From Data to Insights: Research Centre Performance Assessment Model (PAM)

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Abstract: This paper presents the Performance Assessment Model (PAM), designed to refine assessment practices for the impact of scientific projects and make them easier to understand with the help of information visualisation tools (InfoVis). The model incorporates three main dimensions: input, output, and impact, to capture the breadth of scientific contributions. Using PAM, a holistic analysis of project results and impacts can be conducted, integrating qualitative and quantitative data. The project team tested the model on ten research projects, which allowed for its adaptation to different project types and ensured a comprehensive assessment of tangible and intangible impact. Data organised with PAM was transferred to Power BI, a software that allows for interactive visualisation and detailed data analysis. The model's adaptability and flexibility make it valuable for assessing how effectively scientific projects create positive, enduring impacts on society. The study results indicate that PAM provides a systematic approach to evaluating and enhancing the performance of scientific projects. It is particularly beneficial for research centre managers needing an effective tool to measure their projects' impacts. PAM also promotes transparency and accountability in the evaluation process. Ultimately, it can ensure scientific projects are carried out effectively and efficiently, maximising societal benefits.

1 INTRODUCTION

In recent decades, increased funding for scientific research from international and national bodies has aimed to promote innovation, knowledge transfer, and progress towards the United Nations' Sustainable Development Goals (SDGs). These initiatives provide financial support and encourage advanced training, research development, the creation of international collaboration networks, effective science communication, and robust links with the private sector (Saenen et al., 2019; Santos, 2022).

These efforts have established various research units, such as public-private collaborations, transdisciplinary centres, research networks, and science and technology centres (Science Europe, 2017). These units bring together researchers from different fields, enabling the development of scientific projects aimed at solving complex social problems. However, increased public funding for research projects presents challenges in science management, particularly rigorous evaluation, and accountability (Science Europe, 2021).

This highlights the importance of sustainable project management, which involves planning, monitoring, and controlling project delivery and support processes. It considers the environmental, economic, and social aspects of a project's life cycle of resources, processes, outputs, and outcomes. The goal is to benefit stakeholders transparent, fair, and ethically, including their proactive participation (Silvius and Schipper, 2020).

To address these challenges, the European Science Foundation (2011) has developed a good practice guide to improve the quality and integrity of the European evaluation process. Additionally, European national agencies are working to improve their systems and criteria for evaluating scientific

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projects. For example, in Portugal, the Foundation for Science and Technology I.P. (FCT, I.P.) conducts periodic evaluations of Research and Development (R&D) Units with the international evaluators, assessing scientific and technological activities, strategic objectives, activity plans, and future organization (FCT, 2023).

However, establishing and maintaining adequate procedures to assess research projects quality remains a challenge for public and private funding organisations at national and international levels (By et al., 2022). Each project is unique in scientific terms and follows different research methodologies, and it is challenging to establish clear and simple indicators considering the complexity and contextualization of research (Patrício et al., 2018; Santos, 2022; Steelman et al., 2021).

There has been a questioning of the tendency to evaluate research productivity based on "traditional" bibliometric indicators, such as the volume of publications and their citations (Scruggs et al., 2019). For example, metrics like, such as the SCImago Journal Ranking (SJR) and the Journal Impact Factor (JIF, Clarivate), weren't originally designed to evaluate research quality (Santos, 2022). Consequently, several studies argue for a qualitative approach to assessing research quality, emphasising the need for new evaluation approaches that offer a realistic and comprehensive view of research value (Patrício et al., 2018; Saenen, et al., 2019). These authors emphasize the need to develop new evaluation approaches that provide a realistic and comprehensive view of the value of research. As noted by Steelman et al. (2021), the results of scientific research go beyond academic work and should consider contributions to positive changes in economic, social, and/or environmental contexts. Socially relevant knowledge is not always related to scientific relevance or high production of publications.

Furthermore, some studies argue for considering temporal phases when assessing short, medium, and long-term research benefits (Trochim et al., 2008). The model proposed by these authors defines short-term markers to assess immediate activities and results, such as training, collaboration, transdisciplinary integration, and financial management. Intermediate markers denote progress in developing science, models, methods, recognition, publications, communications, and improved interventions. Long-term indicators include the impact of research on professionals, decision-makers, and society in general. This logic model is valuable because it allows for observing patterns of change in the research impact over time.

