Innovation Caucus

The Economic Returns to Public Investment in Social Science Research: Semi-structured Literature Review

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Research note

This research forms part of the wider work conducted by Innovation Caucus in partnership with Innovate UK (IUK) and the Economic and Social Research Council (ESRC). If you have any questions in regard to this report please contact info@innovationcaucus.

Acknowledgements

This research was commissioned by ESRC. We are very grateful to the project sponsors at ESRC for their input into this research. The interpretations and opinions within this report are those of the authors and may not reflect the policy positions of ESRC.

About the Innovation Caucus

The Innovation Caucus supports sustainable innovation-led growth by promoting engagement between the social sciences and the innovation ecosystem. Our members are leading academics from across the social science community, who are engaged in different aspects of innovation research. We connect the social sciences, IUK and ESRC, by providing research insights to inform policy and practice. Professor Tim Vorley is the Academic Lead.
The initiative is funded and co-developed by the ESRC and IUK, part of UK Research and Innovation (UKRI). The support of the funders is acknowledged. The views expressed in this piece are those of the authors and do not necessarily represent those of the funders.

Cite as: Rowell, A., Graves, A., Ortega-Argiles, R. and De Silva, M. 2023, *The economic returns to public investment in social science research: Semi-structured Literature Review*. Oxford, UK: Innovation Caucus.

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Executive Summary

Based on a semi-structured literature review, this report presents key insights that discuss the economic return on investment in social sciences research. The review illustrates the methodologies and frameworks for assessing social sciences research's economic impacts and the indicators and metrics most used in proxying its economic value (however defined).

Economic benefits from social science research can be measured at different levels of aggregation: individual social scientists, academic departments or research teams, research institutions, social science disciplines and subdisciplines and the totality of social science research. It has also been argued in the literature that to be useful, these indicators should be easy to measure or easy to collect, user-friendly, reliable and meaningful.

Due to the multipurpose roles of social sciences, its return on investment is captured with a broad set of indicators. The indicators to measure economic value can be summarised based on three types of key social science roles: research, teaching and spinouts.

- **Indicators of economic return on social science research investment** – Value of additional grants/income generated as a result of funded-research; Number and value of new collaborative projects with industrial partners secured as a result of funded-research; Number and value of IP – such as copyrights - generated; Number of citation of funded social science research in IP such as patents; Number and value of patents of which social science researchers are co-owners; Number and value of contracts with public/policy services for consulting/production of reports stemming from funded research; Number of businesses supported by social science research; Turnover of data packages sold; Volume of experimental / observational data produced/used in support of public policies; Number of citations of publication from funded research in policy or other non-academic outlets; Estimated income or savings from new processes based on funded research; Number of innovations co-developed with industry as a result of funded research

- **Indicators of economic return on social science teaching investment** - The number and wages of workers who have a social science degree and are employment in occupations and sectors in which it is plausible to argue that their work involves research mediation; Number of training and seminar sessions conducted to industry and the price paid by industry; Number of students (PhD, master) supported by the private sector; Satisfaction of students towards the training courses.

- **Indicators of economic return on social spinout investment** – Sates, growth rates, and mortality rates of social science spinoff companies; Ratio of spinoff impacts to funding and tax impacts (returns to Government) of spin-offs emerging from social

sciences; Value of funding received from industry to spin-off companies; Number of joint-ventures with industry; Number of suppliers benefited from the spinout; Number of new collaborations formed the spin-out.

The existing literature articulates different methodological frameworks and approaches to generate some form of estimate of the economic value of social science investment. Among the most used ones are the following:

- **Survey-based approaches –** with the use of random firm samples, these approaches approximate what proportion of the firm's performance could not have been developed without social-science research investment.
- Survey-data approaches are often used as an input to **econometric approaches –** this approach explores the economic impact of public-funded research at different aggregation levels and with a variety of controls. Among them is input-output modelling (leading to Return-on-Investment calculations) or Cost-Benefit Analysis that could be employed to deliver estimates of the return on investment from social science and particular impacts or investments.
- **Case study approaches –** Although they may not offer a precise quantification of the returns on public investment due to their descriptive nature, case studies provide crucial insights into the contextual process of evaluating a social sciences programme or project.
- **Bibliometric approaches -** identifying "knowledge" (citations, patents, research collaborations) as a common measure of the direct "impact on science"; bibliometric approaches can be useful in social sciences research programme evaluations.

There has been criticism from experts regarding the current assessment frameworks and methods. They have been found to need more consideration of the potential indirect impacts that social science investment may have, as well as its potential moderating role. Furthermore, these frameworks have been criticized for not taking into account the heterogeneity and endogeneity within the social science value transfer mechanisms.

What is clear from our analysis is that there is no one-size-fits-all option for identifying the methodological framework or the perfect indicator for measuring the economic value of social science investments. The choice of framework, methodological approach, and indicator will depend on the objectives and background of the impact assessment.

Therefore, there is a gap in our knowledge of the economic return of the specific types of social science investment made by ESRC. There is thus an avenue for future research - by building on this initial review of the literature and gathering data from those who are funded by ESRC on the nature of economic value generated - to better understand how to economic return on investment in social science.

Introduction

The Innovation Caucus is working with ESRC to investigate existing evidence related to the economic return on investment arising from social sciences research.

ESRC is seeking to understand the approaches, metrics, and frameworks used to capture social science research's economic return on investment. This project will review the existing literature to understand what current available approaches may be suitable. It has also identified where the gaps are and what research is needed. This review has considered both the academic literature and metrics used by practitioners.

The key aim of the study is, therefore, to:

- Understand the methodologies, metrics and frameworks that exist to capture the economic return of investment in social science research.

To deliver this aim, the project has:

- Conducted a literature review of relevant published and grey literature.
- Followed a collaborative approach, drawing in the expertise and insight of academic colleagues; and
- Captured not only existing knowledge on approaches, frameworks, and methods but also quantitative evidence that has been produced to demonstrate the return on investment of social science research.

The following section of this paper describes the approach followed. The paper then presents a review of a number of papers which consider the benefits of publicly funded research, and the challenges of measuring them, before describing examples of attempts to measure the economic benefits of research and innovation.

Methodology

The methodology is based on a semi-structured literature review and assimilation of evidence which relates to the core subject matter. The literature search strategy consisted of two elements:

1. Keyword-based database search to identify relevant academic research and grey literature[1]; and
2. Snowballing (forward and backwards) from key resources.

Therefore, the first stage is to develop a list of key words that will drive the search for relevant literature. These are provided in Appendix 1, page 22.

The identified literature was reviewed in detail, and key results were collated into the Excel template. This draft report presents the key findings from the review. The prime focus was on literature which delivered some form of **quantitative estimation regarding the economic value** (however defined) of social science research or related investments.

[1] Note that the focus here has been to identify new insights from grey literature which builds on that presented in the UKRI review of approaches to measuring economic impact (based on the notion that this report should focus on adding value to existing knowledge, rather than restating that knowledge).

However, it also captured literature regarding the development of **approaches and frameworks** that are proposed as tools to deliver such quantitative estimates. While literature that provided estimates is seen as potentially providing ESRC with benchmarks and estimates that could be employed in their work to ascribe economic value to its investments, literature that proposes approaches and/or frameworks is seen as potentially valuable in highlighting approaches that might be adopted in the future.

Following an initial review of the identified literature, the sources were divided into two categories:

- Literature which **reviews** and/or **develops methods and frameworks** for assessing the economic value of social science research investment.
- Literature which **employs methods or frameworks** to generate some form of estimate.

The subsequent sections of this report summarise the literature within each of these two categories.

Appendix 2 contains a table which summarises the main methodologies covered by the literature review. This provides a range of information regarding each approach, including a list of the studies which utilise the approach and then further detail on the following from at least one such study:

- Main methodological approach
- Nature of the evidence gathered
- Variables developed
- Methods employed
- Pros
- Cons

Approaches to assessing the economic returns to public investment in social science research

The literature includes a number of papers which present 'critical reviews' of the wider literature related to the economic benefits of publicly-funded research. For example, Salter & Martin (2001) and Martin & Tang (2006) review a number of approaches to identifying and measuring such benefits, which they describe as including surveys, case studies and econometrics. Our review suggests that surveys are often used to inform econometric analysis. At the same time, case studies also often involve econometrics to assess the benefits of specific research projects rather than an investment at the programme level or other strategic levels.

