Research Evaluation, 2023, **32**, 273–285
https://doi.org/10.1093/reseval/rvad019
Advance access publication 14 July 2023
Article

OXFORD

How unpredictable is research impact? Evidence from the UK's Research Excellence Framework

Ohid Yaqub [1], Dmitry Malkov [1,2] and Josh Siepel [1,*]

[1]Science Policy Research Unit (SPRU), University of Sussex Business School, Jubilee Building, University of Sussex, Falmer, Brighton, BN1 9SL, UK
[2]Elsevier BV, Amsterdam, Netherlands
*Corresponding author. Email: j.siepel@sussex.ac.uk.

Abstract

Although *ex post* evaluation of impact is increasingly common, the extent to which research impacts emerge largely as anticipated by researchers, or as the result of serendipitous and unpredictable processes, is not well understood. In this article, we explore whether predictions of impact made at the funding stage align with realized impact, using data from the UK's Research Excellence Framework (REF). We exploit REF impact cases traced back to research funding applications, as a dataset of 2,194 case–grant pairs, to compare impact topics with funder remits. For 209 of those pairs, we directly compare their descriptions of *ex ante* and *ex post* impact. We find that impact claims in these case–grant pairs are often congruent with each other, with 76% showing alignment between anticipated impact at funding stage and the eventual claimed impact in the REF. Co-production of research, often perceived as a model for impactful research, was a feature of just over half of our cases. Our results show that, contrary to other preliminary studies of the REF, impact appears to be broadly predictable, although unpredictability remains important. We suggest that co-production is a reasonably good mechanism for addressing the balance of predictable and unpredictable impact outcomes.

Keywords: research impact; broader impacts; research assessment; research evaluation; REF impact; research funding

1. Introduction

Concern is growing about the wider impact of research beyond the ivory tower. Promising, demonstrating and documenting impact outside academia is now a major part of the research policy infrastructure (Collini 2012; Penfield et al. 2014; Greenhalgh et al. 2016). The 'impact agenda' (Martin 2011; Watermeyer 2016) has spread across research systems, featuring in countries such as the USA, Netherlands, Italy, Sweden, Australia, New Zealand, and many others.

The growth of the 'impact agenda' has taken at least three forms: (1) the introduction of impact as an implicit, and sometimes explicit, selection criterion for research funding (Bozeman and Boardman 2009; Bozeman and Youtie 2017; Chubb and Watermeyer 2017); (2) direct funding support for non-academic engagement and knowledge exchange activity (Ulrichsen 2015; Johnson 2022; Durrant and MacKillop 2022) and; (3) the introduction of impact as an assessment criterion for allocating public funding to a university (Smith, Ward and House 2011; Hicks 2012). The expansion of academic researchers' roles to include planning and delivery of impact affects multiple stages of the research process (Collini 2012; Watermeyer 2016; Power 2018).

In the UK, the setting for this study, research impact was introduced as an explicit part of the UK's research evaluation exercise, the Research Excellence Framework (REF) (Smith, Ward and House 2011). As a result, institutions were required to submit exemplary case studies of impact produced by university researchers. Likewise, research councils introduced a requirement for 'pathways to impact' and 'Impact summary' sections in all applications for funding, describing potential or planned impacts on non-academic communities before the work is funded.

Following these changes, universities needed to report *ex post* impacts, and researchers needed to propose *ex ante* impacts (Chubb and Watermeyer 2017; Ma et al. 2021). This allows us to consider whether the *ex post* reported impact resembles the *ex ante* proposed impact. Does research impact tend to emerge largely as planned, or are eventual impacts unrecognizable from initial plans? This question speaks to a broader science policy question about whether the outcomes of scientific research are predictable, whether researchers are able to foresee the nature of the impacts of their funded research, and if so to what extent.

In this study, we trace impact case studies, via their underpinning references, back to their funding sources and descriptions of their 'imagined impact' (Smith, Ward and House 2011; Terämä et al. 2016; Murphy 2017; Watermeyer and Hedgecoe 2016; Bonaccorsi et al. 2021). Specifically, we consider the extent to which the beneficiary stakeholders identified in the *ex post* impact case are identified in the *ex ante* 'pathways to impact' statement, as well as whether the topics identified as being useful to stakeholders in eventual impact cases prove to be the same as those identified in the research funding process.

The study offers an assessment of the unexpectedness of research impact. It is the first study to our knowledge to compare *ex ante* and *ex post* statements of research impact from the same projects to ascertain whether the anticipated 'pathways' to impact did, in fact, materialize in the way anticipated by the researchers. Our findings suggest that research impact

© The Author(s) 2023. Published by Oxford University Press.
This is an Open Access article distributed under the terms of the Creative Commons Attribution License (https://creativecommons.org/licenses/by/4.0/), which permits unrestricted reuse, distribution, and reproduction in any medium, provided the original work is properly cited.

Downloaded from https://academic.oup.com/rev/article/32/2/273/7224528 by guest on 03 November 2023

is non-random and that there is scope for policy intervention. As it remains unclear what the 'optimal' mix of predictable and unpredictable outcomes might be, we suggest that ensuring a mix of outcomes seems preferable to wholly pursuing one or the other.

2. Literature review

Academic 'impact' has been, and remains, a contested concept (see reviews of models of impact in Penfield et al. (2014), Greenhalgh et al. (2016), Boswell and Smith (2017), Muhonen, Benneworth and Olmos-Peñuela (2019), and Razmgir et al. (2021); and of measurement of impact in Reed et al. (2021), all of which highlight the complexity of the impact process). Since the emergence of impact as an extension of research evaluation movement of the 1980s (Martin and Irvine 1983; Irvine and Martin 1983), the policy implications of what impact is, how beneficial it is as a concept, and how to measure it, have often remained unclear. We consider here two ways in which impact has been incorporated into research systems: Firstly as a part of the research funding evaluation process, and secondly as a criterion for evaluation in performance-based research systems. We discuss these two perspectives in more detail below.

2.1 Predicting impact: *ex ante* pathways to impact

Efforts to encourage greater research impact include the introduction of impact as an explicit consideration in research funding. The introduction of impact as an evaluation criterion for funding proposals emerged in the 1990s (Mervis 1997; Holbrook 2005). The US National Science Foundation (NSF) introduced its 'Broader Impacts' criteria alongside more traditional assessment of academic merit (Bozeman and Boardman 2009). In the UK, from 2006 to 2020 'pathways to impact' statements were required for applications to research councils, identifying the impact of proposed research and how it would be delivered. Similarly, the Australian Research Council introduced a requirement for impact statements to form part of grant applications in 2014. These statements, which in principle are meant to show the social value of the proposed research, have been considered problematic for a variety of reasons discussed below.

Any *ex ante* prediction of outcomes requires some degree of imagination. In their study of the attitudes of senior academics in the UK and Australia about impact statements, Chubb and Watermeyer (2017) find that researchers' concerns often centred on the inability to foresee research impacts *a priori*: 'It is impossible to predict the outcome of a scientific piece of work and, no matter what framework it is that you want to apply, it will be artificial and come out with the wrong answer—because if you try to predict things, you are on a hiding to nothing.' (UK Professor, quoted in Chubb and Watermeyer (2017: 2366)).

Others referred to 'pathways to impact' statements as 'virtually meaningless', 'made up stories', 'worse than useless' and 'a whole load of nonsense' (Chubb and Watermeyer 2017; Wilsdon 2020). The general tenor of these sentiments echoes long standing concerns about the unpredictability of research[1] (Polanyi 1962), the serendipitous paths it may take (Merton and Barber 2004; Yaqub 2018), and uncertainty about the myriad ways in which users might exploit research (Freeman and Soete 1997; Andriani and Kaminksa 2021).

Applicants for research funding may also feel pressure to 'sensationalize and embellish' (Chubb and Watermeyer 2017: 2365) impact claims as a normalized part of the research funding structure, particularly if *ex ante* projections of impact are used to bear strongly upon competitive project selection. Cynicism that promises of impact would in fact later transpire as described were often expressed in terms of researchers' own lack of clairvoyance. Scientific impacts tended to still be widely discussed even though the impact statements in question were meant to target economic and social impact, suggesting many applicants either misunderstood or disregarded guidance to articulate pathways to impact (Ma et al. 2021). Conditions are ripe for 'imaginations of impact' (Chubb and Watermeyer 2017: 2368) that might not correspond to what in fact later emerges.[2]

There is also scepticism about the value of *ex ante* statements of research impact among reviewers and program officers. Surveys showed that reviewers 'ignored' criteria and NSF staff wanted 'clarification' of the criteria (Rothenberg 2010: 193). In their study of reviewers' comments on impact statements from an Irish grants programme, Ma et al. (2021) found that reviewers harboured reservations about claims relating to social impacts or public policy impacts, though direct, tangible and commercial impacts seem less prone to such scepticism (see also de Jong, Wardenaar and Horlings (2016) for similar survey evidence). Moreover, ability to deliver, much less predict, social impact seems dependent on a variety of factors, and hence limited to a few researchers in 'high-performing' contexts (Joly et al. 2015; de Jong and Muhonen 2020).

