Approaches to Monitoring and Impact Assessment in Research Infrastructures

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ABSTRACT

Impact assessment is a critical process in understanding the broader effects of research infrastructures (RI) on various sectors such as science, society, the economy, and policy-making. It helps RI identify their strengths, weaknesses, and areas for improvement. The paper addresses the challenges of monitoring and evaluating the impact of RI, focusing on the distinction between performance monitoring and impact assessment. It emphasizes the importance of demonstrating the broader societal, economic, and scientific impacts of RIs to inform public policy and secure funding. In the article we address different methodological approaches to impact assessment and self-evaluation of RIs as well as the possible challenges in these processes. The paper advances the integration of multiple evaluation approaches to provide a robust and detailed assessment of the contributions RIs make to society, the economy, and scientific development.

KEYWORDS

Impact assessment, monitoring, research infrastructures

1 INTRODUCTION

Research Infrastructures (RIs) are essential facilities that offer resources and services to research communities, enabling them to conduct research and drive innovation. Beyond their primary role in research, these infrastructures can also support education, public services, and other non-research activities. They may take various forms, including single site, distributed, or virtual setups. RIs encompass human resources, major equipment, and/or sets of instruments, as well as resources containing knowledge, such as collections, archives, and databases. They are used by scientists from various disciplines – e.g. astronomy, biology, chemistry, physics, human and social sciences, etc. RIs can maintain their competitive advantage only if they keep pace with the latest advancements in relevant scientific fields and the newest techniques and technologies. Therefore, it is crucial for RIs to connect with the research community and industry to stay aligned with developments in both science and technology. [1]

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In recent decades the significance of research infrastructures has become increasingly evident across all fields.

Although RIs are primarily designed to meet research needs, their influence extends well beyond promoting scientific excellence. The advanced technological capabilities and concentration of skilled expertise they provide can stimulate innovation, create or expand markets, attract foreign investment, boost economic activity, and potentially enrich the social and cultural life of a region. [2]

RIs necessitate relatively large and long-term financial investments, making it crucial for investors, policymakers, and other stakeholders to ensure that these infrastructures operate successfully and effectively, contributing to scientific advancement and addressing societal and economic challenges.

Although reflections and publications on defining and measuring impact have increased in recent years, there is still no unified framework or consensus on how to assess the impact of RIs. Therefore, it is crucial to explore the potential for developing such a framework and investigating its practical application.

2 PERFORMANCE MONITORING AND IMPACT ASSESSMENT

To this end, various solutions have been developed to enable stakeholders to monitor performance and evaluate the impact of RIs. However, there is a distinction between these two activities, which this paper aims to clarify. The concepts of performance monitoring and impact assessment represent two distinct yet related processes for evaluating the activities of institutions. Although both processes involve data collection and analysis of RI performance outcomes, their focus, scope, and objectives differ.

Performance monitoring, often simply referred to as "monitoring", involves the systematic and regular collection and analysis of data related to activities and outcomes. This process is crucial for assessing progress toward predefined goals, identifying areas where activities are achieving success, and pinpointing areas that require improvement. Typically, performance monitoring focuses on tracking key performance indicators (KPIs), which serve as measurable values that reflect the effectiveness and efficiency of the activities being evaluated (e.g. Number of publications, Number of master and PhD students using the RI, Outreach through media, ...).

Impact assessment, in contrast, focuses on identifying and evaluating the changes within the broader ecosystem that result from the activities and outcomes of RIs. This process aims to determine which specific RI activities lead to impacts across

various domains. A well-established approach, developed through European initiatives (such as the RI-PATHS [3] project), is the concept of "impact pathways". This method enables evaluators to trace the different routes through which activities translate into impacts at various socio-economic levels.

Impact assessments can be conducted either before or after the implementation of RI. When carried out during the planning phase, this process is known as an "ex-ante" impact assessment. Its purpose is to forecast the potential impacts of the RI, anticipate its effects, and inform strategic planning to ensure those outcomes are realized. This type of assessment is largely conceptual and, to some degree, abstract. Once the RI is established and fully operational, an "ex-post impact assessment" is conducted to evaluate whether the RI has successfully met its intended objectives.

When determining criteria and indicators for monitoring and evaluating (e.g., research infrastructures, measures, programs, policies), it is crucial to recognize the differing roles of these two processes. Monitoring focuses on real-time oversight of implementation: as a funder, one needs to know the current status, whether progress is on track, whether funds have been appropriately allocated, whether a sufficient number of target audiences has been engaged, etc. While monitoring can alert us that things are not proceeding as planned, it does not reveal the causes of deviations nor provide adequate information for making necessary corrective actions [4].