Survey-based approaches to demonstrating impact

An example of a survey-based approach to estimating the economic impact arising from academic research is demonstrated in Mansfield (1991). He used a random sample of 76 US firms in seven industries, in order to obtain estimates from company R&D managers about what proportion of the firm's products and processes over a 10-year period could not have been developed without the academic research. The survey also collected data on sales in 1985 in relation to the developed products and services. By accounting for the proportion of sales that could be attributed to these new products/processes, the research calculated a rate of return on academic research of 28%. Survey analysis was complemented with econometrics (regressions) in order to test the statistical significance of the results and any differences between the seven industries studied, as well as to investigate time lags in the between academic research and industrial innovation. This approach therefore demonstrates how survey data often are used as an input to econometrics in this area of research (as commented on below).

Case study approaches to demonstrating impact

Smith (1998) notes that if a case study approach is to be effective, care must be taken to ensure the selected case studies are representative of the programme of research. Large-scale case study collection is resource intensive but can be used to demonstrate research impact, as in the case of a language analysis of the 7,000 case studies collected by the Higher Education Funding Council for England for the 2014 Research Excellence Framework (Noorden, 2015). This descriptive analysis made no attempt to quantify the returns to public investment in research and innovation programmes, however. Similarly, Donovan (2007) describes a qualitative, contextual process to evaluate the extra-academic impact of publicly funded research in the Australian Research Quality Framework. This process promises to combine impact statements, case studies, appropriate quantitative[2] data and qualitative evidence, and stakeholder testimony; and impact evaluations made by panels of peers and end-users.

Bibliometric approaches to demonstrating impact

The literature describes conceptual and practical challenges in measuring the impacts of research and innovation. Attempts to measure the benefits of research have tended to identify the direct output from research as 'knowledge' (Martin & Tang, 2006). Counting the number of citations is a common measure of the direct 'impact on science' (Godin & Doré, 2005); similarly, our review identified studies in which patent citations were used to measure the impact of R&D (Acs et al, 2002; Bacchiocchi & Montobbio, 2009). While bibliometric indicators (such as number of citations) can be useful in research programme evaluation, they are limited in their applicability to inter-disciplinary comparisons of impacts, and, therefore to future investment planning. Problems identified with using bibliometric indicators to measure research impacts include technical problems with the database used, variations in the citation rate over the "life" of a paper, the treatment of critical and refutational citations, variations in the citation rate between different types of paper, and biases introduced by "self-citation" and "in-house" citations (Office of Technology Assessment, 1986).

Econometric approaches to demonstrating impact

Salter & Martin (2001) note that as well as the scientific information shared in academic papers as a direct output of research, tacit knowledge (embedded in individuals, and often built up over time) is a further benefit of research, with indirect economic impacts. They argue that the relationship between research, technological change and economic growth tends to be

[2] The precise indicators to be used in the new Australian RQF were yet to be determined at the time that the article was published. However, prior quantitative indicators of research quality have included: research income, volume of higher degree completions, publication and citation counts, whilst extra-academic indicators have included number of patents, amounts of funding from industry and number of spin off companies.

over-simplified in the types of econometric models[3] used in research which explores the economic impact of publicly-funded research, and that such approaches also employ simplistic or unrealistic assumptions. Similarly, Wolfe & Salter (1997) argue that econometric approaches often fail to account for the heterogeneity of what they call 'the innovation process'. Godin & Doré (2005) also suggest that identifying the specific transfer mechanisms by which research translates into impacts is a challenge.

Martin & Tang (2006) argue that the linear relationship between investment, research, knowledge/technology transfer, innovation and socio-economic benefits that are represented by many econometric models is insufficient. They propose more circular models in which the different stages of the process feedback on each other. However, they do not offer operationalised versions of their conceptual models for practical use. Their proposed models are designed to recognise that there are **several channels through which the benefits of research flow, each with economic impacts**, including:

- increased knowledge;
- supply of skilled graduates and researchers;
- creation of new scientific instrumentation and methodologies;
- development of networks and stimulation of social interaction;
- enhancement of problem-solving capacity;
- creation of new firms; and
- provision of social knowledge.

The literature is clear that the benefits from public investment in research can take a **variety of forms**. But the impacts of social science research on economic welfare are often subtle, heterogeneous, largely indirect, and diffused in space and time, and are therefore difficult to measure or estimate (Smith, 1998; Salter & Martin, 2001; Godin & Doré, 2005). The benefits accruing from research can be sector-specific, or joint effects (Smith, 1998). Research on spillovers from university research show localised economic impacts (Salter & Martin, 2001), while impacts that cross regional or national boundaries may not be captured (Smith, 1998).

Benefits from social science research can be measured at **different levels of aggregation**. At a minimum, assessments can be carried out for individual social scientists, academic departments or research teams, research institutions, social science disciplines and subdisciplines (economics, sociology, anthropology, etc.), and the totality of social science research (Jaffe, 1989; Smith, 1998). Benefits might also be measured at project level, or aggregated by type of investment programme (e.g. climate change and sustainability, Digital Footprints; improving health, wellbeing and social care, etc.)

Martin & Tang (2006) note that quantitative studies tend to focus on the more easily measurable channels through which the benefits of research accrue. A limited range of indicators is available to measure the full range of benefits (Godin & Doré, 2005), and it is easier to assess scientific impact than economic impact (Bornmann, 2013). Martin & Tang

[3] This finding follows on from work by Griliches (1995) which suggests that it is difficult to find reliable indicators of technological change and there is the econometric problem of drawing inferences from non-experimental data, and also Nelson (1982, 1998), who indicated that the models he studied did not explain the link between publicly funded basic research and economic performance in a direct way.

(2006) warn that a narrow focus on those impacts that can be easily quantified, while others are ignored, risks distorting science policy.

Frameworks for assessing impact

There is no 'one-size-fits-all' solution, no 'blueprint' or 'easy-to-follow' manual for assessing impacts (Hajdinjak & Havas, 2019; Kah & Akenroye, 2020). In a literature review of frameworks adopted to measure social, economic and environmental impacts, Kah & Akenroye (2020) identified a range of approaches but noted there was little evidence of their integration into practice. Hajdinjak & Havas (2019) propose an impact assessment framework for research infrastructures in which ex-ante evaluation, monitoring and the assessment of socio-economic impacts are closely interlinked. The authors identify two preconditions for a useful assessment exercise. First, the intervention logic of a given research infrastructure – why investment is needed, what impact can be expected and through what mechanisms – needs to be clarified as part of an ex-ante evaluation.

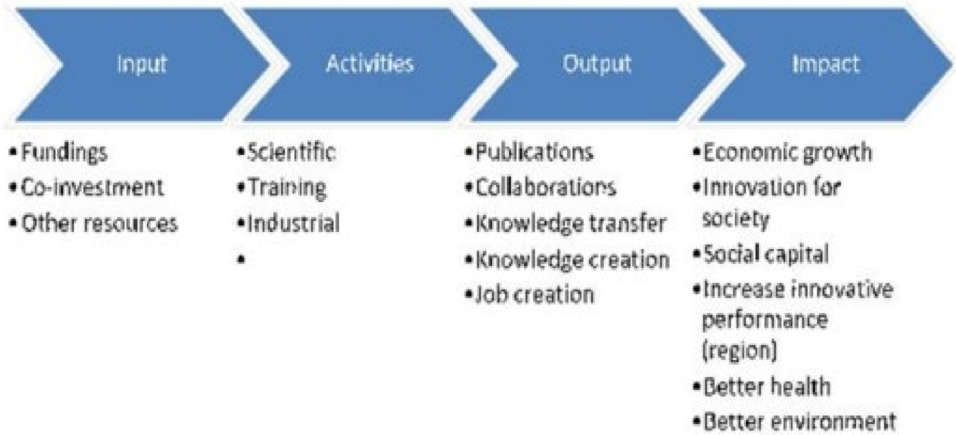
There is no single method or set of indicators that would be automatically appropriate for every research infrastructure; each needs to be understood first, and then assessed in its own context. Certain types of impacts are more relevant for some research infrastructures, and less for others. Each research infrastructure must select the appropriate impacts, assessment methods and indicators based on its own specific goals, while also taking into consideration the strategic visions and heterogeneous objectives of its stakeholders. Moreover, the socio-economic impact of different research infrastructures should not be compared, because each research infrastructure is unique. An assessment should, therefore, compare impacts only against the specific objectives of the given research infrastructure. Second, an appropriate system should be in place not only for the purpose of monitoring and evaluation, but also to systematically collect relevant data for socio-economic impact assessment. Often, it can be difficult to gather data about impacts, and to verify these data.