If research impact emerges in complex and unpredictable ways, and if reviewers ignore sensationalized claims, then accounts of eventual impact should bear only weak resemblance to *ex ante* claims. If some of these concerns are overstated, we would expect to see similarity between *ex post* and *ex ante* claims.

2.2 Reporting impact: *ex post* assessment of impact by REF

The challenges of assessing impact after it has happened is not necessarily any easier. Social impact is difficult to assess and measure, particularly compared to economic impact, where there are more established methodologies (Bozeman and Boardman 2009; Bozeman and Youtie 2017). Martin (2011) argues that while social and economic impact of research can be assessed after the fact, the methodologies that produce robust results are often time- and labour-intensive and unsuited to operation at the scale that would facilitate the evaluation of an entire national research system. In countries with performance-based research funding systems (Hicks 2012), this introduces a substantial methodological dilemma.

A range of approaches are possible to document the impact of research—for instance, econometric analysis, surveys, or quantitative metrics (Salter and Martin 2001; Wilsdon et al. 2015; Bozeman and Youtie 2017). But qualitative approaches to capturing impact—including narratives and case studies—allow more complex and nonlinear evidence of impact to be presented, and consequently have been adopted in research systems including in Australia, the UK, the Netherlands, Sweden, Italy, Spain, Norway, Poland, Finland, Hong Kong, and New Zealand. (Reed et al. 2021).

Downloaded from https://academic.oup.com/rev/article/32/2/273/7224528 by guest on 03 November 2023

Our interest in this article is in the study of those exemplary cases put forward by their institutions as evidence of impact. These give us an interesting lens to explore how reported impact presented in *ex post* in narrative form compares with *ex ante* 'imaginations of impact' (as per Chubb and Watermeyer 2017). In particular, we seek to understand whether the 'pathways' identified in Pathways statements (in terms of beneficiaries and topic) appear in subsequent impact cases.

A key characteristic of a qualitative, case study-based approach to impact evaluation is that there may be some element of selection regarding which cases are put forward. Institutions or academics are incentivized to put forward their 'best' impact cases. Whilst the design of a research evaluation exercise can exert a selective pressure on the kinds of impact that are eventually included, and this might mean that some impacts go unnoticed, a focus on REF impact cases seems warranted because the distribution of impact is likely to be highly skewed (cf. Joly et al. 2015).

A distinct but related challenge comes from the nature of impact as being cumulative as well as skewed (Joly et al. 2015). This means that the accumulation of impact is the result of a bundle of activities and projects. Ross et al. (2021) argue that the underlying logic of impact cases seeks 'chains' of impact (an antecedent, perhaps, of the linear models discussed above) rather than 'nets' in which multiplicities of actors interact to effect change. This places considerable emphasis on attribution of impact to a single principal claimant.[3] Since impact cases are 'designed for immodesty' (Power 2018), important complementary and allied contributions from unexpected sources could be overlooked. Their omission would mean that indirect impacts are potentially undervalued by the by these evaluation frameworks, despite efforts to draw on a qualitative case study approach.

Moreover, studies focusing on REF cases overall (Terämä et al. 2016) and discipline-specific approaches to impact (e.g. Smith and Stewart (2017) for social policy; Meagher and Martin (2017) for mathematics, and Ross et al. (2021) for human relations) have highlighted the immense complexity of research impact, and the wide array of possible pathways through which it may materialize further suggests that reports of impact may bear little resemblance to impact predictions. The complexity and diversity of impact may mean that few impact cases resemble *ex ante* impact claims. However, if case selection strongly favours direct and predictable impact, we would expect to find greater similarity between *ex post* and *ex ante* claims.

2.3 Alignment of *ex post* and *ex ante* impact claims: topic, beneficiaries and co-production

By comparing *ex post* claims with *ex ante* claims, we can consider not only how often they align, but also the extent to which they align to varying degrees of specificity (exact-match; match; no-match). We can then also consider whether degrees of topic alignment might interact with degrees of stakeholder alignment (see Figure 1).

Alignment is based on the extent to which the stakeholder or topics identified *ex ante* correspond to those that are listed in the impact case. On one extreme, the topic or stakeholder in the impact case would be exactly what was predicted in the funding bid. The converse would be to observe impact claims that are unrecognizable and bear little resemblance with each other. The following sections set out how these claims might emerge in the data. Table 1 provides fictional examples of what these examples of alignment might look like, for purposes of clarification; redacted examples from actual REF cases are provided in Supplementary Table A2 in the Appendix.

2.3.1 Topic alignment: can researchers anticipate what topic the research will impact?

Given the planning that goes into the preparation of a research proposal, we may not be surprised to see the proposed impact as set out in the 'pathways to impact' statement match with what is eventually described in the REF impact case. But this may not always be the case. As noted above, the contexts into which research diffuses may be too varied and complex for researchers to be able to foresee in this way.

Exact topic identification occurs when the same technology or research output is predicted in the funding application and subsequently appears in the impact case. This is perhaps more in line with traditional, more linear models of impact. It is certainly part of the underlying logic behind the introduction of 'pathways to impact' statements (Ma et al. 2021) in that it is expected that assessing projects on potential impact will lead to funding research that presents a more convincing case for generating impact (Chubb and Watermeyer 2017).

General topic identification might occur if topics are broadly similar but the precise topic, or technology, identified in the impact case is not specifically mentioned in the original funding application.

No general topic identification would be expected in the most radical cases of serendipity (Yaqub 2018). Targeted search (of sufficient quality to get funded after a competitive peer review process) might yield an impact on a topic completely unrelated to that previously identified.

2.3.2 Stakeholder alignment: can researchers anticipate who will benefit from impactful research?

It has been suggested that the impact agenda may enhance stakeholder engagement (Hill 2016). There is a large and established literature on the engagement activities of academics (see the review in Perkmann et al. 2021). While this body of literature captures more concrete interactions (e.g. consultancy project, patents etc.), this is rather different to knowing the end-users and potential beneficiaries of a piece of research, particularly when a researcher is making an initial funding proposal. From this perspective, we consider the extent to which the *ex post* beneficiaries identified in a REF impact case were the stakeholders explicitly identified in a Pathways statement.

Exact identification of stakeholders may be presumed to be associated with 'productive interactions' (Spaapen and van Drooge 2011) between researchers and stakeholders, wherein the relationship between the two parties means that there is sufficient understanding of the topic such that a researcher can identify a specific end-user or organization before the research is funded. Such relationships can be based on social capital and ongoing relationships (Arza and Carattoli 2017).

General identification of stakeholders takes place when a researcher in their Pathways statement identifies a broad general target (e.g. 'government' or 'businesses') which proves to match with the eventual location of the impact case. One may reasonably infer that researcher would in this context be able to identify the broad class of stakeholders who might find research useful, even if there is not a clearly identified specific target.

Downloaded from https://academic.oup.com/rev/article/32/2/273/7224528 by guest on 03 November 2023

