INNOVATION & RESEARCH CAUCUS

EVIDENCING THE ECONOMIC, SOCIETAL, SCIENTIFIC BENEFITS OF UK RESEARCH AND INNOVATION

IRC Insight Paper 013

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Delivered with ESRC and Innovate UK

CONTENTS

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This document relates to IRC Project IRCFFEI0002: Evidencing Impact Projects

Acknowledgements

This work was supported by Economic and Social Research Council (ESRC) grant ES/X010759/1 to the Innovation and Research Caucus (IRC).

We are very grateful to the project sponsors at UK Research & Innovation (UKRI) 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 UKRI or its constituent councils. We would also like to acknowledge and appreciate the efforts of the IRC Project Administration Team for their support in preparing this report.

About the Innovation and Research Caucus

The Innovation and Research Caucus supports the use of robust evidence and insights in UKRI's strategies and investments, as well as undertaking a co-produced programme of research. Our members are leading academics from across the social sciences, other disciplines and sectors, who are engaged in different aspects of innovation and research systems. We connect academic experts, UKRI, IUK and the (ESRC), by providing research insights to inform policy and practice. Professor Tim Vorley and Professor Stephen Roper are Co-Directors. The IRC is funded by UKRI via the ESRC and Innovate UK, grant number ES/X010759/1. 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.

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You are also welcome to email us if you have any questions about this report or the work of the IRC generally: info@ircaucus.ac.uk

Cite as: Vanino, E. Feb 2026. *Evidencing the economic, societal, and scientific benefits of UK Research and Innovation*. Oxford, UK: Innovation and Research Caucus

Introduction

UK Research and Innovation (UKRI) plays a pivotal role within the United Kingdom's research and innovation landscape, stewarding public investment to advance knowledge, drive economic growth, and address complex societal challenges. As the national funding body, UKRI's influence extends beyond the allocation of resources: it shapes the structure and effectiveness of the research and innovation (R&I) system, catalyses collaborations, and fosters the conditions necessary for discovery and impact. Given the scale and strategic importance of its activities, a robust, transparent, and methodologically sound assessment of UKRI's value and impact is essential.

This note sets out the proposed framework, approach, and analytical methods for evidencing the economic, societal, and scientific benefits associated with UKRI. It recognises UKRI's multifaceted role: as an expert funder that enhances system performance through strategic prioritisation, funding design, and operational efficiency; as a funder of programmes, infrastructure, and capabilities that generate tangible outputs and outcomes; and as a creator of enabling conditions that connect actors, stimulate innovation, and sustain long-term ecosystem vitality.

The note is structured around six overarching outcome areas, reflecting the breadth and diversity of UKRI's objectives and contributions. For each area, it sets out the rationale underpinning the selected evaluation methods, explains their suitability for addressing the core research questions, and identifies the data sources required to support robust and credible analysis. The framework also explicitly recognises the inherent limitations, uncertainties, and attribution challenges involved in assessing impacts within a complex and dynamic R&I system.

The proposed framework primarily emphasises quantitative approaches, with particular focus on identifying the causal effects of UKRI activities rather than relying on simple correlations. This distinction is critical to ensuring that estimates of UKRI's value are both robust and credible, while avoiding over-interpretation of observed relationships. Econometric methods can be employed to compare UKRI-supported activities with carefully constructed control groups, approximating quasi-experimental conditions wherever feasible. Generating reliable insights will depend heavily on linking UKRI's internal data with relevant external sources, including business performance indicators, patent records, and education outcomes. This data

integration presents several challenges, such as constraints on data access, difficulties in attributing indirect or spillover effects, and limitations in geographic granularity. Addressing these constraints will require sustained collaboration across government, data providers, and the research community.

The framework adopts a modular design, with distinct analytical strands corresponding to each outcome area. This structure is intended to support credible causal identification tailored to the specific mechanisms and impacts under investigation. However, UKRI's activities are inherently interconnected, with effects that frequently operate through complementary and mutually reinforcing channels. To capture these system-wide interactions, an overarching theoretical structure would be required to map the linkages between activities and their joint influence on economic, societal, and scientific outcomes. One feasible approach is to first obtain credible parameter estimates from the individual research questions outlined in this note, and subsequently embed these within a general equilibrium framework. Such a model would enable consideration of economy-wide externalities, indirect effects beyond directly supported activities, and the dynamic evolution of impacts over time, thereby facilitating estimation of UKRI's aggregate contribution.