On the other hand, the role of evaluation is to explain how the institution/measure/program/policy functioned, how successful it was in achieving its objectives, and what its impacts were. Evaluation allows us to determine success, identify what worked and what did not, and, if not, what changes need to be made in future planning. The focus of evaluation may be on assessing the degree to which objectives are achieved, or it may focus on the process of implementing the instrument/program/policy itself.

Impact assessment is beneficial for RIs when used to evaluate and enhance their functioning. It plays a crucial role in the strategic planning of an RI by informing decisions on internal resource allocation and driving continuous improvement and alignment of services with the needs of users and other stakeholders. Additionally, impact assessment fosters accountability and transparency, thereby enhancing the legitimacy, visibility, and overall value of the RI. Furthermore, it serves as a platform for meaningful dialogue and exchange among relevant stakeholders regarding the objectives, direction, and operations of RIs, which can be exceptionally valuable. [5]

The OECD defines impact as "the extent to which an intervention has produced, or is expected to produce, positive or negative, intended or unintended effects at a higher level." [5] The European Commission mandates the implementation of impact assessments for every policy intervention or law (including investments in research infrastructure and their activities) expected to cause significant effects or require substantial financial resources. Impacts represent all "direct or indirect changes" relative to the baseline scenario. Such impacts may occur over different time periods, affect different stakeholders, and be relevant at different levels (local, regional, national, and EU) [6].

2.1 Defining Areas for Impact Assessment

Impact assessment becomes especially crucial in times of limited public funding for science. By highlighting the effects of RIs on science, society, the environment, the economy, and other sectors, impact assessments can demonstrate the value of both potential and actual investments in RIs. This analysis helps to underscore the relevance of these investments in addressing societal needs. Moreover, impact assessments provide policymakers with a clear picture of the broader benefits that RI activities offer, thereby supporting the development of informed public policies and decision-making.

Impact assessment is closely tied to the goals of RIs and the expectations they set. The ESFRI [1] working group on RI performance monitoring has identified nine objectives which are relevant to RIs [7], and largely correspond to the following five impact areas:

- **Contribution to Scientific Excellence**: At the heart of every RI is the drive for scientific excellence. RIs contribute in numerous ways, including data collection and preservation, providing access to infrastructure and databases, sample collection and dissemination, facilitating analytical experiments, offering software, and providing general support to researchers. These activities are fundamental to the research process, fostering scientific progress by advancing innovative research, expanding the frontiers of knowledge, and generating new insights and discoveries.
- **Addressing Societal Challenges**: In recent years, addressing societal challenges has become an increasingly important focus for RIs. Their impact ranges from contributing to the United Nations' Sustainable Development Goals and the European Green Deal to enhancing public understanding of science.
- **Contribution to Innovation and Economic Development**: Given the substantial financial investments required by RIs, it is crucial to highlight their role in driving innovation and economic growth. This can be reflected in job creation, economic development, or increased competitiveness, particularly at local, regional, and national levels. Large RIs, in particular, employ a significant workforce and, in some cases, make substantial investments in constructing and offering high-value-added components.
- **Contribution to Policy-Making**: Research facilitated by RIs can significantly inform policy-making across various thematic areas. This is especially important for organizations responsible for policy development at the European or national level.
- **Contribution to Human Resource Development**: Many RIs also focus on education and training, often dedicating significant resources to these efforts. As centers of scientific excellence, they play a crucial role in developing human resources and training the next generation of scientists. They impact their users and their careers through enhanced scientific excellence, productivity, networking, and training opportunities.

[1] European Strategy Forum on Research Infrastructures

Listed areas are not relevant only to RIs, but can be relevant also to other research organizations.

3 METHODS AND APPROACHES FOR MEASURING IMPACT

In the RI-PATHS project [3] a comprehensive review of literature was conducted on methodologies for evaluating and measuring the socio-economic impacts of RIs. The project focused on ex-post impact evaluation methodologies, which are employed during the operation of RIs when it is possible to ascertain whether they are creating certain impacts and in what manner. The effectiveness of the analysis is demonstrated quantitatively (e.g., through indicators) or qualitatively (e.g., through case studies). [8]

Six main approaches/methods for measuring impact based on the literature review were identified:

1. Socio-economic assessment based on impact multipliers: This approach evaluates the socio-economic impact of a policy or project by quantifying the effects on various economic sectors. The assessment is based on impact multipliers that estimate the indirect effects of the policy or project on the economy. This approach expresses impacts on aggregated macroeconomic variables such as GDP, gross value added, or employment. The main advantage of this methodology, which is grounded in a well-established theory and uses input/output analysis tools, is its reliability in producing reproducible and comparable project results. However, its limitation is its restricted validity, as it often cannot reliably measure non-monetary effects (e.g., cultural, social, and environmental).