Many models proposed by the international scientific community aim to develop fairer and more impartial evaluation models, using quantitative and qualitative approaches to identify "success stories" in research (Patrício et al., 2018; Silvius et al., 2020). Among the proposed models there are approaches such as "input-process-output", "input-output-outcome-impact", "input-activities output-outcome-impact", or "input-output-impact", which emphasize measurements and weightings throughout the knowledge production process (European Commission, 2009; Frey & Widmer, 2009; Djenontin & Meadow, 2018). For example, Frey & Widmer (2009) propose evaluating a project by analysing its efficiency about the effectiveness of its performance. This model mainly distinguishes input, process, output, outcome, and impact (Figure 1).

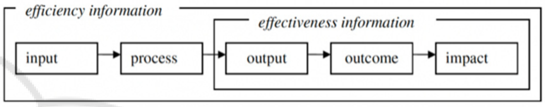

Figure 1: Project assessment model by Frey and Widmer (2009).

This model considers various aspects of the project, including the resources invested (input), the activities carried out (process), the deliverables produced (output), the changes or results achieved (outcome), and the broader effects or influence generated (impact). According to the authors, to truly assess effectiveness, it is necessary to consider the relationship between efficiency and effectiveness and evaluate the project's performance holistically, considering all the above-mentioned dimensions.

Most project study models are focused on biology and medicine, as depicted in the figure below.

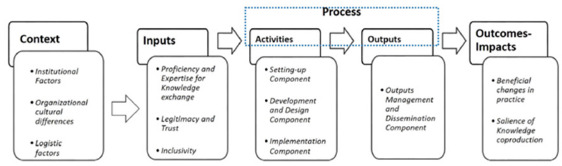

Figure 2: Factors involved in knowledge co-production activities by Djenontin and Meadow (2018).

The co-production of knowledge applies principles and processes that lead to developing the logical model of the Centres for Disease Control and Prevention (CDC, 2004). This model includes Context, Inputs, Process (Activities and Outputs), and Outcomes-Impacts, illustrates the placement and significance of each variable within a project management framework. This approach organizes and presents outcomes, enabling researchers and project managers involved in co-production work to evaluate each stage of their project cycle critically. This evaluation helps improve activity planning (Djenontin & Meadow, 2018).

Another model for evaluating scientific projects was developed in Portugal, validated in three polytechnic higher education institutions (Patrício et al., 2018).

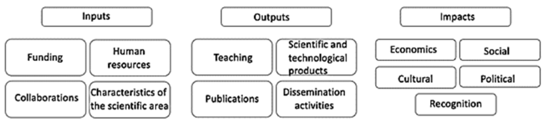

Figure 3: Applied research performance evaluation model by Patrício et al. (2018) (adapted by authors).

Figure 3 shows the model's three main dimensions:
i) Input - refers to the resources needed to implement interventions, measuring the quantity, quality, and timeliness of these resources, including policies, human resources, materials, and financial resources.
ii) Output - encompasses the most valued results, including scientific publications in articles, books, book chapters, and scientific communications.
iii) Impact - values a variety of indicators, considering different dimensions and values, as well as positive, desirable, unforeseen, direct, and indirect effects in the short, medium, and long term (Patrício et al., 2018).

It's crucial to apply these indicators flexibly, considering the research areas' peculiarities, the difficulties in measuring impacts, and the time needed to evaluate results, covering short-, medium-, and long-term goals (Patrício et al., 2018; Silvius et al. 2020).

Most of the models identified in this study are designed to address a particular issue, such as evaluating projects to allocate funding. The Project Assessment Model (CCA, 2012) is introduced as a conceptual framework that delineates the objective of the evaluative study. It assists research funders in determining the type of contributions they may provide to the financing process and the necessary information to establish key indicators – Inputs, Outputs and Impacts on Science, Socio-Economics Impacts – related to Contribution Pathway, Information Needs, Potential Indicators and Potential Data Sources.