Important limitations nevertheless remain, particularly in relation to activities that are not readily captured by conventional quantitative metrics. These include UKRI's non-funding roles, such as convening, stewardship, and system leadership, as well as the provision of infrastructure and support for institutes and capabilities. A more comprehensive assessment of these dimensions would benefit from complementary qualitative approaches, including interviews, expert elicitation, and case studies capable of providing richer contextual understanding. The design and implementation of such methods would require specialist expertise and therefore fall beyond the immediate scope of this note.

By adopting this integrated and methodologically rigorous framework, UKRI can more effectively articulate how its diverse activities collectively contribute to economic growth, societal progress, and scientific advancement. This approach provides a coherent and defensible basis for understanding how UKRI's interventions translate into measurable benefits for the economy, society, and the expansion of knowledge. Taken together, these elements offer a comprehensive perspective on UKRI's impact, spanning outcomes from frontier research breakthroughs to broader productivity, innovation, and regional development effects, which can be summarised as follows.

Scientific and Technological Impact

Public funding through UKRI plays a vital role in advancing scientific frontiers and enabling discovery. The proposed analysis compares funded and unfunded projects to assess whether UKRI support increases research quality, originality, and the translation of ideas into new technologies, products, or standards. Using publication and patent data, this work will provide robust evidence on how UKRI investments strengthen the UK's global scientific competitiveness and capacity for innovation.

Developing and Sustaining Research Talent

UKRI investment in studentships, fellowships, and training grants shapes the pipeline of skilled researchers and innovators. This work will explore whether public funding improves career outcomes, supports mobility across academia, industry, and government, and enhances the UK's ability to attract and retain talent. Understanding how UKRI support contributes to human capital formation will help ensure that funding mechanisms continue to build a dynamic, inclusive, and high-performing research workforce.

Strengthening Connectivity and Collaboration

A thriving innovation system depends on collaboration. The analysis will examine how UKRI funding promotes partnerships across universities, businesses, and public organisations, and how these networks support knowledge diffusion between disciplines and regions. Mapping collaborative networks will shed light on how UKRI acts as a connector and catalyst within the broader R&I ecosystem.

Economic and Societal Benefits

Public investment in research has measurable economic and social returns. The evaluation will look at how UKRI funding influences firm-level outcomes, such as employment, productivity, and innovation, as well as broader societal priorities like health, sustainability, and inclusion. It will assess UKRI's contribution to achieving Net Zero, improving population health, and widening participation in innovation. These analyses will help demonstrate the real-world value of UKRI's activities beyond the research base.

Wider Externalities and Regional Impacts

UKRI's influence extends beyond the organisations it funds. Research clusters, Catapults, and universities generate spillovers that benefit nearby firms and communities. This strand will explore how UKRI-supported activity stimulates local economic growth—through job creation, rising wages, and increased demand for skilled labour—and how these multiplier effects contribute to levelling up across the UK.

1) Scientific Advancement: Bibliometric, Altmetric, and Translational Outcomes

Public investment in R&D plays a crucial role in advancing scientific frontiers, yet its direct effects on the quality, originality, and translational potential of research outputs remain debated. This section explores methodological approaches to evaluate the scientific impact of UKRI activities across STEM disciplines, focusing on how public R&D support influences breakthrough innovation, research quality, and knowledge spillovers. Using a rich combination of bibliometric (citations per output, field-normalised citation impact), altmetric, and translational indicators (e.g., clinical trials, standards, protocols), this analysis would help assess whether funded projects outperform comparable unfunded applications in generating high-impact papers and patents. Drawing on detailed administrative data, these studies could employ econometric techniques to identify causal effects while accounting for the timing of outcomes. Despite data limitations on directly reported outputs, the integration of natural language processing and text classification methods offers an innovative way to link grant proposals to subsequent scientific and technological achievements. This empirical framework contributes to ongoing debates on the effectiveness of public R&D policy in stimulating high-quality, broadly beneficial scientific advancement.

Research Questions:

a. Does public R&D funding stimulate a greater incidence of breakthrough innovations?

b. Does public R&D funding enhance the quality, sophistication, and scientific complexity of research outputs?

c. What are the spillover effects of publicly funded R&D on the productivity and direction of subsequent unfunded research projects?

Policies to Consider:

The analysis will primarily focus on R&D grants awarded by UK Research and Innovation (UKRI) Research Councils, with particular attention to funding in STEM disciplines.