The authors suggest that the timing of an impact assessment is crucial. In many cases, impacts can be observed only after several years, and are not always imminent even when the first scientific results and outcomes of a research infrastructure have already been achieved. A research infrastructure's socio-economic impacts can be direct and indirect, intended and unintended, expected and unexpected, positive and negative. Socio-economic impacts are also heavily influenced by a large variety of external factors, and hence a research infrastructure can never be considered fully responsible either for the positive or the negative impacts of its work. Indicators, which are used to establish that a certain impact has occurred, are rarely able to provide a comprehensive explanation as to why the impact happened. Some impacts may be produced by the indirect use of a research infrastructure, making it even more difficult to assess them (Hajdinjak & Havas, 2019).

Similarly, the Organisation for Economic Cooperation and Development (OECD, 2019) proposes what it calls a 'reference framework' for assessing the scientific and socio-economic impacts of research infrastructures. It is intended to be a generic and versatile tool, based on community practices, which can be adapted for different types of research infrastructure and different stages in their life cycles.

The OECD argues that to assess the impacts of research infrastructures, indicators should be defined that can be used as proxies for various types of impact. To be useful, these indicators should be easy to measure or easy to collect, user-friendly, reliable and meaningful. The framework proposes a total of 58 indicators, including 26 core indicators (categorised by seven common strategic objectives) which the OECD believes can provide a general picture of impact at a given time and that can be used by most research infrastructures whatever their type and discipline. The indicators were identified through a literature review and a survey of research infrastructures, and align to the logic model shown in Figure 1.

Figure 1: OECD impact assessment framework: logic model



Source: OECD, 2019

The indicators are described in Appendix 2. The OECD notes that the proposed economic impact indicators are practical and selected from among commonly recognised indicators (induced turnover, innovation, start-ups, direct and indirect employment, etc.). Social/societal impact indicators are more difficult to design and to interpret, and require more in-depth validation or coupling with narratives.

The OECD acknowledges that its proposed indicators are not necessarily perfect proxies for the impacts to be analysed. For example, patent numbers only partially reflect technological impact, and a better indicator might be the actual use of licences. Similarly, the number of spin-off companies generated is not a great indicator of economic impact (many new companies will fail) and better indicators could be imagined that measure turnover. The proposed indicators are those which are already in use by many research infrastructures, for which data are often collected or available, and which are recognised as useful by many of the stakeholders surveyed. The intention is to identify indicators that can be effectively used to measure impacts (OECD, 2019).

Examples of measuring the economic benefits of research.

The literature review identified a range of **econometric approaches** to assessing the economic returns to research and innovation, which are summarised below. The investments in research and innovation whose return the authors seek to assess vary in nature and scale, as well as in geographic location.

Early attempts to measure the economic benefits of research and innovation tended to use **cost-benefit analyses** to measure the return on investment, while more recent work has tended to focus on productivity impacts and spillover effects (Godin & Doré, 2005). Some studies focus on private rates of return, i.e., the return on investments in research that flow from an individual research project to the organisation directly involved. Others examine the social rates of return to research, i.e., the benefits which accrue to the whole society (Salter & Martin, 2001). Our review has focused on studies which attempt to measure the benefits of research to society with a greater focus on economic impacts. While some authors focus on economic impacts, others take a broader view of social benefits.

The literature includes few specific attempts to measure the rates of return to publicly funded research and development; the impacts of university research, for example, tend to be considered in the round. Nevertheless, the limited evidence gathered to date indicates that publicly funded basic research does have a large positive rate of economic return, although this is perhaps smaller than the rate of return on private R&D, which is commonly estimated to range from 20% to 50% (Wolfe & Salter, 1997; Salter & Martin, 2001).

UK studies

Miller et al (2023) assessed the economic impact of the University of Cambridge. This is one of a number of studies that assess the impact of individual institutions. This uses an impact evaluation methodology based on an input-output model, leading to a cost-benefit analysis. The team behind the research mapped the range of economic impacts derived from the knowledge-exchange activity of the University and that are experienced within the UK. The activities explicitly covered by the study include:

- Spinout and start-up companies (key indicators include how many spinouts and startups, and levels of turnover drawn from primary research with the firms or secondary sources such as university data or Companies House records)
- Contract research provided by the University (the key indicator being contract value)
- Consultancy services provided by the University (the key indicator being contract value)
- The business and community courses provided by the University (the key indicator being contract value)
- Facilities and equipment hire, and related activities (the key indicator being contract value)
- Licensing of University IP to other organisations (the key indicator being contract value).

The methodology also follows HM Treasury Green Book guidance in converting the estimated gross direct effects into net additional effects (that include indirect and induced effects and take account of factors such as leakage and displacement. The research team developed a multi-regional input-output model for the UK in order to derive Type II multipliers, which in turn supported the estimation of total effects (direct, plus indirect, plus induced)

The authors found that the total economic impact on the UK economy associated with the University of Cambridge in 2020-21 corresponds to a cost-to-benefit ratio of 1:11.7. They estimated that the direct benefits accruing from the university's research activities total £339 million of added value. Applying a multiplier of 12.7 from the literature (Haskel & Wallis, 2010), the authors estimated that every £1 million invested in research at the University of Cambridge in 2020-21 resulted in an additional economic output of £6.35 million across the

UK economy. The paper reports that UK Research Councils provided 27% of the university's research income. The heterogeneity of research and its impacts mean that the economic benefits accruing from the university's research cannot be apportioned to UK Research Councils on the same basis, though we note that this is the approach adopted by Martin (1998) to apportion the value-added accruing from R&D in Canada to university research. Unfortunately, this study does not present estimates for the return on investment across different research disciplines and funders.

Guerrero et al. (2015) assessed the total economic impact of UK universities' teaching, research and entrepreneurial activities in the period 2005–2007. They focused on Russell Group institutions as a proxy for 'entrepreneurial universities', with all other UK universities forming a control group. **Structural equation modelling** (SEM – a form of econometric modelling) was used to assess GVA impacts, conservatively assuming a 2-year lag. SEM was chosen because it allows the examination of a set of relationships between one or more independent or dependent variables, either continuous or discrete. The study draws on data for a number of variables, as follows:

- Dependent variable: GVA per capita.
- Independent variables: Employment rate of HEI leavers, research collaborations (number), research contracts (value), consultancy contracts (value), facilities (contract value), intellectual property (income values), spin offs (number and value, with and without HEI ownership, staff and graduates).
- Control variables: University expenditure, GVA per capita.

Their results show a positive and significant economic impact of university teaching, research, and entrepreneurial activities. As explained by entrepreneurial spinoffs, Russell Group universities have a higher economic impact than others. The highest economic impact of non-Russell Group institutions was associated with knowledge transfer (measured across the number of research collaborations, number and value of research contracts, value of consultancy contracts, contract value associated with facilities, and income from intellectual property).

Cambridge Econometrics (2012) used **an input-output model** to estimate the economic impact on the UK economy of UK-based academic social science research. In practice, the study took the following steps:

- Drawing a boundary around the subject areas that were deemed to count as 'social science research' (SSR).
- Drawing together information about different types of funding to estimate the overall scale of funding of SSR.
- Using supplier-purchaser relationships that are measured in input-output tables to determine the scale of the associated value added that is captured in the UK (rather than leaking out to imports), and the sectors that are most affected.
- Distinguishing the wage bill within the associated value added and uses the relationship between household incomes and spending to estimate Keynesian multiplier effects (which flow to the producers of consumer products and their suppliers).