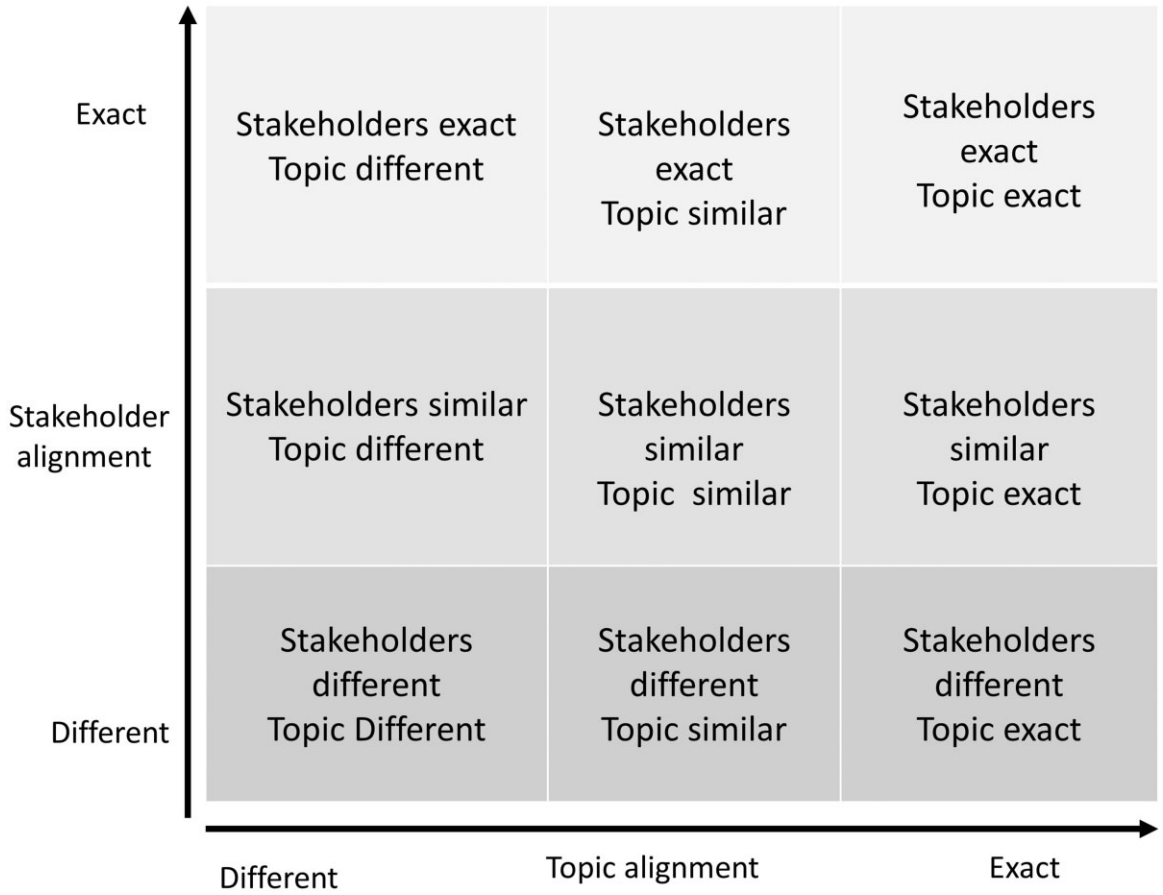

Figure 1. Stakeholder alignment and topic alignment.

Table 1. Hypothetical examples of forms of topic and stakeholder identification

Level of *ex ante* identification	Example of Pathways statement	Example of impact case study
Exact topic identification	'This research will improve our algorithm regarding pain processing'	'The research on pain process in Prof X's group led to the following impacts. . .'
General topic identification	'This research will develop new wave amplifiers using XYZ technology'	'The wave amplification technology developed at ABC university had the following commercial impact.
No general topic identification	'This research will build knowledge on ageing and well-being'	'Prof X's work on prenatal exposure to stress has been influential. . .'
Exact stakeholder identification	'We will collaborate with XYZ Ltd to commercialize this research'	'This research was used by XYZ Ltd as a part of their new model, which helped the company to increase sales by 30%'.
	'This research will be particularly relevant to the Scottish prison system'	'This research was used in Scottish prisons'
General stakeholder identification	'This mathematical modelling has application in commercial settings'	'Through engagement with XYZ Ltd the mathematical models had the following impact. . .'
No general stakeholder identification	'This research will provide commercial benefits by local businesses in Essex'	'This research was part of a museum exhibition in the USA'

No general identification[4] *of stakeholders* takes place if the intended recipient identified in the application is in a completely different sphere than those who eventually were identified in the impact case. Cases in which this happens would be in line with the serendipitous pathways of impact suggested by respondents in Chubb and Watermeyer (2017).

2.3.3 Co-production: mechanism for impact?

In addition to outcome-oriented impacts, as discussed above in terms of topic and beneficiaries, process-oriented impacts via *co-production* of knowledge seems a distinguishable form of impact. (see Muhonen, Benneworth and Olmos-Peñuela (2019) for a more variegated framework impact types, including co-production among others, in the case of social sciences and humanities). Co-produced research can be explicitly acknowledged by statements of collaboration, secondments, internships, people exchange, co-funding or provision of materials and equipment between the research group and identified stakeholders. Active co-production of knowledge with an end-user is not only a pathway to impact, but also one that may drive alignment between researchers and stakeholders.

Downloaded from https://academic.oup.com/rev/article/32/2/273/7224528 by guest on 03 November 2023

The increasingly co-evolutionary nature of knowledge production, as a distinct mode (Gibbons et al. 1994) or as a broader part of the relationship between science and society (cf. Jasanoff 2004), means that the co-production of knowledge, wherein end-users inform, shape, or actively participate in the research process, is becoming increasingly important to science policy (Nutley 2010; Hickey, Richards and Sheehy 2018). Co-production of knowledge can be a particularly effective means of ensuring academic–industry (academic–stakeholder) collaborations (Gibbons et al. 1994; Cherney 2015).

Given the perceived benefits, these collaborations have been actively encouraged (in the UK for instance by the Lambert Review 2003). Indeed, in Armstrong and Alsop (2010), written by the head of knowledge exchange and head of research at the Economics and Social Science Research Council (ESRC) at the time, co-production was explicitly advocated as a crucial mechanism for generating impact.

Because co-production directly involves end-users (Hickey, Richards and Sheehy 2018) the resulting work is more likely to have the desired value and/or outcome for those end-users once research is completed. For this reason, co-production has been touted as a model for driving academic impact (Armstrong and Alsop 2010). Despite this, co-production is also inherently risky, time-consuming and challenging to academic norms (Flinders, Wood and Cunningham 2016). To this end, incentivizing co-production through impact (both through funding priorities and through research evaluation such as the REF) is a way of encouraging academics to engage. In a co-production mode, we therefore expect researchers to explicitly identify research outputs as being co-produced with stakeholders, either identified in the bidding stage or the impact case. This would be an indication that the intended recipients of the research were also the end-users and source of the impact.

3. Research approach and methodology

Our aim in this article is to compare *ex post* claims of impact with their *ex ante* predictions of impact and assess the extent to which research impact is predictable. In order to make this comparison, we use evidence from one of the largest and most-studied *ex post* assessment exercises in the world: the UK Research Excellence Framework, or REF.

3.1 The UK research excellence framework

The REF was announced in 2011, following from the UK's Research Assessment Exercise, which ran from 1986 to 2007. The REF serves to allocate quality-related (QR) research funding to institutions worth just over £1.5bn. This institutional block funding is considerably less than the £8bn in research council funding, but it remains a sizable award for many universities and is also likely to confer status advantages.[5]

The impact component of the REF is intended to direct some of this QR funding towards rewarding institutions for research impact, *post hoc*.[6] The number of impact case studies each institution is expected to submit is related to the number of research-active staff members. On this basis, institutions are incentivized to identify the most promising impact cases and to invest in presenting these as clearly and convincingly as possible.[7]

Working within these restrictions, a university must identify and submit its strongest impact cases for each of the 36 disciplinary panels in the REF. The impact cases are reviewed by the senior academics who form the REF panel, and who award cases a rating, from 1* ('recognized but modest') to 4* ('outstanding'). The higher the rating of a department's research, the more public research funding the department will receive. The 2014 REF exercise saw 6,679 impact cases submitted to the 2014 REF were and assessed by disciplinary evaluation panels. Notably, following conclusion of the exercise all submitted impact cases were published. The impact cases submitted to the 2014 REF not only showcased exemplars of research impact, but also systematically accounted for around one case for every nine faculty members across UK institutions.

3.2 Methodological approach

We began by collecting information on REF impact case studies and linked grants awarded by UKRI (UK Research & Innovation), the umbrella group including all UK public research councils.[8] This was done in two steps: algorithmic extraction of DOIs of the 'underpinning references' contained in REF impact case studies,[9] and then a search of Gateway to Research using these DOIs for UKRI grants.

Our dataset comprised 2,194 case–grant pairs. For these we collected the panel and sub-panel unit to which the case was submitted, and the impact type of the case, and the research council awarding the grant linked to the case. Of these, 209 pairs have potential/planned impact statements available in their grant descriptions.[10] We used all of these 209 pairs as a subsample, for more detailed analysis and comparison with REF impact statements.[11] Examples of matched impact cases and REF impact statements are provided in Supplementary Appendix 4.

In the initial analysis, we compared the topic-focus of the research impact with the topic-focus of its funding council. On the impact case side of the pair, we are able to explore the topic-focus of the research impact by observing which of the four REF panels (or 36 sub-panels) the cases were submitted to, and we can also observe which of the eight impact type labels were assigned to the cases as reported in the REF2014 website.[12] On the grant side of the pair, we are able to explore the topic-focus at the outset of projects by observing which research councils funded them. However, since research councils have broad and overlapping remits (see Supplementary Appendix 1), this remains a rough proxy for topic-focus.

So, in our second set of analyses, we manually reviewed a subsample of case–grant pairs in more detail. This allowed us to assess the topic-focus of grants beyond identifying the funding council that funded the impact to a greater degree of specificity. Additionally, by reviewing these manually, we were also able to assess stakeholder-focus of the cases and their grants, and identify special cases where there seemed to be co-production from the outset.

