The changing research landscape and reflections on national research assessment in the future

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Preface

Research England asked RAND Europe to conduct a landscaping study to understand the changing research landscape over the next 5 to 10 years, and the possible application of technology within the process of national research assessment. The aim of this study is to help Research England understand the direction of change within the research system in order to consider how national research assessments may need to adapt going forwards. It considers factors such as the international environment, technological advances and public policy developments.

This report provides an in-depth analysis of the views gathered from the sector and existing literature. It is intended for those who fund and evaluate research in the United Kingdom and internationally. It may also be of interest more broadly, for researchers and those who lead higher education institutions.

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Executive Summary

A national retrospective assessment of research is carried out in the United Kingdom every five to seven years. This exercise assesses research in all disciplines across the country and is used to allocate funding to higher education institutions (HEIs). While the preparation and execution of these exercises continues, the research landscape is changing as technology advances, public policy develops and the international environment shifts. Research England commissioned RAND Europe to conduct a study to understand the direction of change within the research system in order to explore how national research assessments may need to adapt. It considers factors such as the international environment, technological advances and public policy developments.

This report provides an in-depth analysis of the views gathered from the sector and existing literature. It is intended for the research community, those leading and managing HEIs, and those funding and evaluating research in the United Kingdom and internationally.

ES.1 What is this study about?

The purpose of this study was to explore how the research landscape and research assessment may be affected by trends in the international environment, technological advances and public policy developments in the next 5 to 10 years. It considers the current system and possible changes to the research environment in the future in relation to the following questions:

- Why do we assess research and how might that change in the next 5 to 10 years?
- How do researchers expect the forms of output they are producing to change in the next 5 to 10 years?
- How do researchers expect the types of societal impact their research produces to change in the next 5 to 10 years?
- How do researchers expect the research environment they are in to change in the next 5 to 10 years?
- How could national research assessment exercises learn from developments in peer review?

The study used a mixed-methods approach to gather a wide range of evidence that could be triangulated. It consisted of four rapid evidence analyses of academic and grey literature (each focusing on a different theme); a survey of over 3,600 researchers from across England (see Figure ES.1 and Table ES.1 for the distribution of respondents by geography, career stage and discipline); views on the key questions from representative bodies across the sector associated with academic research; and three workshops with representatives from the government and national funding bodies, organisations that fund research, the

higher education sector, academics, academic publishing houses, and experts in emerging technologies (with each workshop focussing on a different theme). The relationship between the methods used and the key questions is summarised in Table ES.2. A detailed explanation of the methods, including limitations, can be found in the full report.