The final two steps determine the economic multipliers to be applied in the analysis in order to estimate the 'total' impact of SSR.

The key methodological challenge faced, and addressed, by this study revolves around determining and approach to measuring benefits of the SSR to its users. The study states that it is important to recognise that in the case of the social sciences, the most important outputs tend not to be embodied in products or codified knowledge that can readily be used or accessed by those with no training in the relevant discipline. Instead, the benefits of research activity must be applied or 'mediated' by experienced researchers, whether employed directly by the final user of the research or by specialist consultancies and think tanks. The impact estimation methodology therefore centres on the development of estimates of what the users of research mediation activities currently pay for the outputs of those activities (which could not be sustained in the long term in the absence of UK-based academic SSR). The analysis then calls on labour market data to estimate the number and wages of workers who have a social science degree and are employed in sectors and occupations most likely to involve research mediation. Turnover data related to consultancies most likely to be involved in research mediation services is then used to estimate bought-in consultancy inputs. Data on employment by profession within central government has also been included, which supports a much narrower and more focused definition of the occupations that are likely to be involved in research mediation, but the data is not available to extend this definition more widely.

The study presented the following logic model for identifying economic impacts on the UK arising from UK-based SSR.

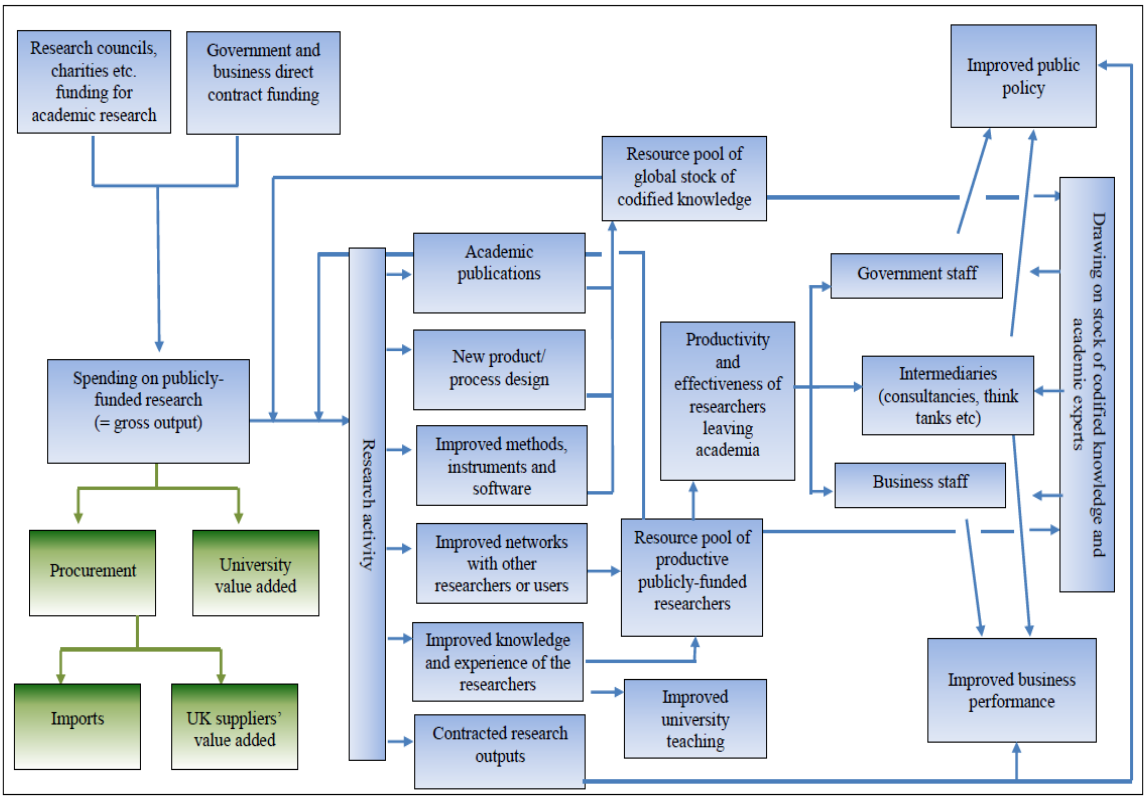


Figure 2: SSR Impact Logic Model

Source: Cambridge Econometrics, 2012

The study found that the £3.35 billion spent in 2010/11 by university social science departments generated direct impacts of £2.7 billion of value added within the departments themselves, a further £0.5 billion of indirect value added in other (supplying) sectors, with induced impacts of £1.6 billion, giving a total of £4.8 billion of value added. This equates to a cost-to-benefit ratio of around 1:1.43.

Non-UK studies: Static approaches

Pfister et al. (2021) studied the effect of the establishment of **Universities of Applied Science (UASs)** in Switzerland and the supply shock in applied research that it generated on regional innovation activities by using a **difference-in-differences (DiD) approach** to compare treated regions (with newly established UASs) to untreated regions (with no UASs). The study used patent data to measure innovation effects, with the location of applicants and inventors determining the geographic origin of inventions. Recognising that a simple analysis of patent quantity could be misleading, it is noted that estimating the effect of the establishment of UASs on **patent quality** requires further measures. The researchers test whether the grant rate has been affected as well, making use of information on forward citations, number of claims and size of the international patent family to assess patent quality. The results show that the establishment of UASs led to an increase of up to 6.8% in regional patenting activity. To estimate the effect on innovation quality, the research team used a set of proven correlates of patent value (claims, citations, family size) and found positive and statistically significant effects on patent quality as well. The results strongly suggest that the increase in innovation quantity is indeed a causal effect of the establishment of UASs.

Ecchia et al (2021) undertook an **ex-ante socioeconomic impact assessment** for a social science research infrastructure, called EuroCohort. This is an accelerated cohort survey including a sample of newborn babies as well as a sample of school-age children that will provide, over the next 34 years, a longitudinal study of the well-being of children and young people across Europe. The study was based on a **cost-benefit analysis**, basing its approach on Florio and Sirtori's (2016) framework for the assessment of the net socio-economic impact of an applied research facility. The authors identify four potential benefits:

- Use value and efficiency gains for researchers.
- Knowledge output.
- Human capital accumulation.
- Benefits provided to end-users (policy makers, children and young people).

Using data on the salaries of EU researchers and PhD students alongside estimates of the time spent working with EuroCohort data, the authors arrive at an annual use time value of €108k. By estimating the efficiencies made by using EuroCohort instead of administrative data, the study suggests an annual efficiency gain generated by EuroCohort of €54k. The marginal production cost of academic papers is estimated at €9k, with 60 papers per year attributed to EuroCohort as additional research that would not have been possible without the survey. The net benefit of these papers is valued at €540k. Applying the average number of citations for social sciences papers (4.67), and an estimate of the time taken to evaluate and cite a paper (1 hour), the authors value the influence of these 60 papers on the scientific community at close to €8k per year.

The paper estimates that performing research and acquiring skills by using EuroCohort will lead to a salary premium of 2.5% more than the normal return to education. Taking account of the number of PhD students who will use EuroCohort, the authors estimate that the total value of human capital accumulation generated by EuroCohort will be €400k per year. A time lag of six years between the beginning of EuroCohort's fieldwork and the time when its benefits will start to materialise is assumed. The authors note that many of their assumptions about the value of human capital accumulation are based on studies assessing the impact of capital-intensive, physical research infrastructures. They suggest further research is needed to quantify the human capital accumulation benefits generated by a social science research infrastructure such as EuroCohort.

EuroCohort costs are estimated over its lifetime, from implementation and operation to termination (including the cost of archiving the resulting dataset). Total costs are estimated to be between €710m and €954m. The study does not attempt to measure a benefit-to-cost ratio, but concludes that improvements in the effectiveness of European countries' expenditure related to children and young people's well-being (due to the availability of EuroCohort) of a measure of around 1 over 15,000 would be sufficient for the benefits of such a survey to outweigh its costs.