We reviewed each case–grant pair in our subsample and categorized the following:

- *Type of stakeholder* identified in the Pathways statement and in the impact case. These were coded as public sector (e.g. government, schools, or hospitals); private sector (e.g. businesses or industry associations); third sector (e.g. NGOs, charities, museums, or cultural organizations,

Downloaded from https://academic.oup.com/rev/article/32/2/273/7224528 by guest on 03 November 2023

etc.); or international government or agency (e.g. World Bank, OECD, UN, NATO, etc.). Multiple categories could be used. We coded any academic user (for instance referring to the academic impact of a piece of research) as null for the purposes of this article.

- *Co-production* between the academics and the end-user. If the Pathways statement made explicit reference to producing a piece of research directly with a specific stakeholder who was then mentioned in the eventual impact case, this was coded as a *Yes*.
- *Topic alignment* between the Pathways statement and impact case. Comparing the Pathways statement and impact case, this captured whether the topics covered in the two texts were at least roughly within the same research domain. This was a binary variable; if the topics were deemed to be distant, they were to be coded as *No*.
- *Specific matches of stakeholders or topics*. Building on the stakeholder and topic categories above, we coded for two binary variables: exact stakeholder match or exact topic or technology match. These were coded as Yes if the exact same stakeholder or topic was mentioned in the Pathways statement and impact case.

To categorize the subsample, we prepared a categorization manual (see Supplementary Appendix 2). To assess reliability of categorization with this manual, 10% of the subsample was randomly selected and reviewed by three independent reviewers with backgrounds from across the physical sciences, social sciences, and humanities.[13] Inter-rater reliability was calculated using Krippendorf's alpha, with scores exceeding 0.7 across all categories, indicating substantial agreement, beyond chance (Hayes and Krippendorff 2007).

For clarity, we did not attempt here to address how research impact could be 'increased', and questions regarding the possible characteristics of research that lead to REF-impact versus non-REF-impact. For this, we would ideally have statements of intended impact on record for all instances of impact and non-impact. This is not possible on multiple counts.[14] Instead, we examined sources of impact, conditional on REF-inclusion. We looked back in time to see the extent to which impact claims were explicitly anticipated.

4. Results

As highlighted above, this article is based on a dataset of REF impact cases that have been traced back to UK research council-funded projects. These were analysed as case–grant pairs, the results of which are presented below.

4.1 Impact topic and funder remit show alignment

In the first instance, we begin by considering the overall sample frame of 2,194 case–grant pairs.

Table 2 below sets these pairs out across the four large REF panels (Medicine and Health, Engineering and Environment, Law and Policy, and Arts and Culture), and shows what share can be traced to funders with different remits.

The panel remit, to which impact cases have been submitted, broadly align with the remits of the Research Council funding the impact. Some case–grant pairs seem to be linked to funders with differing remits, though these rarely rise above third-place funder. Table 3 shows that each REF impact panel has a research council with which it is most closely associated (for instance, Medicine and Health panel has 70% of its cases linked back to Medical Research Council-funded projects). However, it also shows that impact panels draw on other funding sources. There is a dominant funder, but it does not act alone; there are allied funding sources too.

Supplementary Table A3.1 in the appendix breaks these cases down by panel and sub-panel. Across the 36 sub-panels, the median share of cases linked to the top funder is 76%. This also shows that impactful research is not exclusively funded by the dominant funder.

Looking at sub-panels in particular it is possible to imagine the cases in which different funders' research might result in variation in impact case submissions. For instance, Panel D32, Philosophy, has a majority of impact cases arising from the Arts & Humanities Research Council funding (79%) but also has impact cases emerging from the Economic and Social Research Council (14%) and the Medical Research Council (7%), both of which have funding interests (for instance, issues around ethics) that could be captured by philosophy as a discipline.

These results show that panels are generally dominated by a particular research funder. Equally, it also shows a diversity of minority funding sources contributing to impact in particular disciplines.

In addition to panels and sub-panels, we also explored different impact types and their funding sources (Table 3). These classifications were manually coded on behalf of Research England and are part of the publicly accessible data. These offer further corroboration of our results above.

However, both of these approaches above rely on using the research council's remits as an initial indication of topic. As discussed, the research council may be too coarse a unit of topic-analysis since research councils have overlapping remits. Accordingly, we manually reviewed and categorized a subsample of case–grant pairs to examine their topic alignment and their stakeholder alignment. This allowed us to assess not only the frequency with which we might observe alignment, but also the degree and specificity of the alignment.

Table 2. Share of impact cases, by REF panel, linked to funding, by UK Research Council

REF impact panel	Number of case–grant pairs	Share of impact cases linked to funders (top 3, by %)
A—Medicine and Health	784	MRC (70); BBSRC (11); ESRC (9)
B—Engineering and Environment	800	EPSRC (49); NERC (23); STFC (15)
C—Law and Policy	459	ESRC (57); NERC (14); EPSRC (14)
D—Arts and Culture	151	AHRC (64); ESRC (20); EPSRC (14)

AHRC, Arts & Humanities Research Council; BBSRC, Biotechnology and Biological Sciences Research Council; EPSRC, Engineering and Physical Sciences Research Council; ESRC, Economic and Social Sciences Research Council; MRC, Medical Research Council; NERC, National Environment Research Council; STFC, Science and Technology Facilities Council.

Downloaded from https://academic.oup.com/rev/article/32/2/273/7224528 by guest on 03 November 2023

4.2 *Ex post* and *ex ante* impact claims show alignment in more detail

When we turn to the 209 case–grant pairs that were manually coded, we can begin to see in more detail the extent to which the framework set forth in Section 2 plays out within the data. This is presented below.

For stakeholders, as defined in Section 3, case–grant pairs were categorized as those where the type of stakeholder in the REF case and impact statement did not match (e.g. the impact statement in the funding proposal said the beneficiary would be government but the beneficiary in the impact case was in the private sector); where at least one type of stakeholder matched but was not specifically identified, or specific organizations did not match (e.g. the impact statement said a government ministry would benefit and the government was indeed cited in the REF case); or where the exact stakeholder was identified in the impact statement and the REF impact case. For topics, we considered them matched if the REF case and impact statement were in the same general research domain, and considered them to be exactly matched if precisely the same technology were mentioned in both instances.

In Table 4, we see that a majority of impact cases identify either the general or exact type of stakeholders (89%), and a similar majority set out either the general or exact topic of impact (83%), as was initially set out in their funding proposals. A small percentage even identified the precise topic or stakeholder in their funding bid that then subsequently appeared in the REF impact case. Conversely, it is notable that only 16% of impact cases cited research that was funded on the basis of a completely different topic; and only 12% of cases featured stakeholders not already previously identified.

Some differences emerge when we disaggregate these figures by research councils. Considering stakeholder alignment, exact stakeholders were more likely to be identified in the arts, humanities and social sciences, with 61% of Arts and Humanities Research Council-funded cases and 36% of Economic and Social Science Research Council-funded cases reflected the same exact stakeholders between funding bid and impact case. By contrast, the highest percentage of cases where stakeholders were not predicted were for funding for science and technology facilities (e.g. research infrastructure), with 39% and life sciences, with 27%. This perhaps speaks to differences in funding expectations—for infrastructure the use cases are likely be more uncertain than in arts and humanities, where end-users may be easier to identify. Topic alignment is a slightly different picture, with comparatively few cases completely identifying the precise topic of impact in the impact case at funding stage. For each research council a majority of topics were generally aligned, and the absence of alignment was most common with 28% with facilities investment again, and for medical research.

We turn to where the identification of stakeholders and topics interact. From Figure 2 below, we can see that it was very uncommon that the exact stakeholders were identified but the topic of impact was subsequently different from the impact statement, or that the topic was exactly identified but with substantially different stakeholders (1 pair). Case–grant pairs where stakeholders were similar and topics were similar, were the most common (89 pairs). This is followed by case–grant pairs where the stakeholders were exactly identified and the topics were similar (51 pairs). A relatively low number cases had prior identification of the precise stakeholders and topic of the impact (11 pairs). Likewise, relatively few had substantial differences from the stakeholders and topics that had been identified in the funding proposal (12 pairs).

Overall, the six cells on the right of Figure 2, where the topic is aligned to at least some extent, make up 84% of the 209 pairs. These resonate with our findings from Section 4.1 where 76% of 2,194 pairs showed alignment with the dominant funder's remit. The six cells across the top of Figure 2, where the stakeholders are aligned to at least some extent, make up 88% of the 209 pairs.