2. Methodologies utilizing the knowledge production function: This approach focuses on the impact of research and development activities on the economy. The knowledge production function method quantifies the relationship between research and development investments and economic growth. The approach focuses on only a small portion of the expected socio-economic impacts of RIs.

3. Cost-benefit analysis (CBA): This approach compares the advantages and disadvantages of a policy or project and determines whether the benefits outweigh the costs. The analysis considers both quantitative and qualitative factors to enable well-informed decision-making. All costs or benefits are monetized, even if the effects are not solely financial. Governments and economists frequently use this approach to assess the impact of various investment projects. It is reliable for comparing positive and negative effects and can capture numerous RI impacts. However, it can be expensive and time-consuming and has limited causal explanatory power. Additionally, it may not always capture all drawbacks.

4. Multi-methods multiple partial indicators: This approach combines multiple methods and indicators to evaluate the impact of policies or projects. Methods can include surveys, focus groups, and statistical analysis, while indicators encompass economic, social, and environmental factors. An example of this approach is the OECD framework for socio-economic impacts, which includes a list of 25 essential impact indicators and 58 additional standard indicators.

5. Theory-based approaches: These approaches rely on established economic or social theories to evaluate the impact of a policy or project. They depend on theoretical models and empirical evidence to predict impact. A typical example is the "logical framework/model", which is based on a logical sequence of steps from inputs to impacts. Theory-based approaches share common features such as considering the broader context and external factors that can affect success and defining "impact pathways". The impact pathway approach was further developed in the RI-PATHS project, which explores more details than the logical framework and provides a descriptive vision with more information on causes and effects.

6. Case studies: This approach involves an in-depth analysis of a specific case to understand the effectiveness of a policy or project. The analysis focuses on the specific context, identifying factors contributing to success or failure and deriving lessons that can be applied to future policies and projects. When used in impact evaluations, case studies aim to better reflect the uniqueness and complexity of RIs.

It is evident that some approaches are more suitable for assessing economic rather than social or scientific impact, and vice versa. In general, these approaches can complement each other—some are more quantitative, such as macroeconomic modelling or cost-benefit analysis (CBA), while others are more qualitative, like case study descriptions.

The RI-PATHS project systematically evaluated each of the mentioned approaches using criteria such as reliability, validity, precision, cost and time efficiency, and relevance to both policymakers and research infrastructure managers. It is evident that no single methodological approach can comprehensively address all the questions intended for impact evaluation. However, combining different approaches can offer greater value and effectiveness compared to relying on existing methods alone.

4 IMPACT PATHWAYS AND INDICATORS

While there is not a universally accepted approach to impact assessments in RIs, the work of the RI PATHS project has, as mentioned, become well established in Europe. Indeed, results from the survey conducted by ESFRI among RIs [7] show that impact pathways have become a common method for impact assessments among European RIs. Several RIs have conducted their impact assessments with the help of impact pathways as part of the RI-PATHS pilot exercises (for example, ALBA, ELIXIR, EATRIS) [9]. Identifying impact pathways was also an integral component of the impact assessment of ICOS [10].

The mechanism of impact pathways is recommended as a way to demonstrate causal links between inputs, various activities and outputs of RIs, and their identifiable impacts [3] [11]. These can be both intended or unintended – while impact pathways always have a clear origin in one or few related activities, which are under control of RIs, these activities branch out into different directions and trigger effects in different areas, which can be outside the sphere of influence of RIs. An example of exploring impact pathways according to spheres of control, influence, and interest can be seen in AnaEE's position paper [12], which sought to build a framework that would specify AnaEE's position in the chain of actors generating impact in its scientific field.

In order to map the path from activities of RIs to outcomes and impacts, it is crucial to systematically collect data. This is recommended for both performance monitoring and impact assessment. Several lists of indicators have been proposed in recent years (OECD, RI PATHS, ESFRI WG). The indicators can vary – from those that primarily measure performance, also known as key performance indicators (KPIs) [5], and those which are focused on impact (e.g. OECD prepared a list of impact indicators) [13]. The purpose of impact indicators is to create a link to strategic objectives of RI, as well as to different areas of impact that RIs create. In addition to the connection of indicators with strategic goals, the OECD recommends that the

indicators provide information related to operational issues and that the data is measured in a specific time frame.