Outcomes:

Key outcome measures will include patent applications and academic publications. Research quality will be assessed through forward citations, journal rankings, and field-normalised citation metrics. Both backward and forward patent and paper citations will be used to evaluate the generality, originality, and influence of funded research.

Data:

These studies will integrate multiple data sources. Internal UKRI administrative records will provide detailed information on successful and unsuccessful Research Council applications, including funding organisation, time period, grant value, application scores, team composition, and other project characteristics. Patent-related data will be drawn from the EPO PATSTAT database, which contains comprehensive global information on patent applications, inventors, owners, technological classifications, offices, and citations. Bibliometric and publication-level data will be sourced from OpenAlex, offering detailed metadata on scientific papers, authors, journals, and institutional affiliations.

Methods:

The empirical strategy will combine econometric and quasi-experimental techniques. A staggered difference-in-differences design (Callaway & Sant'Anna, 2021) will be applied in conjunction with Propensity Score Matching to compare funded projects with observationally similar unfunded applications. This framework will account for the temporal lag between funding decisions and observable outcomes. Additionally, the availability of application scores will enable a Regression Discontinuity Design (RDD) approach, comparing marginally successful and unsuccessful proposals that received nearly identical evaluation scores from review panels.

Limitations:

A key limitation is the incomplete reporting of project outcomes, as few funded projects provide comprehensive information through Researchfish, and no equivalent data exist for unfunded applications. To address this, machine learning techniques, particularly Natural Language Processing (NLP) and text classification, can be used to predict the likelihood that a given project leads to patents or publications within specific

technological domains (as in Corradini and Vanino's recently funded IRC project). These predicted linkages would allow the construction of more complete mappings between funding applications and subsequent scientific or technological outputs.

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2) Talent Pipeline Metrics: Human Capital, Mobility, and Trajectories

Public investment in R&D not only generates new knowledge but also shapes the development, mobility, and long-term productivity of the research workforce. This section investigates methodological approaches that can be used to evaluate how UKRI-activities contribute to human capital formation and talent flows within the UK's innovation ecosystem. Specifically, it explores whether public R&D funding enhances PhD completions, supports sustained careers in research and development, and facilitates cross-sector mobility between academia, industry, and the public sector. By leveraging linked administrative data, this analysis will assess both individual-level outcomes and broader economic benefits, such as productivity gains and local multiplier effects associated with publicly funded inventors and researchers. Combining both robust econometric approaches and qualitative evidence, these studies could identify the causal impact of public R&D support on the UK's research talent pipeline. These findings will provide valuable insights into how R&D policy can better nurture, retain, and mobilise scientific talent to strengthen national innovation capacity and regional growth.

Research Questions:

a. Does public R&D funding enhance human capital accumulation and the development of highly skilled researchers?

b. Does public R&D funding increase the likelihood of talent mobility and knowledge exchange between academia and industry?

c. What is the impact of publicly funded researchers and inventors on organisational and team-level productivity and innovation performance?

- **Policies to Consider:**

  The analysis will focus on UKRI-funded fellowships, studentships, training grants, and knowledge exchange programmes designed to support research capacity building and career development in the UK.

- **Outcomes:**

  Key outcomes include PhD completions, retention within R&D careers, and mobility across academia, industry, and the public sector. Additional outcomes will capture the attraction of international talent and the broader economic benefits of public R&D funding, such as increased productivity, innovation spillovers for employers and collaborators, and improved labour market outcomes.

- **Data:**

  These studies will need to combine internal UKRI administrative data on applications for fellowships, studentships, and training grants with individual-level education and labour market data. This linkage can be achieved through the Department for Education's Longitudinal Education Outcomes (LEO) database, which tracks individuals born in England after 1985, containing detailed information on educational attainment (degree, subject, institution, grades) and subsequent labour market outcomes (employment status, employer, industry, location, and earnings). Additional datasets will be required to assess organisational impacts, including employer-level productivity and innovation indicators.

- **Methods:**

  The empirical strategy will combine econometric and quasi-experimental approaches. A staggered difference-in-differences design (Callaway & Sant'Anna, 2021), complemented by Propensity Score Matching, will be used to compare supported and unsupported applicants. The longitudinal structure of the data will allow for tracking long-term career trajectories, mobility patterns, and labour market outcomes over the life cycle. To strengthen causal inference, exogenous variation in support, such as the introduction of Doctoral Training Partnerships (DTPs) or other policy reforms, can be exploited. This quantitative analysis may also be complemented by qualitative evidence,

including interviews with funded individuals, to capture nuanced insights into career motivations and transitions.