Table 3. Share of impact cases, by impact type, linked to funding, by UK Research Council

REF impact, by impact type	Number of case–grant pairs	Share of impact cases linked to funders (top 3, by %)
Technological	612	EPSRC (50); MRC (25); BBSRC (10)
Health	449	MRC (81); ESRC (9); EPSRC (5)
Societal	442	ESRC (38); EPSRC (17); STFC (17)
Environmental	300	NERC (66); ESRC (13); EPSRC (12)
Economic	85	EPSRC (39); ESRC (39); NERC (11)
Cultural	125	AHRC (59); ESRC (14); NERC (11)
Political	155	ESRC (35); MRC (34); EPSRC (14)
Legal	26	ESRC (81); AHRC (8); EPSRC (8)

AHRC, Arts & Humanities Research Council; BBSRC, Biotechnology and Biological Sciences Research Council; EPSRC, Engineering and Physical Sciences Research Council; ESRC, Economic and Social Sciences Research Council; MRC, Medical Research Council; NERC, National Environment Research Council; STFC, Science and Technology Facilities Council.

Table 4. Identification of stakeholders and topics mentioned in REF impact cases in original impact statements, by Research Council

	Stakeholder class of REF case not identified in impact statement (%)	Stakeholder class of REF case identified in impact statement (%)	Exact stakeholder mentioned in REF case identified in impact statement (%)	Topic of REF case not identified in impact statement (%)	General topic of REF case identified in impact statement (%)	Exact topic of REF case identified in impact statement (%)
AHRC	3	35	61	0	90	10
BBSRC	27	55	18	9	73	18
EPSRC	11	61	28	15	68	15
ESRC	9	55	36	23	77	0
MRC	6	81	13	28	59	13
NERC	0	75	25	0	100	0
STFC	39	50	11	28	72	0
Total	12	59	30	16	72	11

AHRC, Arts & Humanities Research Council; BBSRC, Biotechnology and Biological Sciences Research Council; EPSRC, Engineering and Physical Sciences Research Council; ESRC, Economic and Social Sciences Research Council; MRC, Medical Research Council; NERC, National Environment Research Council; STFC, Science and Technology Facilities Council.

Downloaded from https://academic.oup.com/rev/article/32/2/273/7224528 by guest on 03 November 2023

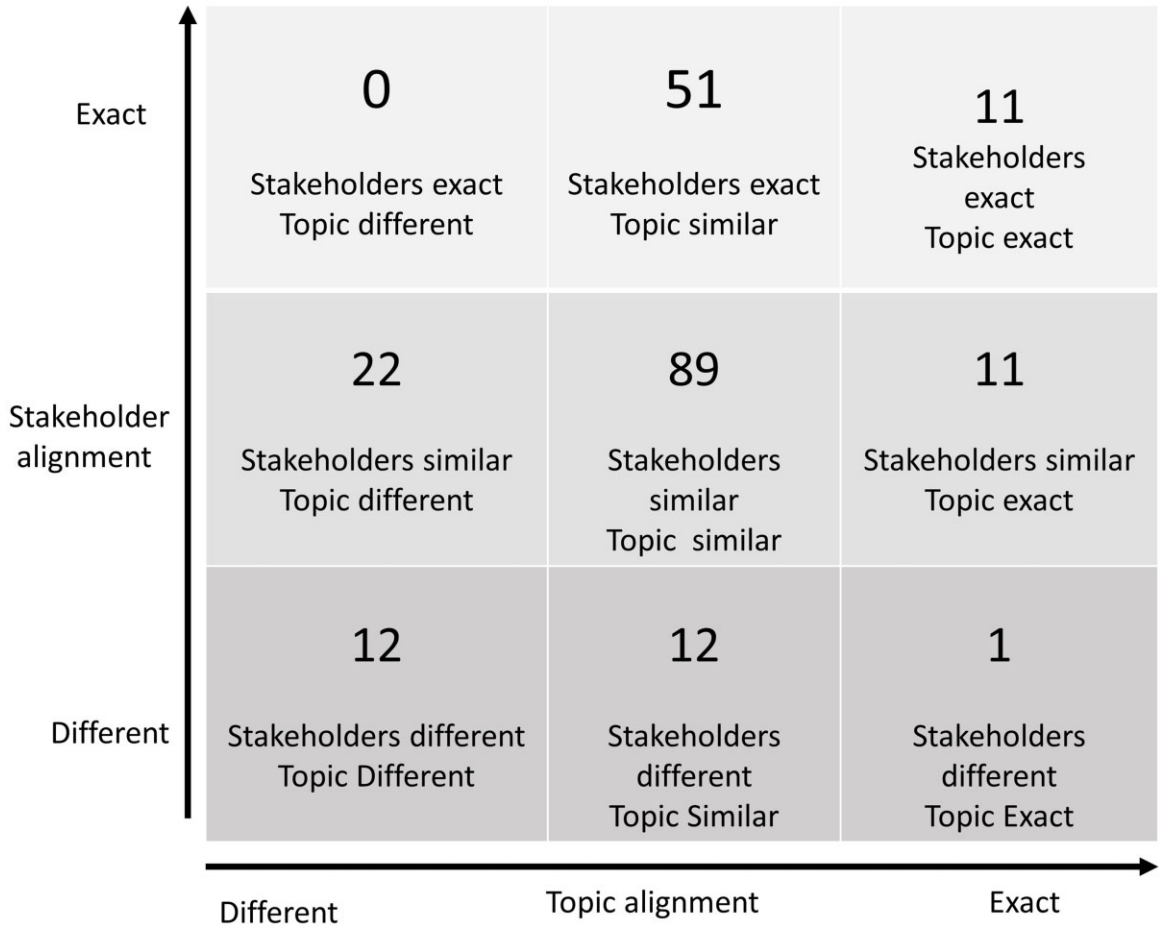

Figure 2. Stakeholder and topic alignment in the sample of REF impact cases (n = 209).

4.3 Co-production in funding-REF case pairs

In coding the data, we also coded for 'co-production', that is, an explicit mention in the pathways to impact statement of working with an end-user that was then mentioned in eventual impact case. We found that 'co-production' was coded in 112 (54%) of our sample.

Co-production was prevalent, and featured across research council funding sources as shown below. Table 5 shows that co-production in case–grant pairs did not vary substantially between research councils, with the exception of Science and Technology Facilities Council (STFC, which invests in facilities and infrastructure, and hence could be expected to show less co-production). Notably, the funder with the highest share of its pairs coded as positive for co-production was Arts & Humanities Research Council (AHRC). As noted previously in Table 4, AHRC also had the highest level of exact stakeholder alignment at 61%. The next highest, Engineering and Physical Sciences Research Council (EPSRC) was substantially lower in terms of exact stakeholder alignment (at 28% in Table 4) but still had 60% of pairs representing co-production in Table 5.

It is possible that some of this variation is influenced by the type of impact (as seen above in Table 4). These are broken down in Table 6 below. These show that co-production in REF impact cases is indeed more common in cultural impacts (as expected) but also where impacts are economic and technological (which might not be anticipated by the research council figures in Table 5). Between them, these perhaps point to different modes of co-production and stakeholder engagement in the disciplines and types of impact funded by this research.

Table 5. Percentage of cases co-produced, by research council

Funding council	% cases co-produced	Number of cases
AHRC	61	31
BBSRC	55	11
EPSRC	60	91
ESRC	50	22
MRC	47	32
NERC	50	4
STFC	22	18
Total	54	209

Table 6. Percentage of cases co-produced, by impact type

	% cases co-produced	Number of cases
Cultural	63	24
Economic	69	13
Environmental	53	17
Health	40	30
Legal	0	1
Political	50	10
Societal	47	57
Technological	61	57
Total	54	209

Downloaded from https://academic.oup.com/rev/article/32/2/273/7224528 by guest on 03 November 2023