Impact indicators can be quantitative or qualitative, e.g. in form of "narratives". This information is usually collected via tailored methods, such as interviews, surveys, or case studies. These indicators are more difficult to be standardised and must be tailored for specific RIs and depend on the context. These methods can help RIs to report on intangible impacts.

5 INTERNAL AND EXTERNAL IMPACT EVALUATION

Both external and internal evaluations are relevant for assessing the impact of RIs, each with its advantages and disadvantages. External evaluations are conducted by independent evaluators who assess the institution's impact. This approach ensures an objective and impartial assessment, as external evaluators are not affiliated with the evaluated institution and are, therefore, less likely to be influenced by internal biases or personal interests. Additionally, external evaluations can provide new perspectives and insights that are not available to internal evaluators. However, external evaluations are often costly and time-consuming and may sometimes fail to account for the contextual nuances and priorities of the evaluated institution.

In contrast, internal impact evaluations rely on an evaluation process conducted by the institution's staff or stakeholders. This approach is more cost-effective and efficient, as internal evaluators are already familiar with the institution and its operations. Internal evaluations may also better consider the institution's contexts and priorities and be more adaptable to changes in RI goals. However, internal evaluations may be biased due to internal motivations and conflicts of interest and may lack the objectivity and independence of external evaluations. Moreover, internal evaluators may be limited by their knowledge and expertise, reducing their ability to bring new insights and perspectives.

The choice between external and internal evaluation often depends on internal capabilities, available resources, evaluation objectives, and so on. To ensure a comprehensive and balanced assessment, it is beneficial to combine both approaches. It is also increasingly common for institutions (including RIs) to periodically self-evaluate, thereby preparing for external evaluation.

6 CHALLENGES AND OBSTACLES

There are several challenges that RIs encounter while conducting impact assessments. Some of them were outlined by respondents to an ESFRI survey among RIs (2023). According to the survey, a recurring challenge was to identify an appropriate method or framework or finding appropriate indicators. Other respondents mentioned the amount of resources required and the time frame needed to properly evaluate the impacts of their infrastructure. In general, some RIs are concerned that impacts may not be properly detected. This is a similar issue to what was described in the ERIC forum's "Report on Socio-economic impact framework" [14] as a "traceability" problem – there is uncertainty about how to link RI activities or data generated within an RI to their subsequent use. One of the RIs responded that measuring innovation or social impacts could take several decades.

It is important to note that some challenges may be specific (or more common) to a certain type of RI or to certain thematic areas they cover. To address this challenge, the recommendation is to avoid directly comparing impacts of RIs, and to consider the diversity of RIs. When deciding on a methodology, it is advisable to tailor the selected methodology to each RI, and first establish a consensus between RIs, funders, governments and other relevant stakeholders. This agreement should establish clear expectations regarding the objectives of the RI and the assessment itself. However, all RIs should strive to demonstrate impact in the field of scientific progress, while considering various other socio-economic impacts.

Providing adequate resources for the implementation of an impact assessment is indeed challenging, in particular as it is necessary to adopt a long-term plan for evaluation in order to capture impacts that take years to reveal. At the same time the data collection needs to be done systematically and begin early enough, which can be more resource intensive although also helps to lower the amount of "ad-hoc" data collection when conducting impact assessments.

In spite of these challenges, impact assessments provide important information for all RI stakeholders, as well as the general public, as they allow RIs to demonstrate their contributions to science, society and the economy, and help improve their performance. As such, they can be used as means to communicate about RI activities. Promoting and disseminating the results of these evaluations can subsequently help promote positive RI development and funding.

7 CONCLUSIONS

Despite the growing focus on this area, there remain significant challenges in developing a unified and comprehensive framework for evaluating such impacts, particularly when accounting for both economic and non-economic factors. There is a reason for that – the unified methodology cannot adequately address all aspects of variety of RIs and the diversity of fields where they operate. There is a number of methods which can be applied, and future work could explore how combinations of different methods (e.g. quantitative, such as macroeconomic modeling and cost-benefit analyses and qualitative such as case studies or theory-based assessments) can be effectively balanced. This could provide more holistic view on RI impacts, especially in understanding intangible impacts like societal and environmental changes.

There are already lists of indicators suggested to be used for impact assessment, nevertheless the selection of indicators should be done with a great deal of prudence and not to be used to compare RIs, given the diversity in their structure and objectives.

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