Discovery research activities necessitate inputs, encompassing both current and retrospective measures. These measures are typically dependable and readily accessible and can be obtained at various levels of aggregation. The data utilised in these activities has been collected and developed over an extended period (Cvitanovic et al., 2016). Outputs research process's intricate, dynamic, and uncertain nature serves as a valuable source of intermediate data, showcasing the gradual progress and contributions made towards scientific advancements, as well as the anticipated long-term effects (Castellanos et al., 2013). Impacts the research process's intricate, dynamic, and uncertain nature to determine the extent to which the outcomes align with the stated objectives of the funding initiative. In contrast to inputs or outputs, impacts manifest themselves over several temporal dimensions, embodying the intricate, dynamic, and uncertain nature (Bautista et al., 2017).

As research becomes increasingly collaborative and interdisciplinary, developing new evaluation methods to capture the full impact and value of scientific contributions is crucial (Silvius et al., 2020). This includes traditional metrics such as citations and publications and considering factors such as data sharing, open science practices, and societal impact. By embracing these challenges, we can ensure that the evaluation of scientific research keeps pace with the evolving landscape of digital transformation.

2 METHOD

This study was conducted by the DigitalOBS team at the DigiMedia Research Centre at the University of Aveiro. Using the explanatory methodology, this study's objective was to better understand the results and impacts of activities within projects funded by international and national funds and define the research centre's development strategies. To achieve these goals, a model was developed to evaluate the productivity of a Research Centre. The PAM Model seamlessly incorporates data analysis and visualization tools, enabling researchers to quickly and easily present data through interactive reports and dashboards.

The methodology used in this study began with identifying relevant indicators for evaluating the outcomes of funded scientific research projects. Building on the insights of Frey and Widmer (2009), Patricio et al. (2018), Cvitanovic et al. (2016), and Djenontin and Meadow (2018) we recognized the significance of presenting a more concise model. The researchers organized all collected data following the "input-output-impact" model to simplify the evaluation process and minimize bureaucratic obstacles. This model enables the seamless integration of qualitative assessments and quantitative indicators. Moreover, it facilitates extracting pertinent information from existing project reports, effectively reducing administrative complexities. On the other hand, the more intricate "input-process-output-outcome-impact" models were found to be excessively convoluted. They posed challenges when retrieving information, particularly for projects that had already been concluded some time ago (Frey & Widmer, 2009).

Through the analysis of existing evaluation models, two models were identified as the most suitable for the intended evaluation: the scientific production model (Patrício et al., 2018) and the Results Logic Model (Trochim et al., 2008). Based on this analysis, three main dimensions of analysis were identified: input, output, and impact. Subcategories and indicators were proposed for each dimension based on the analysed models. These dimensions and indicators will be presented in detail in the following section.

The PAM model was then tested by evaluating ten projects with different types of funding (national and international). The test facilitated the customization of the model to suit the requirements of the Research Center by eliminating certain indicators that were deemed non-essential or challenging to gather. For instance, metrics such as the "Magnitude of sales/revenues/profits generated from goods or services", and "Operational expenditures" were revised due to the need for intricate data gathering.

However, considering the specific characteristics of the projects developed in the DigiMedia Research Center, there is a need to include several indicators, such as “New infrastructures”, in the input dimension. These indicators, specifically in the "scientific-technological products" sub-dimension, are crucial role in streamlining the data collection. They are paramount in helping researchers effectively catalogue and organize their data.

The developed model was subsequently applied to evaluate 10 funded projects conducted at the Research Center, allowing for minor adjustments, and validating the model. Currently, this model is being used to analyse the scientific activity of research projects, supported by the Power BI tool.

3 RESULTS

The developed PAM provides a comprehensive conceptual and analytical framework for presenting and evaluating scientific activities, project results, and their potential impacts on society. By identifying the key variables that need to be measured and integrating both qualitative and quantitative data typically obtained from scientific projects, this model allows for a more thorough understanding and interpretation of the collected data (Figure 4).

Figure 4: Performance Assessment Model (PAM).

Based on the analysis of existing models, three main dimensions of analysis were considered: input, output, and impact (Attachments 1: https://doi.org/10.5281/zenodo.10678914).

3.1 Input Dimension

The initial phase of this model involves a comprehensive analysis of project inputs, which encompass crucial elements required for the successful implementation of scientific projects. The Input dimension analyses the resources allocated to the project under scrutiny. It includes five main sub-areas: Funding, Human Resources, New Infrastructures, Collaborations, and Features of the Scientific Area (Figure 5).