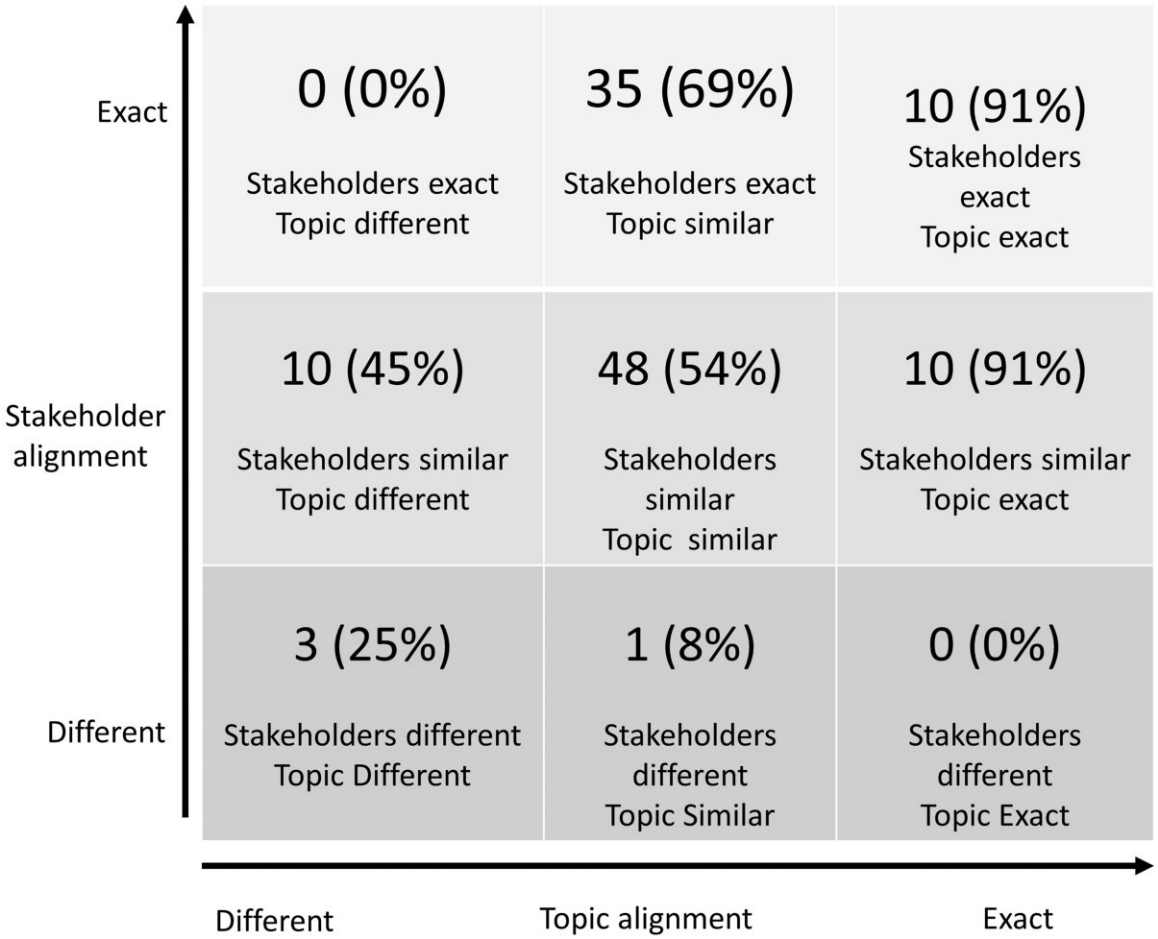

Figure 3. Counts of cases reporting co-production (percentage of cases reporting co-production as share of all cases in cell in brackets).

Figure 3 shows the count and percentage of cases coded for co-production against our framework originally set out in Section 2. We see here that there is an association between co-production and alignment of topic and stakeholders. Co-production appears to be common where impact cases are closely aligned and less so where there is less alignment. However, the association is not exhaustive and uniform across all pairs, since some cases, where there is substantial disparity between anticipated and actual stakeholders, still proved to be the result of co-production.

5. Discussion

As research impact becomes an increasingly important part of the research evaluation landscape, one fundamental question about impact relates to the extent to which the nature and direction of impact activities can be foreseen by researchers. This question has substantial implications for the effectiveness of research funding in delivering social impacts, particularly with regard to the design of funding mechanisms and incentive structures for funders, universities, and researchers.

This article addresses this question by exploring whether cases of impact claimed in the UK REF were anticipated at the outset of research projects. Using matched pairs of impact cases and underlying cited research projects, and a subsample of predicted impact statements, we explore the extent of alignment between *a priori* and *ex ante* evaluations of impact with respect to the stakeholders identified, the topics of research and the role of co-production as a driver of impact. Our aim in doing this is to assess the extent to which uncertainty and serendipity contribute to (*ex ante*) impact, and the implications for research funding systems (cf. Polanyi 1962; Yaqub 2018).

5.1 Alignment between *ex post* and *ex ante* impact claims: a reflection of multiple funding rationales and perspectives

Our findings regarding alignment of *ex post* and *ex ante* impacts appear to reflect at least two parallel funding rationales; one perspective that seeks to steer research towards specific outcomes, and another that seeks to exploit unforeseen opportunities emerging from research.

For steering research towards specific outcomes, our analysis shows that research impact can, to a measurable extent, be explicitly anticipated before research is funded, at the topic and stakeholder level. Our analysis finds that 76% of impact cases in the REF are submitted to panels within the remit of the UK research councils that funded them. Analysis of our subset of *ex ante* impact statements also shows close alignment between the topics and stakeholders in the *ex ante* and

Downloaded from https://academic.oup.com/rev/article/32/2/273/7224528 by guest on 03 November 2023

ex post impact statements. On this basis, our findings do not support an interpretation that processes of impact are completely unpredictable on a wide scale, or represent window-dressing (in contrast to interviewees in Chubb and Watermeyer (2017)). Indeed, we find that *ex ante* statements of impact, while unpopular (and discontinued in the UK in 2020), provide a reasonable signal of the direction of future impact.

For taking advantage of unforeseen opportunities arising from research, our analysis conversely shows that nearly one-quarter of REF impact cases in our sample were submitted to panels outside the conventional remits of their funding bodies. These include interdisciplinary research related to research councils' core aims (for instance the AHRC funding research on the creative industries, or the EPSRC funding research on ethics of AI). Our subsample analyses further show that there are non-negligible cases in which the impacts of a piece of funded research are not foreseen, with 17% of cases addressing a topic that differs appreciably from the original impact statement, and 12% of cases where the type of beneficiary varied from that which had originally been predicted.

The presence of parallel rationales begs a broader question of what a socially optimal level of expected or unexpected research outcomes might be. Is alignment of 76% between research councils and REF disciplinary panels high or low? Complete 100% unpredictability would not be desirable as it would undermine the value of directed funding at all. Equally, 100% success in targeting impact in a particular field could reflect serendipitous opportunities being overlooked or perhaps even a stifling of creativity. The ratio seen in our data appears to reflect a mix of both rationales. The finding that only a small share of our cases addressed the precise topic identified at the funding stage shows that there are degrees of uncertainty in the research process, and that these vary between disciplines (e.g. the benefits of scientific infrastructure and medicine may be more unforeseeable than, perhaps, arts and humanities where 'normal impact' relations between academics and stakeholders provide an ongoing, and relatively predictable, source of impact (cf. Sivertsen and Meijer 2020)). Our findings also show that end-users of research are often identifiable at the funding stage of research, highlighting the importance of building longer-term relationships between researchers and the stakeholders who have interest in their work (cf. Isett and Hicks 2020).

Perhaps more salient than the actual level of alignment is the ability to adjust it. Our findings regarding co-production as a driver of impact suggests that there is scope for policy intervention, if desired. We find co-production[15] to be common, appearing in more than half (54%) of our sample. The presence of co-production is indicative of close alignment between stakeholders and topic, but the association is not ubiquitous. While co-production has been put forward by research funders as a driver of impact (Armstrong and Alsop 2010), it is only one of many pathways by which impact can be generated (Muhonen, Benneworth and Olmos-Peñuela 2019). On this basis, we can conclude that co-production can be a mechanism for changing alignment of intended and revealed impact outcomes, but it is unlikely to be the only one.

Our article makes a contribution to the literature by teasing out the underlying tensions between *ex ante* and *ex post* descriptions of impact, and relating them to the issue of desirability of predictable impact. In doing so, we show that there are meaningful levels of alignment between anticipated and realized impact outcomes, and that co-production is a common but not definitive channel aligning these anticipated and realized impacts.

5.2 Limitations

There are sources of possible over- and under-estimate in the degree of alignment we see in our data beyond the factors, such as selection, we have previously discussed. One source of overestimate is the use of broad categories within our dataset. A more elaborate classification scheme (for instance using more of the models of impact identified in Muhonen, Benneworth and Olmos-Peñuela (2019)) may have resulted in more cross-category movement, though this would have been more prone to yielding low inter-rater agreement.

One source of under-estimate could lie in the way in which funding sources are acknowledged in research outputs (Hopkins and Siepel 2013; Grassano et al. 2017). Our approach relied on the attribution of research outputs to specific research projects. Mis-attributed grants that have only a tenuous link to either the research output or the impact case could lead to under-estimates, though it should be noted that we found little evidence for this.

Further factors could affect our estimates, though whether these contribute to over- or under-estimates is not obvious. These include the window of time between the *ex post* and *ex ante* claims; the presence of other funding sources attributed to underpinning references; and how negative impact is perceived, where academic guidance meant that a change did *not* happen (for instance, if academic research was used as the basis *not* to adopt a proposed regulation). For each of these, it is not clear *a priori* how they might affect estimates though it is likely that further research would make headway on each of the respective issues.