Florio et al. (2016b) undertook an **ex-ante evaluation to forecast the socio-economic impact** of the Large Hadron Collider (LHC) to 2025. Their cost-benefit analysis measured the benefits accruing from the knowledge output of scientists (publications, including technical reports, preprints, working papers, articles in scientific journals and research monographs); human capital formation; technological spillovers; and direct cultural effects for the public. Welfare effects for taxpayers were also estimated by the contingent valuation of the willingness to pay for pure public good. A Monte Carlo approach was used to estimate the conditional probability distribution of costs and benefits for the LHC from 1993 until its planned decommissioning. The authors conservatively estimated a 90% probability that benefits exceed costs, with an expected net value of about €2.9 billion, not considering the unpredictable applications of scientific discovery.

Battistoni et al. (2016) undertook a cost-benefit analysis of an applied research infrastructure, the National Hadrontherapy Centre for Cancer Treatment (CNAO) located in Pavia, Italy. The paper aimed to test Florio and Sirtori's (2016) framework for the assessment of the **net socio-economic impact of an applied research facility**. A benefit to cost ratio of 4.4 was determined[4].

Empirical testing shows that the composition of benefits of an applied RI is heavily affected by the category of benefits relating to the services provided by the infrastructure to its users. Sources of benefits are mainly health treatments to patients, for whom gains in terms of longer or better lives are guaranteed as compared to a counterfactual situation where they are treated with conventional therapies, or they have no alternatives. Such benefits are the direct consequences of the application to end users of the knowledge developed through research activities in CNAO and are quantified and assessed on the basis of conventional cost-benefit analysis approaches for health benefits.

[4] Note that this paper focuses on research investment in the field of health but is included because it provides some useful insight into the methods employed and lessons learned.

Additional benefits generated by CNAO are typical of research infrastructures in different scientific domains and refer to **technological spillovers** (namely the creation of spin-offs, technological transfer to companies in the supply chain and to other similar facilities), **knowledge creation** (production of scientific outputs), **human capital formation** (training of doctoral students, technicians and professionals in the field of hadrontherapy) and **cultural outreach** (students, researchers and wider public visiting the facilities). The positive results of the study are mainly explained by the fact that the assumptions made for the estimation of applied research benefits on patients are underpinned by a strong and well-accepted scientific case about the effectiveness of hadrontherapy for tumour treatment. At the same time, the test of the methodological framework proved to be challenging due to the issue of data intensity of the analytical tool and, even more, for the specificities of the research activities carried out in CNAO and the resulting knowledge spillovers. The authors suggested further research is needed to refine the framework, particularly with regard to its ability to reflect the nature and magnitude of knowledge creation and technological transfer benefits.

Vincett (2010) undertook an **econometric analysis** of the cumulative, direct, GDP impacts of **academic spinoff companies** formed in Canada in the period1960–1998, focusing on the non-medical natural sciences and engineering. The author ignored indirect economic effects and social impacts, noting that the results of the analysis are, therefore conservative. Vincett found that the GDP impact of spinoffs was 3.3 times the size of Canadian government funding of research in non-medical natural sciences and engineering, with tax returns from the spinoff companies in the region of $1.30 to $1.55 for every $1 of research funding (depending on the benchmark year).

Falk (2006) surveyed some 1,200 firms in Austria in 2004 to assess the impacts of **public support** for industrial innovation by comparing answers to the hypothetical survey question, “What would you have done if public support was denied?” with changes that actually occurred when public support was refused. The effects of policy interventions prove to be cumulative in a dual sense. On the one hand, the **survey** results confirm that large firms make the best use of public funds. On the other hand, substantial changes in the way a company undertakes R&D and innovation-related activities appear to only result from multiple policy interventions of different kinds. While supported firms tend to immediately increase their resources devoted to innovation projects, additionality is only achieved once a threshold level of intervention has been reached.

Anselin et al (1997) used a detailed data set on innovation counts and employment in R&D in 1982 to assess local geographic spillovers between **university research** and **high-technology innovations** in the United States using **spatial econometrics techniques**. Their conceptual framework is based on the knowledge production function, which relates an output measure for ‘knowledge’ to two input measures: research and development performed by industry, and research performed by universities. Their analysis confirmed a positive and significant relationship between university research and innovative activity, both directly, as well as indirectly through its impact on private sector R&D. It found that the spillovers of university research on innovation extended over a range of 50 miles from the innovating area, but not with respect to private R&D. It also confirmed earlier findings on the direction of causality between university and private research, the former being endogenous to the latter, but not vice versa.

Mansfield (1991) assessed the impacts of academic research in the United States on industrial innovation, focusing on new products and processes commercialized in the period 1975–1985 that (according to his sample of firms' R&D executives) could not have been developed without substantial delay in the absence of academic research carried out within 15 years of the first introduction of the innovation. He used an **econometric approach** to undertake a series of regressions in order to measure the social return on investment in academic research. Additional details regarding the methodology are provided in section 3, above. The study found that 11% of new products and 9% of new processes could not have been developed without a substantial delay in the absence of the academic research, accounting for 3% and 1% of sales, respectively. Mansfield estimated the rate of return from academic research to be 28%.

Jaffe (1989) undertook an **econometric analysis** of the relationship between **university research spending** in the United States, industry R&D and patent awards, while attempting to account for the co-location of university and industry research facilities. The methodology is based on the following key steps:

- Examine the production of patents assigned to corporations by state over time. Patents (by technical area) were measured through the US Patents Office.
- Relate patent production this to industry R&D and university research using econometrics. Central to this is the application of a Cobb-Douglas model to undertake regression analysis. The value of industry R&D (by University department) was based on data from the National Science Foundation (NSF), via its R&D Census.
- The author then interprets an influence of university research on these patents at the state level (after controlling for industry R&D) as evidence of the existence of geographically mediated spillovers.
- The hypothesis that university research induces the location of industry R&D spending nearby is then also tested.

Jaffe's analysis provides evidence of the importance of geographically mediated commercial spillovers from university research. There is only weak evidence that spillovers are facilitated by geographic coincidence of universities and research labs, though this effect comes through more clearly within specific sectors than it does in total, suggesting that the spillovers are limited and not just the diffuse effect of large research universities. The indirect impacts of university research are also important. After controlling for population and economic activity, there is an association between industry R&D and university research, and (while noting difficulties in establishing causality) Jaffe suggests that university research causes industry R&D and not the other way around. Thus, a location that improves its university research system will increase local innovation both by attracting industrial R&D and augmenting its productivity. Jaffe's results do not relate directly to the question of the social rate of return to university research because they underestimate that return, to the extent that spillovers flow beyond local areas.

Non-UK studies: Dynamic approaches

Monte & Scatteia (2017) used an **input-output model**[5] **developed** to assess the impacts of the European space launch sector (over the period 2000 and 2012). The GDP and employment impacts of European Space Agency (ESA) spending were assessed. The enabled revenues associated with ESA programmes were also assessed, represented by sales within industries and services enabled by launches during the study period, including downstream satellite industries and non-space industries and services that leverage satellite services and capabilities. The study also included an assessment of qualitative impacts, including non-quantifiable but significant, effects on technology development, workforce skills, outreach, strategic capabilities, and national prestige, drawing on primary research with academics and industry, plus desk research. A **scenario analysis** was also undertaken, aimed at understanding what would have been the space launch market evolution in the absence of the Ariane 5 programme, and what would have been Europe's position in such a case. Finally, the paper includes a case study assessing the GDP impact of ESA space launch activities on French Guiana's local economy (where the ESA's launch facilities are located). The study found that each €1spent on the Ariane-5 launcher programmes by ESA produced a total of €3.2 of value added in the economy. Each job supported by the space launch programme within Europe supports 1 additional job in the rest of the economy, an employment multiplier of 2.

Lehtonen & Okkonen (2016) used the **regional input-output model** of North Karelia, Finland, to analyse the socio-economic impacts of a bioenergy-based local development strategy. Income and employment impacts of the investment in a large-scale biochar factory and its associated industries and annual impacts of the new production were produced for the period 1994 to 2016. The results indicate significant socio-economic benefits, with approximately 12 million euros in annual income impacts and 280 personnel working years in the local district.