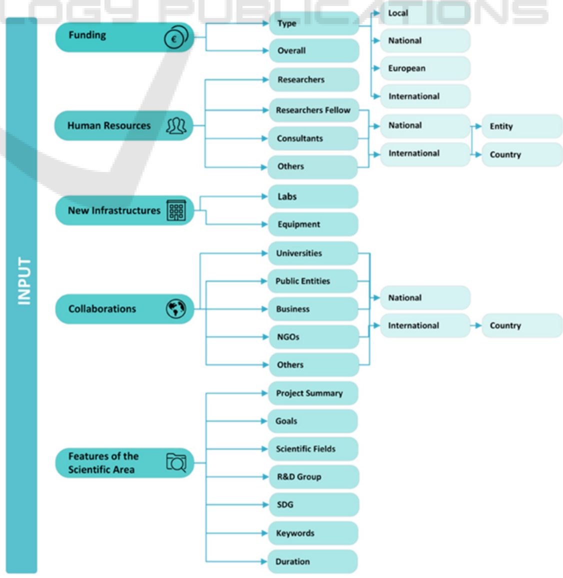

Figure 5: Input dimension of the PAM model.

The "Funding" sub-dimension analysis provides an overview of the main trends in securing project financial resources, allowing researchers to make

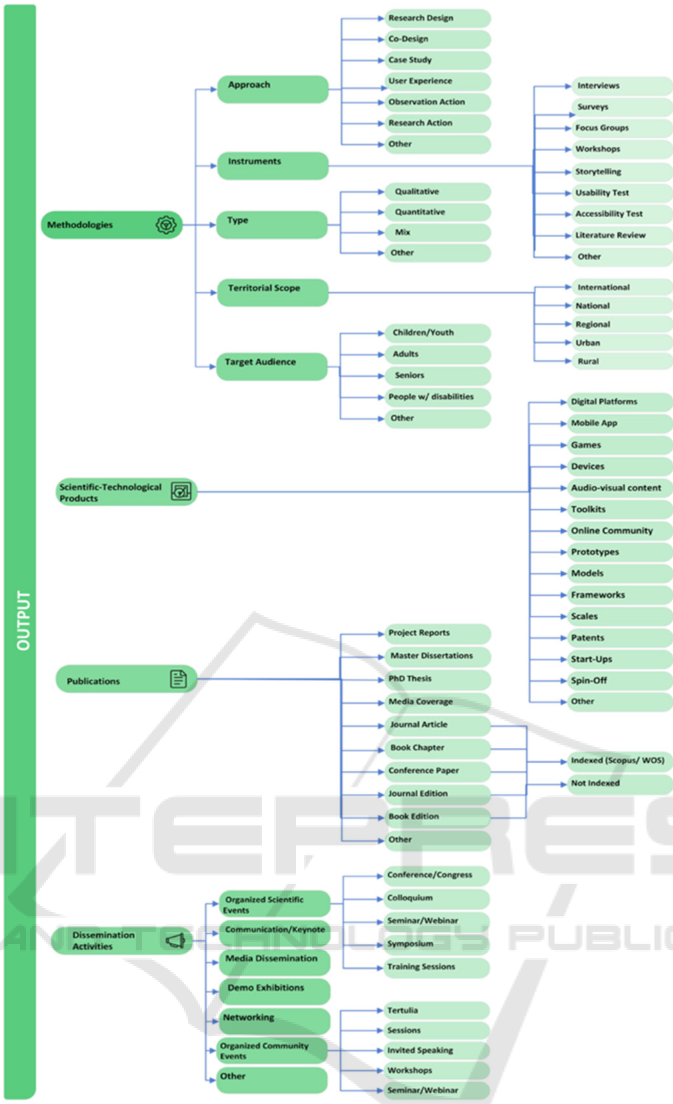

Figure 6: Output dimension of the PAM model.

informed decisions and devise strategies to optimize funding opportunities. Evaluating the human resources involved in scientific projects is also crucial.