- **Limitations:**

  A key limitation is that the LEO dataset is currently accessible only through the ONS Secure Research Service and cannot be directly linked with other administrative or research datasets, restricting its potential for integrated analysis. Addressing this constraint would require policy engagement with the Department for Education to enable secure linkage between LEO, UKRI administrative data, and other ONS datasets, thereby enhancing the feasibility and analytical scope of this research.

- **References:**

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3) Ecosystem Connectivity: Collaboration Networks and Knowledge Diffusion

Public R&D funding plays a crucial role in shaping the structure and dynamics of research collaboration networks, influencing who collaborates, what knowledge is shared, and how innovation diffuses across institutions and regions. This section examines how to evaluate UKRI activities foster ecosystem connectivity by promoting diverse partnerships across academia, industry, and the public sector. Using network analysis of co-authorships, co-inventorships, and co-funding links, these studies could assess whether publicly supported collaborations enhance team diversity, integrate complementary technological capabilities, and facilitate knowledge transfer from leading to lagging organisations and places. Drawing on detailed UKRI administrative data linked with global patent records from EPO PATSTAT, the analysis combines econometric and network-based approaches to uncover the causal role of funding in strengthening research and innovation networks. Overall, these works could provide valuable insights into how public R&D investment enhances the connectivity, inclusiveness, and resilience of the UK innovation ecosystem.

Research Questions:

a. How does public R&D funding influence the formation and structure of collaborative networks, including the diversity, composition, and technological capabilities of participating partners?

b. How do publicly funded collaborative R&D projects facilitate the diffusion of knowledge and technology between leading and lagging organisations, sectors, and regions?

Policies to Consider:

The analysis will focus on collaborative R&D projects supported by UKRI Research Councils and Innovate UK, which aim to foster cross-sector partnerships and strengthen the national innovation ecosystem.

Outcomes:

Key outcomes include the diversity and composition of collaborative teams in both supported and unsupported projects, measured across institutions, disciplines, and technological specialisations, and the extent of knowledge diffusion and technology transfer from frontier to lagging organisations and places.

Data:

The study will combine internal UKRI administrative data on Research Council and Innovate UK collaborative R&D projects, encompassing both successful and unsuccessful applications. Available information includes project timing, funding organisation, grant value, application scores, and team composition. These data will be linked to the EPO PATSTAT database, providing comprehensive information on global patent applications, inventors, assignees, technological classifications, patent offices, and citation networks. This integrated dataset will enable a detailed mapping of collaborative structures and knowledge flows across funded and unfunded projects.

Methods:

The empirical analysis will employ econometric techniques, including a staggered difference-in-differences approach (Callaway & Sant'Anna, 2021) combined with Propensity Score Matching, to compare funded and unfunded but otherwise similar collaborative projects. This framework will account for time lags between funding and observable outcomes, such as publications, patents, and partnerships. Additionally, a Bartik-style shift-share instrumental variable may be implemented to predict funding allocations based on exogenous variations in technological priorities. Network analysis

methods will be used to visualise and quantify collaboration intensity, diversity, and centrality within the innovation ecosystem.

- **Limitations:**

  A key limitation is the limited availability of reported project outcomes, as few funded projects provide comprehensive follow-up information through Researchfish, and equivalent data are unavailable for unfunded applications. To address this, machine learning methods—such as Natural Language Processing (NLP) and text classification—can be applied to predict the likelihood that projects generate patents or publications in specific technological domains (as demonstrated in Corradini and Vanino's IRC-funded research). This approach would enable the linkage of project-level funding data with corresponding scientific and technological outputs, enhancing the completeness and reliability of the analysis.

- **References:**

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  - Mewes, L. and Broekel, T., 2020. Subsidized to change? The impact of R&D policy on regional technological diversification. The Annals of Regional Science, 65(1), 221-252.
  - Uhlbach, W.H., Balland, P.A. and Scherngell, T., 2022. Public R&D funding and new regional specialisations: The contingent role of technological relatedness. Industry and Innovation, 29(4), 511-532.