Martin (1998) assessed the economic impact of Canadian university research and innovation. He rejects a **static input-output approach** (which is based upon simulations through an input–output model or a crude regional multiplier) in favour of a **dynamic approach** which corresponds to the share of university research in the real increase in GDP imputable to the generation of knowledge. The author argues that "not only do universities have a static economic impact like other economic agents, but through their graduates and the research of their star professors, they also have a dynamic impact upon the size and sources of a country's GDP".

The measurement of the dynamic impact of university R&D is based upon aggregate data to estimate total factor productivity (TFP). The methodology adopts a linear research model of innovation presented in Bernstein (1996) and calls upon OECD estimations to calculate TFP (which the study estimates to be $73 billion in 1993). The modelling then proceeds to allocate TFP to its contributors; domestic R&D, foreign R&D and foreign trade.

Martin attributes 7% of the increase in Canadian GDP between 1971 and 1993 ($50 billion) to R&D in Canada and 31% of this ($15.5 billion) to university R&D.

[5] The underlying model was the Cambridge Econometrics E3ME dynamic input-output model. The technical manual is available here: https://www.e3me.com/wp-content/uploads/sites/3/2019/09/E3ME-Technical-Manual-v6.1-onlineSML.pdf

Conclusions

There is a wide body of evidence that demonstrates the socio-economic benefits accruing from investment in research and innovation. However, little of this research focuses specifically on the return to public investment.

The literature broadly falls into two categories, as follows:

- Literature that reviews and/or proposes methods and frameworks for estimating the return arising from public investment in research
- Literature that presents some estimation of the scale of return (defined in a wide range of ways) arising from such investment.

Research that presents estimates of the economic value of the public investment in research and innovation falls into the latter category. Still, the evidence is relatively sparse, and the number of readily employable 'benchmarks' or estimates that can be employed within the context of ESRC investment is limited.

The following key points can be derived from the first category of the literature, which focuses on reviewing or proposing methods and frameworks for the assessment of the return on investment:

- Econometrics, surveys and case studies are seen to be important mechanisms through which evidence of the scale of benefit can be derived. Surveys are often used to inform econometric analysis. At the same time, case studies also often involve econometrics to assess the benefits of specific research projects rather than investment at the programme level or other strategic levels.
- Selection of case studies must be undertaken with care if this approach is to be effective.
- Identifying metrics and indicators through which to measure the outputs from social-science research is challenging. An example is counting citations, though these are limited in their applicability when comparing impacts across disciplines.
- Some researchers argue that one limitation of econometric approaches is that they tend to over-simplify the nature of the relationship between research, technological change and economic growth. The heterogeneity of the innovation and research process can therefore be overlooked.
- Martin & Tang (2006) proposed a more circular model, where research leads to the following potential outcomes:
    - increased knowledge;
    - supply of skilled graduates and researchers;
    - creation of new scientific instrumentation and methodologies;
    - development of networks and stimulation of social interaction;
    - enhancement of problem-solving capacity;
    - creation of new firms;
    - provision of social knowledge.
- The impacts of social science research on economic welfare are often subtle, heterogeneous, largely indirect, and diffused in space and time, and are, therefore difficult to measure and capture.

- Benefits from social science research can be measured at different levels of aggregation; individual social scientists, academic departments or research teams, research institutions, social science disciplines and subdisciplines and the totality of social science research.
- Quantitative studies tend to focus on the more easily measurable channels through which the benefits of research accrue. A limited range of indicators is available to measure the full range of benefits, and it is seen as easier to assess scientific impact than societal impact.
- The Organisation for Economic Cooperation and Development (OECD, 2019) proposes what it calls a 'reference framework' for assessing the scientific and socio-economic impacts of research infrastructures, intended to be a generic and versatile tool. The OECD argues that to assess the impacts of research infrastructures, indicators should be defined that can be used as proxies for various types of impact. To be useful, these indicators should be easy to measure or easy to collect, user-friendly, reliable and meaningful. The framework proposes a total of 58 indicators, including 26 core indicators (categorised by seven common strategic objectives) which the OECD believes can provide a general picture of impact at a given time and that can be used by most research infrastructures whatever their type and discipline.

The literature provides several estimates of the return on investment arising from public investment in research and innovation. The following represent those which are most immediately applicable to the work of ESRC:

- Publicly funded basic research has a large positive return rate, although this is perhaps smaller than the rate of return on private R&D, which is commonly estimated to range from 20% to 50% (Wolfe & Salter, 1997; Salter & Martin, 2001).
- UK-based academic social science research has been shown to deliver a cost-benefit ratio of 1:1.43 (Cambridge Econometrics, 2012).
- Every £1 million invested in research at the University of Cambridge results in an additional economic output of £6.35 million across the UK economy (Miller et al., 2023). UK Research Councils provided 27% of the university's research income.
- Mansfield (1991) found that 11% of new products and 9% of new processes could not have been developed without a substantial delay in the absence of academic research, accounting for 3% and 1% of sales, respectively. Mansfield estimated the rate of return from academic research to be 28%.
- Vincett (2010) found that the GDP impact of university spinoffs was 3.3 times the size of Canadian government funding of research in non-medical natural sciences and engineering. Tax returns from the spinoff companies were estimated to be in the region of $1.30 to $1.55 for every $1 of research funding (depending on the benchmark year).

A study in Switzerland (Pfister et al., 2021) showed that investment in the University of Applied Science led to an increase of up to 6.8% in regional patenting activity.

Florio et al. (2016b) undertook an ex-ante evaluation to forecast the socio-economic impact of the Large Hadron Collider (LHC) to 2025, which estimated a 90% probability that benefits exceed costs, with an expected net value of about €2.9 billion.

Battistoni et al. (2016) undertook a cost-benefit analysis of an applied research infrastructure (albeit in health), which estimated a benefit-to-cost ratio of 4.4.

The existing literature, therefore, articulates a range of methods and frameworks by which techniques such as Input-Output modelling (leading to Return on Investment calculations or Cost-Benefit Analysis) could be employed to deliver estimates of the return on investment from social science, as well as some useful benchmarks and quantifications arising from other papers which focus on particular impacts or particular investments.

This study concludes with a high-level review of five main methodologies, identifying examples of their application and specific characteristics of individual applications of each methodology. The methods which lead to quantification of economic value tend to rely on a dynamic Input-Output approach to generate the required economic multipliers, or an econometric method designed to estimate certain outputs or impacts arising from publicly funded research and innovation support (or, in some cases, both – they are not mutually exclusive).

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Appendix. Boolean search key words

The keywords identified to drive Boolean searches were as follows:

- “social science” AND “research” AND “economic impact” AND assessment OR measurement OR indicators OR evaluation
- “social science” AND “public research” AND “return on investment”
- “social science” AND “research” AND spin-outs OR accelerator OR incubator OR revenue OR product OR process OR market OR cost OR saving OR business model OR funding OR consultancy
- “social science” AND “research” AND economic prosperity OR turnover OR economic return OR productivity OR performance
- “social science” AND “research” AND wellbeing OR socio-economic cohesion OR culture OR social challenges OR grand challenges OR knowledge production OR skill development
- “social” AND “impact” AND “monetise.”