5.3 Further implications

We have seen that researchers who are engaged with stakeholders, and who are funded by research councils, may then subsequently generate impactful research. From a research funder perspective, our work highlights the importance of developing and strengthening capacity for providing impact among researchers (for instance through building strong stakeholder relationships). In particular, awareness of the potential specific beneficiaries at the research design stage appears to be useful.

Current efforts to this end, such as the Higher Education Innovation Fund (HEIF) in the UK, which supports collaboration and dissemination activities through a block grant provided to institutions, point to ways in which capacity-building for stakeholder engagement can be funded. If there is a danger of REF lapsing into an 'audit culture' that prioritizes specific linear, documentable outcomes (cf. Martin 2011; Watermeyer and Hedgecoe 2016; Power 2018), funder-level interventions like HEIF show the potential for complementary forms of funding to support institutional 'impact cultures'. Researchers are responsive to university-level changes in emphasis to impact activities (de Jong and Balaban 2022), so institutional focus on stakeholder engagement and external relationships may help to drive a broad spectrum of impacts. These may include those that are 'REF-able' but also those that are more difficult to capture.

The literature on impact has grown substantially in recent years, and this work points to numerous rich areas for further study. In particular, other ways of exploring the relationship

Downloaded from https://academic.oup.com/rev/article/32/2/273/7224528 by guest on 03 November 2023

between *ex ante* and *ex post* evaluations of impact, particularly outside of public research settings, could be very useful. The role of selection effects, both at the institutional level in the selection of cases to submit to the REF, and in the funding of research projects, is particularly interesting. The forthcoming data from the REF 2021 exercise will also provide new data for exploring and understanding these relationships. The increased weighting on the impact component of REF 2021 suggests there remains appetite to interrogate the impact agenda further.

In conclusion, this article has aimed to explore how eventual impact, as measured in the REF, compares with promises of impact before the research was funded. We have presented evidence showing that, more often than not, impact results from research funding that had anticipated the focal impact.

Notes

1. Polanyi notably wrote 'You can kill or mutilate the advance of science, you cannot shape it. For it can advance only by essentially unpredictable steps, pursuing problems of its own, and the practical benefits of these advances will be incidental and hence doubly unpredictable' (Polanyi 1962: 62). Polanyi's critique reflected anxiety over Soviet approaches to science but the sentiment perseveres in contemporary concerns around research evaluation.
2. The limited usefulness of these statements for making funding decisions, as well as the time involved to write them, were cited as reasons behind the dropping of 'pathways to impact' statements from UK research council grant applications in 2020, as part of a broader review of research bureaucracy (Wilsdon 2020).
3. For example, potential cases were deemed 'not cooked enough' to be submitted, in terms of establishing a direct line of causality back to the underpinning research (Watermeyer and Hedgecoe 2016).
4. We note here that Pathways statements mean that beneficiaries must be identified in some way, so research that does not mention any potential beneficiaries is unlikely to be funded. Indeed, we see no such cases in our data.
5. The award could also serve as 'pump-priming' and help to secure further funding from other sources.
6. The two other components of an institution's REF submission consist of: a selection of its publication outputs, and a statement on its research environment, which are reviewed by REF panel members. Overall, the 2014 REF award is weighted with 65% towards publication outputs, 15% on environment, and 20% for impact.
7. There is evidence indicating that universities have invested considerable resources into generating these impact cases (Manville et al. 2015; Watermeyer and Hedgecoe 2016; Power 2018). These range from identification of impact case candidates, to selecting which to develop and submit, as well as finding corroborating evidence trails for the impact. Impact case studies therefore represent the culmination of a very substantial data collection effort.
8. We are comparing GtR data with REF Case data: https://gtr.ukri.org/resources/data.html; https://gtr.ukri.org/resources/GtRDataDictionary.pdf; https://impact.ref.ac.uk/casestudies/APIhelp.aspx.
9. The extraction of DOIs was undertaken by Digital Science for Research England, UKRI. We thank Steven Hill for helping us with this data.
10. *Ex ante* pathway statements were only introduced in 2007, so we do not have *ex ante* statements for research funded before this time. The cases in our survey therefore capture where impact cases cited funding received in the four years prior to the REF 2011 census date.
11. To summarize, 90% of grants in our subsample were research grants (compared to 10% being fellowships), with the median grant duration being three years and median grant value being £490,106.
12. See 'What is Summary Impact Type?' available at https://impact.ref.ac.uk/casestudies/FAQ.aspx
13. While our inter-rater reliability scores and multidisciplinary background of raters give us confidence that our coding scheme minimized disciplinary biases, the existence of such biases does remain a possibility.
14. First, Pathway statements were only introduced in 2007, so we do not have *ex ante* statements before then. Second, Pathways statements were only required for UK researchers seeking funding from UK research councils, so researchers with other funding sources (such as European funding, or funding from other foundations, or researchers whose research does not require outside funding) do not complete Pathways statements.
15. Co-production was defined as an explicit reference to producing research directly with a specific stakeholder who was then identified in the eventual impact case (see also Supplementary Appendix 3 for further details on our definition).

Supplementary data

Supplementary data are available at *Research Evaluation Journal* online.

Acknowledgements

We thank Ben Martin for thoughtful and detailed comments. We thank Steven Hill for helping us with the data and for several illuminating discussions. We also thank Ismael Rafols, Josie Coburn, Steven Wooding, Constantin Blome, and Amanda Ribeiro for comments and assistance. The views expressed here may not necessarily reflect those of Research England. We acknowledge support from European Research Council grant 759897.

References

Andriani, P., and Kaminska, R. (2021) 'Exploring the Dynamics of Novelty Production through Exaptation', *Research Policy*, 50: 104171.

Armstrong, F., and Alsop, A. (2010) 'Debate: Co-Production Can Contribute to Research Impact in the Social Sciences', *Public Money & Management*, 30: 208–10.

Arza, V., and Carattoli, M. (2017) 'Personal Ties in University-Industry Linkages: A Case-Study from Argentina', *The Journal of Technology Transfer*, 42: 814–40.

Bonaccorsi, A., Chiarello, F., and Fantoni, G. (2021) 'Impact for Whom? Mapping the Users of Public Research with Lexicon-Based Text Mining', *Scientometrics*, 126: 1745–74.

Boswell, C., and Smith, K. (2017) 'Rethinking Policy "Impact": Four Models of Research-Policy Relations', *Palgrave Communications*, 3: 1–10.

Bozeman, B., and Boardman, C. (2009) 'Broad Impacts and Narrow Perspectives: Passing the Buck on Science and Social Impacts', *Social Epistemology*, 23: 183–98.

Bozeman, B., and Youtie, J. (2017) 'Socio-Economic Impacts and Public Value of Government-Funded Research: Lessons from Four US National Science Foundation Initiatives', *Research Policy*, 46: 1387–98.

Cherney, A. (2015) 'Academic–Industry Collaborations and Knowledge Co-Production in the Social Sciences', *Journal of Sociology*, 51: 1003–16.

Chubb, J., and Watermeyer, R. (2017) 'Artifice or Integrity in the Marketization of Research Impact? Investigating the Moral Economy of (Pathways to) Impact Statements within Research Funding Proposals in the UK and Australia', *Studies in Higher Education*, 42: 2360–72.

Collini, S. (2012) *What Are Universities for*? London: Penguin.

De Jong, S. P. L., and Balaban, C. (2022) 'How Universities Influence Societal Impact Practices: Academics' Sense-Making of Organizational Impact Strategies', *Science and Public Policy*, 49: 609–20.

De Jong, S. P. L., and Muhonen, R. (2020) 'Who Benefits from Ex Ante Societal Impact Evaluation in the European Funding Arena? A

Downloaded from https://academic.oup.com/rev/article/32/2/273/7224528 by guest on 03 November 2023

Cross-Country Comparison of Societal Impact Capacity in the Social Sciences and Humanities', *Research Evaluation*, 29: 22–33.

De Jong, S. P. L., Wardenaar, T., and Horlings, E. (2016) 'Exploring the Promises of Transdisciplinary Research: A Quantitative Study of Two Climate Research Programmes', *Research Policy*, 45: 1397–409.

Durrant, H., and MacKillop, E. (2022) 'University Policy Engagement Bodies in the UK and the Variable Meanings of and Approaches to Impact', *Research Evaluation*, 31: 372–84.

Flinders, M., Wood, M., and Cunningham, M. (2016) 'The Politics of Co-Production: Risks, Limits and Pollution', *Evidence & Policy: A Journal of Research, Debate and Practice*, 12: 261–79.

Freeman, C., and Soete, L. (1997) *The Economics of Industrial Innoation*, London: Routledge.

Gibbons, M., Limoges, C., Scott, P., Schwartzman, S., and Nowotny, H. (1994) *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*. London: Sage.