4) Direct Economic Outcomes

This section looks at how to investigate the direct economic outcomes of public R&D funding in the UK, focusing on how support provided by UKRI influences firm-level and university-level performance. Specifically, it could be explored whether public R&D funding promotes employment, turnover, and productivity growth, stimulates private R&D investment and venture capital, and enhances the value and commercialisation of patents and university spin-offs. These studies could use comprehensive datasets that link UKRI internal grant data with firm-level performance records, R&D investment data, venture capital databases, and university innovation outputs, appling advanced econometric methods. Despite limitations in linking certain administrative datasets and the scarcity of spin-off data, this research could aim to

provide robust evidence on the role of public R&D support in driving innovation-led economic growth across UK firms and universities.

- **Research Questions:**

  a. Does public R&D funding promote employment, turnover, and productivity growth?

  b. Does public R&D funding crowd in private R&D investment?

  c. What is the impact of public R&D support on patent value and commercialisation?

  d. Does public R&D funding promote the commercialisation of university innovation?

- **Policy to Consider:**

  The analysis will focus on all UKRI-funded R&D and innovation projects.

- **Outcomes:**

  Key outcomes include firm-level employment, turnover, and productivity, as well as private R&D investment and venture capital funding. Additional indicators include patent box value, firms' stock market performance, and the number and economic performance of university spin-offs.

- **Data:**

  These studies will use internal UKRI data on Research Council applications, both successful and unsuccessful, containing information on funding periods, grant values, application scores, funding organisations, and team composition. These data will be linked with firm-level performance data (employment, turnover, and productivity) from the Business Structure Database (BSD), which covers the full population of UK businesses. Private R&D investment will be drawn from the ONS Business Enterprise Research and Development (BERD) dataset, though coverage is limited to a small subset of firms. For broader population estimates, HMRC R&D tax credit data will be used. The value of patents will be inferred from company returns under the HMRC Patent Box initiative. Data on venture capital and other private funding will be obtained from sources such as Beauhurst or similar private databases. Finally, information on university spin-offs will be collected from the Researchfish platform or ongoing initiatives such as those led by Tomas Ulrichsen (IRC and University of Cambridge).

- **Methods:**

  Several econometric techniques could be employed. A staggered difference-in-differences analysis (Callaway and Sant'Anna, 2021), combined with a Propensity Score Matching approach, will enable comparison between supported and unsupported applications while accounting for time lags between funding and the realisation of

outcomes. Access to application scores will also allow for a Regression Discontinuity Design (RDD), comparing marginally successful and unsuccessful applications with similar evaluation scores. Additionally, an Instrumental Variable (IV) approach may be used, leveraging Bartik shift-share instruments to predict funding allocation across technologies.

- **Limitations:**

  The main limitation arises from the inability to link HMRC R&D tax credit and Patent Box data with other datasets. Moreover, data on university spin-offs in the UK remain limited, constraining the ability to conduct comprehensive analysis in this area.

- **References:**

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  - Kleine, M., Heite, J., & Huber, L. R. (2022). Subsidized R&D collaboration: The causal effect of innovation vouchers on innovation outcomes. Research Policy, 51(6), 104515.
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5) Societal Outcomes

This section focuses on the broader societal impacts of UKRI-funded activities, including improvements in health, progress toward environmental sustainability, and promotion of a more inclusive innovation system. The analysis aims to assess whether public R&D funding generates measurable benefits in terms of health quality-adjusted life years, environmental indicators (e.g., green technologies), and social metrics such as inequality and access to innovation opportunities.

- **Research Questions:**
  a. Do UKRI activities increase health and quality of life in the country?
  b. What role does UKRI play in achieving net zero?
  c. Do UKRI activities promote a more inclusive innovation system?
- **Policies to Consider:**
  All UKRI activities, including funding for R&D and innovation projects, fellowships, Catapults, and related support mechanisms.
- **Outcomes:**
  - Health measures: incidence of diseases, health quality-adjusted life years (QALYs), and other relevant indicators.
  - Environmental and net-zero measures: green patents and publications linked to UKRI-supported projects.
  - Inclusivity metrics: race, gender, and socio-economic status of supported inventors.
- **Data:**
  UKRI internal data on successful and unsuccessful Research Council applications, including grant value, funding organisation, application scores, team composition, and project timelines. Inventor-level data from the Longitudinal Education Outcomes (LEO) database (DfE), providing information on race, gender, and socio-economic background for individuals born in England post-1985. Patent data from EPO PATSTAT, including green technology classifications (tech class Y). Publication data from OpenAlex, including bibliographic information on scientific papers, authors, journals, and institutions, to identify studies linked to net-zero research. Health impact data collected via interviews with leading medical and public health experts.
- **Methods:**
  - Health and quality of life: Qualitative analysis linking UKRI support to the development of new drugs and treatments, and assessing their subsequent impact on population health. This requires collaboration with medical and public health experts to establish credible causal pathways. Machine learning could assist in scaling the review of applications, but expert input remains essential.
  - Net zero and green innovations: Identify green patents and publications associated with UKRI-supported projects. Using the Martin and Verhoeven (2022) methodology, estimate the value of these innovations. Apply a staggered

difference-in-differences approach (Callaway and Sant'Anna, 2021) combined with Propensity Score Matching to assess whether UKRI support increases the value of green technologies relative to unsupported innovations.