Appendix 2. Methods summary

Main methodological approach	Evidence gathered	Variables developed	Methods employed	Pros	Cons
Literature review E.g. Salter and Martin 2001 See also: Martin & Tang 2006	Reviews existing studies	No quantitative measures of economic impact	Literature review	Provides a review of other studies rather than providing models for economic impact assessment or undertaking an economic impact assessment	No quantitative assessment
		Delivers a classification of the types of benefits arising from publicly funded research		Helps map the range of benefits arising from publicly-funded research (i.e. to inform new studies)	
				Useful feed-in to any quantitative study	
Survey-based (as an input to econometric modelling) E.g. Falk 2006 E.g. Mansfield 1991	Explores additionality through a survey of 1200 Austrian Firms to understand anticipated behaviour in the absence of publicly-funded innovation support	No quantitative measures of economic impact	Survey	Provides insight regarding additionality of publicly-funded innovation support, which firms benefit most and what actions are taken when support is denied/unavailable	No quantitative assessment
		Provides an assessment of the additionality of publicly-funded innovation support			
	Uses a survey as an input to an econometric modelling of the social return on investment from academic research	Proportion of new products and processes that could have been developed (without substantial delay) in the absence of recent academic research	Survey of R&D managers (sample = 76)	Demonstrates a survey-based technique for capturing data to input to an econometric model	Whilst it quantifies the rate of return, it does not provide a monetary value
		Proportion of new products and processes that were developed with very substantial aid from recent academic research	Econometric modelling		Covers all academic research (is not limited to social sciences)

Main methodological approach	Evidence gathered	Variables developed	Methods employed	Pros	Cons
		Estimated sales of new products based on recent academic research and estimated savings from new processes based on recent academic research			
		Average time lag between recent academic research finding and the first commercial introduction of a new product or process based on this finding			
		Social return on investment from academic research (%)			
Econometric Models E.g. Vincett 2010 See also: Jaffe 1989 Pfister 2021 – (Difference-in-Difference) Anselin 1997 (Spatial econometrics) Guerrero 2015 (Structural Equation Modelling)	Estimation of the impact of academic research on spinoff companies (within the physics discipline)	Government funding for natural sciences (excluding medicine and health, but including life science and engineering)		Can measure the scale or intensity of the relationship between research and impacts	Over-simplify relationship between research, technological change and economic impact (often assumed to be too linear)
		Sales in spinoff companies		Arguably most effective when deployed on more easily measured (and more linear) channels through which benefits accrue	May fail to account for heterogeneity of the innovation process
		Growth rates in spinoff companies			A narrow focus on easily measured impacts may distort policy (applies to all attempts to measure economic impact)
		Mortality rates in spinoff companies			Analysis relies on numerous assumptions

Main methodological approach	Evidence gathered	Variables developed	Methods employed	Pros	Cons
		Mortality rates in spinoff companies			
		Present value of impacts			
		Present value of funding			
		Ratio of spinoff impacts to funding			
		Tax impacts (returns to Government)			
Case studies E.g. Donovan 2007	Evidence of the use of quantitative indicators to evaluate the academic quality and extra-academic impact of publicly funded research.	None	Case studies in the UK and Australia	Can be used to demonstrate (qualitative) research impact	Does not support quantification of impact
					Large volume required to be representative
					Dealing with sample bias is a challenge
					Resource intensive
Input-output models (dynamic) E.g. Cambridge Econometrics 2012 See also: Miller 2023 Martin 1998 (static/dynamic)	Estimates of the economic impact arising from spending on academic Social Science Research (SSR) in the UK	Economic value arising from spending in UK SSR university departments	Desk research (data points)	Provides an estimate that is directly relevant to the line of enquiry	Economic impacts of universities extend well beyond the types that can be accounted for in this analysis
		Estimates of spending on research-mediation (as a measure of the benefits of social science research)	Dynamic Input-Out put modelling	Demonstrates a method upon which a wider impact assessment could be based	The greater the refinement in estimating different impacts, the greater reliance on granular, disaggregated data – and this quickly erodes

Main methodological approach	Evidence gathered	Variables developed	Methods employed	Pros	Cons
Monte & Scatteia 2017 Ecchia 2021 Florio 2016 – Monte Carlo approach Lehtonen & Okkonen 2016		Type I and Type II Multipliers (via dynamic I-O model)		Wide range of models available to investigate different types of impact	
		HEI Expenditure on social science departments			
		Number of workers (and associated wages) in the UK with social science degree (working in research mediation sectors)			
		Turnover estimates for consultancies working in research mediation			
		Central government employment (and associated wages) in relevant occupations			

Appendix 3. OECD Reference Framework for Assessing the Scientific and Socio-Economic Impact of Research Infrastructures

Table 1: Core Indicators

Standard Objectives	Core Impact Indicators	Data
Be a national or world scientific leading RI and an enabling facility to support science	S2-Number of citations	Total number of citations received by publications. May include: authors from the RI or using the RI
	S3-Number of publications in high-impact factor journals	Number of publications from RI users published within Q1 journals
	S4-Number of projects granted	Number of projects funded by external grants (may be divided into user or discipline categories)

Standard Objectives	Core Impact Indicators	Data
	S6-Number of scientific users	Number of users, Discipline distribution, Top scientific users, Nationality distribution
	S9-Collaboration excellence (scientific)	Total number of applications for using the RI Total number of applications from world leading teams
	S10-Structuring effects of the RI on the scientific community	Number of projects developed with other Ris, universities, etc. New collaborations…
Be an enabling facility to support innovation	T18-Patents with a commercial use	Number of patents and licensing (financial value of these patents)
	T20-Innovations co-developed with industry	Number of innovations/patents co-developed with industry
	T24-Collaborative projects with industrial partners	Number of industrial users, number of collaborative projects in which industry is directly involved
Become integrated in a regional cluster/in regional strategies / Be a hub to facilitate regional collaborations	E27-Number of Full Time Equivalent within the RI	Number of FTE (per year), Gender distribution, Nationality distribution. If relevant, number of part-time employees
	S11-Papers co-authored with regional universities	Number of articles co-authored by the RI and one or more regional universities
	T25-Regional firms using the RI facilities	Number of regional firms using the RI (can be categorized by size/turnover)
	E35-Number of local/regional suppliers	Number of suppliers (local/regional), may also add turnover data
Promote education outreach and knowledge transfer	O51-Public visibility of the RI	Number of occurrences of the RI in media (can use online news aggregations services such as Factiva), including analyses at different geographic scales
	O53-Knowledge sharing	Number of scientific conferences, seminars, webinars etc. organised by the RI Total number of people trained (academic and industry)
	H43-Students trained and distribution	Number of students trained and their origin (local/national/international)
	H44-Educational and outreach activities	Number of educational and outreach activities, number of participants
Provide scientific support to public policies	O46-Production of expert advice in support of public policies	Number of contracts with public/policy services for consulting/production of reports
	O47-Production of resources in support of public policies	Number of data/specimen/informatics resources dedicated to support public policies

Standard Objectives	Core Impact Indicators	Data
Provide high quality scientific data and associated services	O49-Production of experimental and observational data in support of public policies	References of experimental / observational data produced / used in support of public policies (in regulations, policy reports…)
	T27-Data sharing	Number of data requests (commercial and academic entities) Number of data accesses (commercial and academic entities)
	T28-Commercial data use and data services	Value of data (direct or indirect commercial value) Data package sold and turnover
Assume social responsibility towards society	O55-Energy consumption O56-Waste management	Statistics on energy consumption, water and waste management and recycling Energy or environmental certification Stories on how the RI minimizes its environmental impact/footprint (initiatives, practices…)
	O57-Gender balance and diversity	Gender distribution of employees, users and trainees Diversity of the staff and users
	O58-Corporate social responsibility	Ethical rules Supply chain Good working conditions

Source: OECD, 2019

Table 2: Full list of indicators

	Indicators	Detail	Data needed
S1	Number of publications	Peer-reviewed articles is an indicator of scientific activity in most scientific fields, demonstrates the impact of the RI on science	Total number of publications of the RI during a given period Online on Scopus, WoS and / or other relevant databases. Including only papers with RI address
S2	Number of citations	Quality of RI publications and number	Total number of citations received by publications which are including authors from RI and RI users.
S3	Number of publications in High-Impact factor journals	Publication in world-class journals with high impact	Number of publications in database from RI users published within Q1 journals.
S4	Number of projects granted	Demonstrates the RI capacity to attract funding and excellence of its projects	Total number of projects funded by external sources including industry funds.