Grassano, N., Rotolo, D., Hutton, J., Lang, F., and Hopkins, M. M. (2017) 'Funding Data from Publication Acknowledgments: Coverage, Uses, and Limitations', *Journal of the Association for Information Science and Technology*, 68: 999–1017.

Greenhalgh, T., Raftery, J., Hanney, S., and Glover, M. (2016) 'Research Impact: A Narrative Review', *BMC Medicine*, 14: 78.

Hayes, A. F., and Krippendorff, K. (2007) 'Answering the Call for a Standard Reliability Measure for Coding Data', *Communication Methods and Measures*, 1: 77–89.

Hickey, G., Richards, T., and Sheehy, J. (2018) 'Co-Production from Proposal to Paper', *Nature*, 562: 29–31.

Hicks, D. (2012) 'Performance-Based University Research Funding Systems', *Research Policy*, 41: 251–61.

Hill, S. (2016) 'Assessing (FOR) Impact: future Assessment of the Societal Impact of Research', *Palgrave Communications*, 2: 16073. doi: 10.1057/palcomms.2016.73.

Holbrook, J. B. (2005) 'Re-Assessing the Science–Society Relation: The Case of the US National Science Foundation's Broader Impacts Merit Review Criterion', *Technology in Society*, 27: 437–51.

Hopkins, M. M., and Siepel, J. (2013) 'Just How Difficult Can It Be Counting up R&D Funding for Emerging Technologies (and is Tech Mining with Proxy Measures Going to Be Any Better)?', *Technology Analysis & Strategic Management*, 25: 655–85.

Irvine, J., and Martin, B. (1983) 'Assessing Basic Research: The Case of the Isaac Newton Telescope', *Social Studies of Science*, 13: 49–86.

Isett, K. R., and Hicks, D. (2020) 'Pathways from Research into Public Decision Making: Intermediaries as the Third Community', *Perspectives on Public Management and Governance*, 3: 45–58.

Jasanoff, J. (2004) *States of Knowledge*. London: Routledge.

Johnson, M. T. (2022) 'The Knowledge Exchange Framework: Understanding Parameters and the Capacity for Transformative Engagement', *Studies in Higher Education*, 47: 194–211.

Joly, P.-B., Gaunand, A., Colinet, L., Larédo, P., Lemarié, S., and Matt, M. (2015) 'ASIRPA: A Comprehensive Theory-Based Approach to Assessing the Societal Impacts of a Research Organization', *Research Evaluation*, 24: 440–53.

Ma, L., Luo, J., Feliciani, T., and Shankar, K. (2021) 'How to Evaluate Ex Ante Impact of Funding Proposals? An Analysis of Reviewers' Comments on Impact Statements', *Research Evaluation*, 29: 431–40.

Manville, C., Morgan Jones, M., Henham, M.-L., Castle-Clarke, S., Frearson, M., Gunashekar, S., and Grant, J. (2015). *Preparing Impact Submission for REF 2014: An Evaluation*. Cambridge: RAND.

Martin, B. R. (2011) 'The Research Excellence Framework and the "Impact Agenda": Are We Creating a Frankenstein Monster?', *Research Evaluation*, 20: 247–54.

Martin, B. R., and Irvine, J. (1983) 'Assessing Basic Research: Some Partial Indicators of Scientific Progress in Radio Astronomy', *Research Policy*, 12: 61–90.

Meagher, L. R., and Martin, U. (2017) 'Slightly Dirty Maths: The Richly Textured Mechanisms of Impact', *Research Evaluation*, 26: rvw024.

Merton, R., and Barber, E. (2004) *The Travels and Adventures of Serendipity: A Study in Sociological Semantics and the Sociology of Science*, Princeton, NJ: Princeton University Press.

Mervis, J. (1997) 'NSF Adopts New Guidelines', *Science*, 276: 26.

Muhonen, R., Benneworth, P., and Olmos-Peñuela, J. (2019) 'From Productive Interactions to Impact Pathways: Understanding the Key Dimensions in Developing SSH Research Societal Impact', *Research Evaluation*, 29: 34–47.

Murphy, T. (2017) 'Revising the Research Excellence Framework: Ensuring Quality in REF2021, or New Challenges Ahead?', *Perspectives: Policy and Practice in Higher Education*, 21: 34–9.

Nutley, S. (2010) 'Debate: Are we All co-Producers of Research Now?', *Public Money &Management*, 30: 263–5.

Penfield, T., Baker, M. J., Scoble, R., and Wykes, M. C. (2014) 'Assessment, Evaluations, and Definitions of Research Impact: A Review', *Research Evaluation*, 23: 21–32.

Perkmann, M., Salandra, R., Tartari, V., McKelvey, M., and Hughes, A. (2021) 'Academic Engagement: A Review of the Literature 2011-2019', *Research Policy*, 50: 104114. doi: 10.1016/j.respol.2020.104114.

Polanyi, M. (1962) 'The Republic of Science: Its Political and Economic Theory', *Minerva*, 1: 54–73.

Power, M. (2018) 'Creativity, Risk and the Research Impact Agenda in the United Kingdom', *European Review*, 26: S25–S34.

Razmgir, M., Panahi, S., Ghalichi, L., Mousavi, S. A. J., and Sedghi, S. (2021) 'Exploring Research Impact Models: A Systematic Scoping Review', *Research Evaluation*, 30: 443–57.

Reed, M. S., Ferré, M., Martin-Ortega, J., Blanche, R., Lawford-Rolfe, R., Dallimer, M., and Holden, J. (2021) 'Evaluating Impact from Research: A Methodological Framework', *Research Policy*, 50: 104147.

Ross, C., Nichol, L., Elliott, C., Sambrook, S., and Stewart, J. (2021) 'From Chain to Net: Assessing Interdisciplinary Contributions to Academic Impact through Narrative Case Studies', *Studies in Higher Education*, 46: 2309–24.

Rothenberg, M. (2010) 'Making Judgments about Grant Proposals: A Brief History of the Merit Review Criteria at the National Science Foundation', *Technology & Innovation*, 12: 189–95.

Salter, A. J., and Martin, B. R. (2001) 'The Economic Benefits of Publicly Funded Basic Research: A Critical Review', *Research Policy*, 30: 509–32.

Sivertsen, G., and Meijer, I. (2020) 'Normal versus Extraordinary Societal Impact: How to Understand, Evaluate, and Improve Research Activities in Their Relations to Society?', *Research Evaluation*, 29: 66–70.

Smith, K. E., and Stewart, E. (2017) 'We Need to Talk about Impact: Why Social Policy Academics Need to Engage with the UK's Research Impact Agenda', *Journal of Social Policy*, 46: 109–27.

Smith, S., Ward, V., and House, A. (2011) '"Impact" in the Proposals for the UK's Research Excellence Framework: Shifting the Boundaries of Academic Autonomy', *Research Policy*, 40: 1369–79.

Spaapen, J., and van Drooge, L. (2011) 'Introducing "Productive Interactions" in Social Impact Assessment', *Research Evaluation*, 20: 211–8.

Terämä, E., Smallman, M., Lock, S. J., Johnson, C., and Austwick, M. Z. (2016) 'Beyond Academia – Interrogating Research Impact in the Research Excellence Framework', *Plos One*, 11: e0168533.

Ulrichsen, T. C. (2015) *Assessing the Economic Impacts of the Higher Education Innovation Fund: a Mixed-Method Quantitative Assessment*, Bristol: HEFCE, http://dx.doi.org/10.13140/RG.2.1.2272.7287.

Watermeyer, R. (2016) 'Impact in the REF: Issues and Obstacles', *Studies in Higher Education*, 41: 199–214.

Watermeyer, R., and Hedgecoe, A. (2016) 'Selling "Impact": Peer Reviewer Projections of What is Needed and What Counts in REF

Downloaded from https://academic.oup.com/rev/article/32/2/273/7224528 by guest on 03 November 2023

Impact Case Studies. A Retrospective Analysis', *Journal of Education Policy*, 31: 651–65.

Wilsdon, J. A requiem for impact? Wonkhe (blog) (2020) <https://wonkhe.com/blogs/a-requiem-for-impact/> accessed 8 Mar 2022.

Wilsdon, J., Allen, L., Belfiore, E., Campbell, P., Curry, S., Hill, S., Jones, R., Kain, R., Kerridge, S., Thelwall, M., Tinkler, J., Viney, I., Wouter, P., Hill, J. and Johnson, B. (2015) *The Metric Tide: Report of the Independent Review of the Role of Metrics in Research Assessment and Management*. Bristol: HEFCE. https://doi.org/10.13140/RG.2.1.4929.136.

Yaqub, O. (2018) 'Serendipity: Towards a Taxonomy and a Theory', *Research Policy*, 47: 169–79.

Downloaded from https://academic.oup.com/rev/article/32/2/273/7224528 by guest on 03 November 2023