing, and sharing, ensuring secure and systematic management throughout the research lifecycle.

TIMING SCHEDULE OVER FOUR YEARS

Phase 1: Thesis Design and Planning (Months 1–5)

Task 1.1: Define the objectives, hypothesis, research questions, and scope of the study, resulting in a clear research design aligned with the focus on societal impact (Months 1–4).

Task 1.2: Prepare the detailed project timeline, set milestones, and secure necessary ethical approvals (Months 2–5).

Phase 2: Literature Review and State of the Art (Months 3–16)

Task 2.1: Conduct a systematic literature review on societal impact assessment to ensure a comprehensive understanding of current evaluation practices (Months 3–12).

Task 2.2: Analyse national and international evaluation frameworks, positioning the research within both contexts (Months 6–14).

Task 2.3: Identify emerging trends and theoretical gaps to highlight areas for contribution (Months 10–16).

Phase 3: Indicator Identification and Mapping (Months 12–22)

Task 3.1: Map academic, altmetric, and novel indicators of societal impact, consolidating a relevant list (Months 12–20).

Task 3.2: Perform bibliometric and altmetric analysis using tools such as VOSviewer and GraphPad, mapping networks and impact patterns (Months 14–22).

Phase 4: Data Strategy and FAIR DMP (Months 16–24)



Task 4.1: Design the data management strategy following FAIR principles and draft the Data Management Plan (DMP) (Months 16–24).

Phase 5: Data Collection and Preparation (Months 20–30)

Task 5.1: Collect datasets from Scopus, Altmetric.com, Dimensions, and PlumX (Months 20–28).

Task 5.2: Select research outputs with high academic and societal visibility for analysis (Months 24–30).

Phase 6: Framework Development (Months 28–36)

Task 6.1: Explore the feasibility of a multidimensional framework and draft its initial version (Months 28–34).

Task 6.2: Consult with experts regarding metric relevance and weighting to strengthen methodological validity (Months 30–36).

Phase 7: AI Integration and Network Analysis (Months 32–42)

Task 7.1: Explore the application of AI techniques to support key phases of the project (Months 32–40).

Task 7.2: Assess the potential of network analysis and visualisation tools for representing societal and academic impact (Months 36–42).

Phase 8: Validation via Case Studies (Months 38–46)

Task 8.1: Apply selected framework elements in case studies to gather evidence of functionality and applicability (Months 38–44).

Task 8.2: Conduct exploratory analysis and refine the framework based on findings (Months 40–46).

Phase 9: Tool Development and Prototyping (Months 42–48)

Task 9.1: Explore the development of an assessment tool for automated societal impact evaluation (Months 42–48).

Task 9.2: Assess the feasibility of a responsive and accessible prototype (Months 44–48).

Phase 10: Stakeholder Consultation and Refinement (Months 42–48)



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Task 10.1: Conduct interviews with stakeholders to assess the clarity, relevance, and usability of the framework and tool, incorporating feedback into final refinements (Months 42–48).

Phase 11: Writing, Submission, and Defence (Months 45–48)

Task 11.1: Write and revise the PhD thesis; prepare for defence and final submission (Months 45–48).

Ongoing Activities (Throughout Months 1–48):

Participate in relevant conferences and doctoral training programmes.

Conduct interviews with key actors involved in research dissemination and evaluation (e.g., journal editors, researchers, policymakers).

Work towards fulfilling the requirements for the International Doctorate distinction, including potential research stays abroad.

Mobility Actions (Months 13–42): Engage in mobility actions during the second to fourth years, enriching the research with international experience aligned with the requirements for the International Doctorate distinction.



PERSONAL TRAINING PLAN

Year 1: Foundations and Core Competencies

- Research Design and Methods: Enrolment in courses on qualitative and quantitative methodologies to reinforce the mixed-methods approach of the thesis, with a focus on rigour, replicability, and integration of different data sources.
- Microcredential in Bibliometrics (University of Salamanca): Completion of a specialised module to acquire a solid foundation in bibliometric techniques and their use in the assessment of scientific performance and influence.
- Introductory Workshops on Altmetrics and Societal Impact Indicators: Participation in seminars addressing the conceptual and methodological challenges of measuring non-academic impact, with particular attention to altmetrics and science-society interfaces.
- Scientific Writing and Communication: Attendance at academic writing and science communication training to develop high-quality outputs adapted to both scholarly and broader audiences.
- Open Science and Research Integrity: Engagement in training related to FAIR data management, open access policies, ethical research practices, and responsible use of metrics.
- Engagement with the Scientific Community: Attendance at national conferences, research seminars, and thematic events to present early insights, receive feedback, and build academic networks in the fields of science policy and research evaluation.

Year 2: Specialisation and Data Strategy

- Advanced Analytical Tools: Training in software and platforms relevant to the thesis, such as GraphPad (statistical analysis), NVivo (qualitative data coding), VOSviewer (network visualisation), and Tableau (data presentation).
- Seminars in Science Policy and Evaluation Cultures: Active participation in seminars and academic discussions focusing on national and international research evaluation models, funding criteria, and responsible research assessment frameworks.



- Stakeholder Mapping and Fieldwork Design: Preparation of protocols for interviews and surveys with relevant actors (researchers, policymakers, evaluators), focusing on their perspectives on societal impact and assessment practices.
- Thematic Conferences and Early Dissemination: Presentation of preliminary results in thematic sessions of national and international congresses to foster academic dialogue and refine the research framework.
- Initial Phase of International Mobility: Execution of the first research visit to an institution or research centre with strong activity in research impact analysis, public engagement, or knowledge transfer. The visit will contribute to the consolidation of conceptual and methodological components of the thesis.

Year 3: Development, Validation, and Internationalisation

- AI Applications in Research Evaluation: Training in artificial intelligence techniques applicable to impact assessment, including natural language processing, large language models, and tools for data automation and content analysis.
- Testing of the Multidimensional Framework: Implementation of the composite indicator on a selected sample of research outputs to explore its reliability, sensitivity, and potential for wider application.
- Second Mobility Period: Continuation of international collaboration through a research stay in a different institutional context, ideally with a focus on science-policy interfaces or alternative evaluation frameworks.
- Stakeholder Interviews and Qualitative Validation: Collection and analysis of qualitative data to assess the clarity, feasibility, and relevance of the proposed framework from a practitioner and policy perspective.
- Scientific Dissemination and Peer-Reviewed Outputs: Presentation of intermediate findings at conferences and submission of manuscripts to academic journals in the areas of scientometrics, research policy, and science-society relations.

Year 4: Consolidation, Dissemination, and Thesis Completion



- Finalisation of Prototype Tool: Development and refinement of a user-friendly dashboard or web-based application for societal impact evaluation, incorporating the validated composite indicator.
- Final Phase of International Mobility (if pending): Completion of any remaining mobility activities during the early stages of the year to finalise collaborations and consolidate the International Doctorate trajectory.
- Training in Public Speaking and Defence Preparation: Engagement in workshops to prepare for the oral defence of the thesis, including academic presentation skills and argumentation techniques.
- Final Thesis Writing and Submission: Intensive writing and revision of the doctoral dissertation, integrating all stages of the research process.
- Scientific Dissemination and Knowledge Transfer: Presentation of the final results in academic and institutional forums, with an emphasis on practical recommendations for integrating societal impact metrics into evaluation processes.



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