	Indicators	Detail	Data needed
			Projects = scientific collaboration, industrial collaboration, technical development etc.
S5	RI attractiveness	Demand for use such as: % subscribed % oversubscribed	Number of applications for the use of the RI's facility Number of non-scientific users
S6	Number of scientific users	Demonstrates the RI attractiveness in different disciplines	Number of users Discipline distribution Top scientific users Nationality distribution
S7	User satisfaction	Based on survey results; a survey can be run to measure user satisfaction on project selection, support and other items, to evaluate how the RI answers its user needs	Satisfaction of RI users regarding project selection, access, support, availability of instruments…
S8	User project excellence	Demonstrates the RI capacity to attract and select excellent projects	Ratio of funded projects vs the total number of projects applications
S9	Collaboration excellence (scientific)	The number of scientific collaborations is a way to measure how a RI enables cooperation in its scientific domain and impacts science	Total number of applications for using the RI and origin Total number of applications from world leading teams (World leading teams publish regularly in Q1 journals) Joint grants
S10	Structuring effects of the RI on the scientific community	To measure the visibility, attractiveness and community building of the RI	Number of projects developed with other RIs, universities, etc. New collaborations...
S11	Papers co-authored with regional universities	Measure scientific productivity and the capacity to enable cooperation with regional scientific actors	Number of articles co-authored between the RI and one or more regional universities or research organisations. Information from Scopus, World of Science or other relevant databases Including only papers with RI address
S12	Use and production of open data	How the RI contributes to the development of open science	Number of access, upload and download of open data Use and users of the open data produced by the RI (users, publics, external researchers, and internal researchers)

	Indicators	Detail	Data needed
S13	Data openness	Attractiveness and quality of access to RI resources can create/reinforce scientific communities and improve their quality	Number of applications to use RI's existing data Number of access granted
S14	Digital resource openness	Attractiveness and quality of access to RI digital resources create / reinforce scientific communities	Number of access to digital resources granted Number of digital resources access requests
T15	National grants	National grants received demonstrate the RI excellence	Number of grants/total amount from the host country for research and development projects
T16	Collaboration with national industry	Measures the attractiveness to industry and innovation potential	Number of projects in collaboration with national firms Story of successful collaboration
T17	Patents	The number of patents developed by the RI demonstrate its impact on innovation	Number of patents granted
T18	Patents with a commercial use	Commercial use demonstrates the usefulness of the patents developed by the RI	Number of patents and commercial/financial value of these patents
T19	Co-patenting with companies	The number of patents co-developed by the RI demonstrates its impact on innovation and development of cooperation networks	Number of co-patents with companies
T20	Innovations co-developed with industry	Emergence of new cooperation networks with industry is a major mechanism through which knowledge circulates and impacts innovation	Number of innovations co-developed with industry
T21	Joint technology development projects between RI and industry	These projects are a major mechanism through which knowledge circulates and impacts innovation	Number of joint technology development projects between RI and industry
T22	Students working for industry	Development of high skill students for industry	Number of students (PhD, master) supported by the private sector and using the RI
T23	Projects funded by companies	A proxy to understand the RIs attractiveness and its potential for innovation	Number of funded projects by companies
T24	Collaborative projects with industrial partners	New collaborative projects carried out with industry are a major mechanism through which knowledge circulates and impacts innovation	Number of collaborative projects in which industry is directly involved
T25	Regional firms using the RI facilities	Contributes to the development of the regional firms skills and impacts on their innovation capacity	Number of regional firms using the RI
T26	Collaborative projects with regional industrial partners	Contribute to the development of the regional firms skills and impact on their innovation capacity	Number of collaborative projects with regional industrial partners

	Indicators	Detail	Data needed
T27	Data sharing	Access and use of the data produced and services provided by the RI	Number of data demands Number of data accesses Number of data accesses by commercial actors and public entities
T28	Data commercial use and data services	Commercial use of the data and services provided by the RI	Financial/commercial value of data Turnover of data packages sold
T29	Data usage	The usage of the resources delivered by the RI illustrates its various technological impacts	Overall usage via browser and other methods Usage in research (through citations) Use of data by public entities
E30	Total expenditure in regional / local area	All the regional/local RI expenditures have an impact on the economy	Total amount of expenditures in regional area, including total amount of purchase from suppliers, contract with suppliers and others, estimation of economic impact on regional area
E31	Public procurement and contracts	Development of new skills, technology and industrial processes, innovation induced through public procurement	Total amount of purchase from local/national/regional suppliers Total amount of contracts with local/national/regional suppliers
E32	Total number of visitors and users of the RI	Increased revenues for the local economy (tourism principally)	Number of visitors and users (to be related to average spending within local area)
E33	New tax payers	Employees living in the local area can increase revenues for the region	Number of employees, living in the local area for 3 years at least
E34	Number of Full Time Equivalent within the RI	Development of new skills and increase of the economic activity of the region (multiplier)	Number of FTE (all persons working within the RI), per year Diversity distribution RI Alumni
E35	Number of local/ regional suppliers	Increased revenues of suppliers and related new skills impact the economic activity of the region	Number of suppliers (regional and local)
E36	Number of employees	Highly skilled employees can provide indirect benefits for the local economy	Number of engineers Number of scientists Number of administrative staff Other (technicians…) Diversity distribution Evolution of employees and their distribution
E37	Spin-off companies	New jobs created in the local economy, R&D spillovers	Number of spin-off companies (start-ups created by researchers of RI)
H38	Trained students satisfaction	Based on survey results: a survey can be run to measure students satisfaction (on training	Satisfaction of students towards the training courses

	Indicators	Detail	Data needed
		courses, support, help, etc.), to assess how a RI answers its students' needs	
H39	Use of the data for training	To illustrate the impact of the data produced by the RI on teaching and training	Survey within RI and among teachers
H40	Number of graduates (regional)	Development of new skills and indirect benefits for the economy	Number of MSc and PhD students from local universities using the RI
H41	Career of students trained within the RI	Indicator to demonstrate the effect of the RI training on students, and its impact on society	Survey results
H42	Grants for trainees	Illustrates the importance of the training activity of the RI	Volume of grants awarded to trainees (regional, national grants for example) to use the RI (total volume)
H43	Students trained and distribution	Illustrates the RI attractiveness and excellence of its training	Number of students trained within the RI Distribution (national and international students)
H44	Training programmes for high level students	Illustrates the RI role in the training of future scientists	Number of masters and PhD training programs
H45	Educational and outreach activities	The educational and outreach activities have an indirect impact on participants knowledge and skills	Total number of participants Total number of educational and outreach activities (open days and other events), internal human resources dedicated
O46	Production of expert advice in support of public policies	Consulting activity for public services shows the potential RIs' influence on public policies (and further impact for citizens in the longer term)	Number of contracts with public services for consulting or reports related to support of public policies
O47	Production of resources used in support of public policies	Resources dedicated to support public policies can impact citizens in the long term	Volume of databases / biobanks / informatics resources used to support public policies
O48	Contribution of the RI researchers to public policies	Indicators demonstrating the researcher contributions (conferences, meetings, reports...) to public policies	Number of meetings with policy makers Number of other contributions (expert reports, conferences, articles in regulatory or legal texts)
O49	Production of experimental and observational data in support of public policies	These data dedicated to support public policies can impact citizens in the long term	Volume of experimental / observational data produced/used in support of public policies
O50	Public awareness	Public and users reached by the RI website	Number of visits/consultations on the RI website
O51	Public visibility of the RI	Measuring the RI occurrence in online media is an efficient way to see its popularity	Number of appearances of the RI on Factiva (all subjects) in online media

	Indicators	Detail	Data needed
O52	Popularity of the RI (public and users)	The number of followers on social media is a measure of the public interest in the RI	Number of followers on selected social medias (LinkedIn, Facebook, YouTube, Twitter, Baidu, etc.)
O53	Knowledge sharing	Scientific events organized and number of people trained to demonstrate the impact on human resources (development of skills and knowledge)	Number of scientific and technological conferences, seminars, workshops, webinars etc. organised by the RI Total number of people trained (academic and industry)
O54	Openness to public	Events successfully organized by the RI for the public to produce / improve its image	Number of events organized for the public Number of visitors in those events
O55	Energy consumption	What is done by the RI to save energy during construction and its functioning: effect on environment and RI exemplarity	Energy usage Energy labels Narrative on energy saving during the different RI lifecycle phases
O56	Waste management	How the RI manages the waste: effect on environment RI exemplarity	Waste production, water usage, recycling data, label
O57	Gender balance and diversity	Demonstrates the effort made by the RI for equity (RI exemplarity)	Gender distribution of employees, users and trainees Diversity of the staff, users...
O58	Corporate social responsibility	Showing the RI as an example of social responsibility	Internal survey Ethical guidelines Responsible suppliers (label) Good working conditions

Source: OECD, 2019

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