The "New Infrastructures" sub-dimension involves a detailed analysis of various topics directly related to the implementation and management of both physical and technological infrastructures. This investigation gives Research Center managers insights into the benefits that these projects bring to the overall development and progress of this Center. The "Collaborations" sub-dimension enables understanding of the network of partners established within the project framework. This analysis helps identify key stakeholders, collaborations, and synergies between different organizations and research groups. It allows project managers and decision-makers to foster effective partnerships, leverage existing resources, and enhance the overall project impact.

This model also incorporates a "Features of the scientific area" sub-dimension, focusing on the qualitative analysis of the projects. It examines the objectives, keywords, and scientific areas of these projects. By analysing these features, organizations can better understand the projects' focus and scope, identify emerging trends, and research areas, and align their strategies and resources accordingly.

3.2 Output Dimension

The output dimension focuses on the direct results due to the actions taken, which are directly linked to the project's objective and can be achieved in the short or medium term (Figure 6). This dimension consists of four main sub-dimensions: methodologies, scientific and technological products, publications, and dissemination of activities.

The "methodologies" sub-dimension aims to understand the main trends in digital media research by mapping the methodological procedures used in the projects in detail. The indicators used to assess the methodologies include: the approach type; the specific instruments applied; the research type; the projects' territorial scope, and the target audience being studied. This comprehensive examination allows researchers to discover valuable insights and make informed observations about the evolving landscape of digital media research.

The "Scientific and technological product" sub-category encompasses the tangible outcomes of scientific research and technological innovation. These products are created by applying scientific knowledge and methods to foster innovation in various domains and address real-world challenges. The indicators established for this sub-dimension aim to facilitate comprehension of their complexity and purpose and the key trends in advancing these products within the context of scientific projects.

The "Publications" dimension encompasses a broad spectrum of outcomes that are highly valued and respected by numerous models and frameworks in the scientific community (Patricio et al., 2018). These publications range from articles, books, and book chapters to reports, PhD Theses, master dissertations, media coverage, and other grey literature such as brochures and information notes. Indicators for indexing articles in databases such as Scopus or Web of Science, given their importance to some funding organisations.

The "Dissemination" dimension evaluates how the knowledge or results of projects are shared, communicated, and accessible to stakeholders like researchers, policymakers, and the community. It is essential to understand that specific strategies and approaches to dissemination may differ based on the context, project goals, and the nature of the information being shared, influencing the choice of dissemination channels and the evaluation of the project impact and effectiveness.

3.3 Impact Dimension

The third dimension, "Impact," focuses on a project's long-term consequences. Defining a project's exclusive impact is challenging, as multiple projects' outcomes can contribute to the same impact. For instance, an impact could be observed within digital media through improved digital literacy among senior citizens or enhanced accessibility of mobile applications (Figure 7).

Whether economic, social, cultural, environmental, political impacts aim to understand the variability of applied research results. They represent the multifaceted results and effects that research can have on society. Measuring these impacts is crucial to understanding research contributions' real value and significance. Impacts aren't confined to tangible results but include intangible benefits and societal changes.

Economic impacts, for instance, extend beyond monetary gains and include benefits like developing new or improved products, processes, or services. Regarding social impacts, they incorporate aspects related to changing or altering social conditions or social practices and habits. Cultural impacts are reflected in the involvement and engagement of communities and changes in cultural practices and products. They can influence behavioural patterns and shape cultural norms.

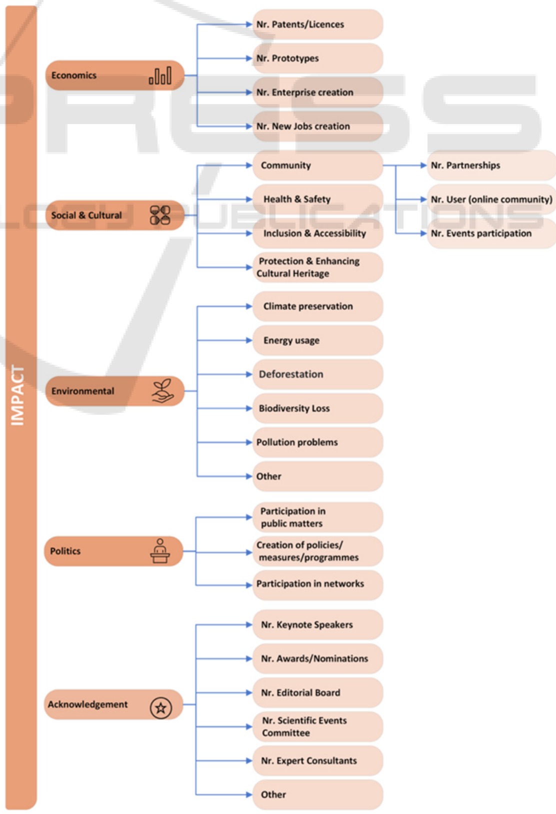

Figure 7: Impact dimension of the PAM model.