- Inclusivity in innovation: Using data on successful and unsuccessful applications, combined with inventor-level information from PATSTAT and LEO, assess whether UKRI funding promotes more diverse inventor teams in terms of gender, ethnicity, and socio-economic background. This will be analysed using a difference-in-differences framework comparing supported and unsupported applications.

Limitations:

The LEO dataset is currently available only through the ONS Secure Research Service Datalab, and cannot be linked to external datasets, which limits its usefulness. Engagement with DfE is required to enable broader data integration. The health and quality of life analysis requires extensive manpower to review applications and link funding to societal health outcomes. While machine learning may help scale the review process, expert judgment from medical and public health professionals remains critical to establish credible causal relationships.

References:

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6) Externalities and Multiplier Effects:

This section examines how to evaluate the broader regional and economic impacts generated by UKRI-supported activities, focusing on how public investment in research and innovation can produce externalities and multiplier effects beyond directly funded organisations. In particular, it could be possible to investigate the potential for technological diffusion, spillover benefits to unsupported firms, and local economic prosperity resulting from the presence of innovation hubs, publicly funded researchers, and associated knowledge networks.

- **Research Questions:**

  a. What are the spillover effects on unsupported businesses arising from innovation hubs and clusters of publicly supported firms?

  b. Do technologies developed through UKRI-supported research and innovation generate measurable externalities for other firms and local economies?

  c. What local multiplier effects emerge from the presence and activities of publicly funded inventors, researchers, and institutions?

- **Policy to Consider:**

  All UKRI activities, including research and innovation funding, fellowships, investments in Catapults, and related R&D programmes.

- **Outcomes:**

  Key outcomes include firm-level indicators such as employment, turnover, productivity, and innovation performance. Additional measures should capture future engagement with the public innovation system. To assess broader multiplier effects, local economic indicators should be incorporated, such as population growth, share of skilled workers, average wages/incomes, and house prices, at granular geographical levels (e.g., neighbourhoods).

- **Data:**

  Internal UKRI administrative data will serve as the primary source, covering Research Councils and Innovate UK applications (both successful and unsuccessful), as well as firm engagement with Catapults. Relevant variables include funding organisation, grant value, application scores, team composition, and project timelines. These data will be linked to firm-level performance metrics from the Business Structure Database (BSD), which encompasses the full population of UK businesses and includes detailed location data. Patent-related information will be drawn from the EPO PATSTAT database, which

provides comprehensive data on patent applications, inventor and owner locations, technological classifications, and citations. Measures of local economic prosperity will be sourced from Census data (e.g., population, education levels, and income), HMRC price-paid data (house prices), and other relevant micro-level datasets aggregated to local geographies.

- **Methods:**

  The analysis will combine several complementary econometric approaches. A staggered difference-in-differences (Callaway and Sant'Anna, 2021) framework, potentially integrated with Propensity Score Matching or Synthetic Control Methods, can identify dynamic treatment effects while controlling for self-selection and enabling long-term impact assessment. Additionally, a Border Discontinuity Design (BDD) can compare firms or areas in close geographic proximity, subject to similar conditions, but different exposure to UKRI-supported activities. A Bartik-style shift-share instrumental variable may also be employed, as in the urban and regional economics literature, to predict area-specific effects based on exogenous national-level variation in UKRI activities.

- **Limitations:**

  A key challenge lies in identifying and quantifying spillovers and externalities, which are often indirect and intangible. While the literature on knowledge externalities offers established identification strategies, linking these effects specifically to UKRI activities remains complex. Moreover, the precise geographical location of R&D and innovation activities is often obscured, as firms' registered headquarters may differ from the sites of research execution. Data availability at fine spatial scales can also be limited, necessitating careful consideration of the appropriate subnational geographical units (e.g., neighbourhoods, cities, commuting zones, or regions).

- **References:**

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