Political impacts deepen specific social impacts by bringing about alterations and changes at the level of political activities and public issues. These effects can lead to transformative changes that benefit individuals, communities, and society.

Environmental impacts can include promoting active citizenship, increased participation in public environmental activities, and community resilience and sustainability.

Recognition, a more measurable impact can be quantified through the number of invitations, awards, and other forms of acknowledgement. The aim is to assess the project impact as an integral part of the science-society relationship, showcasing the outcomes and effects of applied research.

The PAM model aims to help research centre understand the extensive impact of ongoing research activities. This facilitates effective communication not only with society at large but also with the scientific funders. The goal is to foster the creation of knowledge and diverse perspectives, providing decision-makers with the necessary insights to make well-informed choices for Research Centre's optimal progress and expansion.

3.4 Data Presentation Using Power BI

Project results data, collected using the PAM model, was transferred from an Excel file to Power BI software. Using this data, the team developed a Power BI report with the following sections: Projects, Human Resources, Collaborations, Scientific Area, Applied Methodologies, Products, Publications, and Dissemination Activities (Figure 8). Each of these sections was designed to provide precise insights into various aspects of the projects, facilitating the process of decision-making and strategizing (Silva et al., 2024).

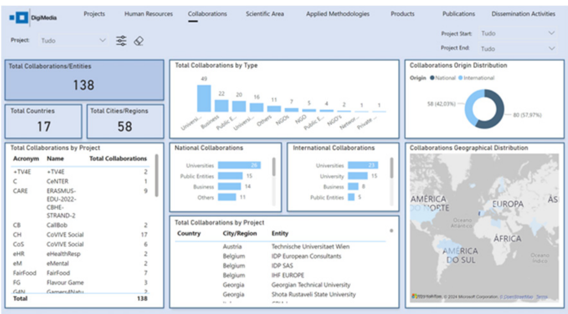

Figure 8: Data presentation using Power BI.

These reports and dashboards facilitate the effective communication of knowledge and conclusions. They present complex information in a simple, understandable way, making it easier for researchers to share their findings, communicate their insights, and influence decision-making. In conclusion, Power BI software revolutionises how researchers handle and present data, making the process more efficient, comprehensive, and communicative.

4 CONCLUSIONS

The Performance Assessment Model (PAM) provides a framework for comprehensively evaluating the results and impacts of funded scientific projects. It simplifies the evaluation process into three main dimensions: input, output, and impact, offering a structured approach to understanding the multifaceted nature of research endeavours.

One of the PAM model's key strengths is its ability to integrate qualitative and quantitative data, enriching the evaluation process. Indicators carefully selected within each dimension provide insight on critical aspects such as funding trends, human resources composition, research methodologies, scientific and technological products, and dissemination of research results. The model's successful application to research projects and its ongoing use in analysing scientific activities within our research center highlights its practicality and relevance in research management.

Adapting evaluation models to reflect the evolving research landscape, including integrating innovative InfoVis tools, is vital. Power BI software allows researchers to present project data visually, engagingly, and interactively. It enables the analysis of all project results and the creation of a project-specific dashboard. Researchers can create and share interactive reports and dashboards by utilising the PAM model and this software's features, simplifying analysis and knowledge communication. This streamlined approach not only saves time but also enhances data presentation.

However, this study faced limitations related to finding up-to-date models. Many of the models discovered required updates to align with current scientific advancements, mainly digital technologies. Additionally, most models identified were designed to assess project proposals for funding rather than the project outcomes and impacts.

Adapting the PAM model in different research areas could benefit greatly. With its clear structure and flexibility, this model can be easily customized to meet the specific needs of various fields, enabling research centres to gain a more profound understanding of their projects and increase their societal contributions.

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