Figure ES.1: Locations of researchers participating in the survey

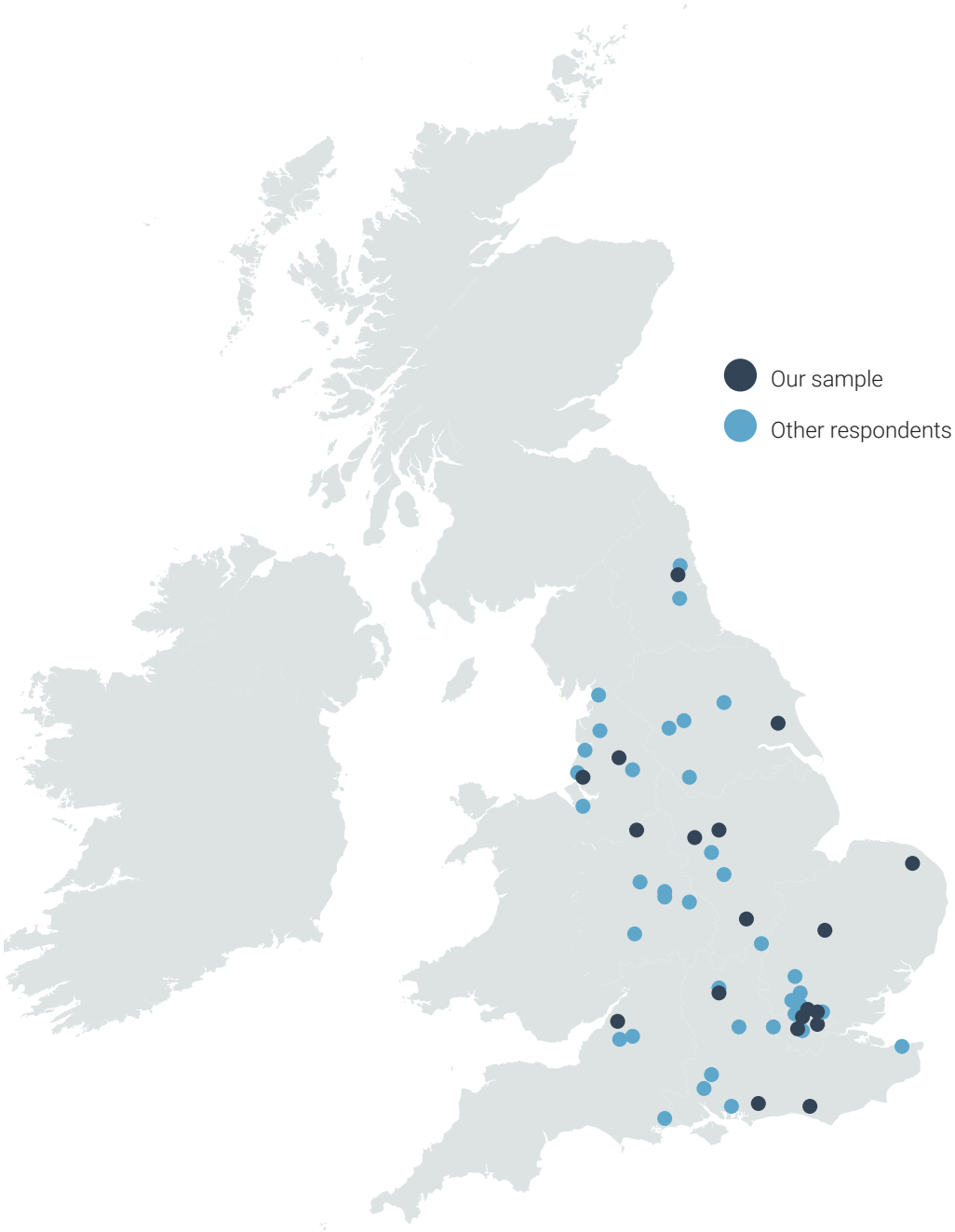


Table ES.1: Distribution of respondents participating in the survey by discipline and career stage

Discipline[1]	Number of respondents
Medicine, health and life sciences	1,409
Physical sciences, engineering and mathematics	955
Social sciences	664
Arts and humanities	582
Interdisciplinary	126
Unknown	32

Career stage[2]	Number of respondents
PhD Student	896
Early-career researcher	1,045
Mid-career researcher	804
Established researcher	955
Retired or emeritus researcher	47
Unknown	21

ES.2 Why do we assess research and how might that change in the next 5 to 10 years?

Key findings:

- The reasons for doing research assessment can be summarised by six 'A's: analysis, advocacy, allocation, accountability, acclaim and adaptation.
- The reasons for assessing research are understood and interpreted differently by different stakeholders.
- The rationale for, and emphasis of, research assessment is likely to evolve in the future.

There are many reasons for assessing research. This study expands on the four 'A's previously described in the literature[3] – accountability, advocacy, analysis, and allocation – by adding two further 'A's: acclaim and adaptation (Box ES.1).

The reasons for research assessment are both implicit and explicit, which results in a varied understanding and interpretation by different stakeholders as to why research is assessed. Over time there has been a shift in the focus of the rationale behind assessment, possibly due to the legitimacy of the aims developing and the different aims gaining popularity or importance within the research system and wider society. Within the United Kingdom, while the explicit aims of the Research Excellence Framework (REF) are allocation, accountability and acclaim, the Stern review and recent research on the REF have illustrated that the effects of the assessment exercise went beyond these broad aims. For example, the inclusion of the impact element in REF 2014 has driven researchers and HEIs to increase their focus on the wider societal impact of research (i.e. adaptation).

1 We used REF 2021 units of assessment (UOAs) and main panels as a proxy for disciplines by which to interrogate the analysis. Main Panel A: medicine, health and life sciences; Main Panel B: physical sciences, engineering and mathematics; Main Panel C: social sciences; and Main Panel D: arts and humanities. Respondents were assigned to a main panel based on the main UoA they reported that represented them. They are classified as interdisciplinary if they selected two main UoAs that spanned multiple main panels. 'Unknown' indicates that the respondent did not fill in this question.

2 Career stage was self-reported. 'Unknown' indicates that the respondent did not fill in this question.

3 Morgan Jones, Molly & Jonathan Grant. 2013. 'Making the Grade: Methodologies for Assessing and Evidencing Research Impact.' In 7 essays on impact. DESCRIBE Project Report for Jisc. Exeter: University of Exeter.

Table ES.2: Methods used to address the key questions

		Questions				
		Why do we assess research and how might that change in the next 5 to 10 years?	How do researchers expect the forms of output they are producing to change in the next 5 to 10 years?	How do researchers expect the types of societal impact their research produces to change in the next 5 to 10 years?	How do researchers expect the research environment they are in to change in the next 5 to 10 years?	How could national research assessment exercises learn from developments in peer review?
Rapid evidence assessments	Reasons for research assessment	✓				
	The trends and factors changing the research landscape		✓	✓	✓	
	The role, process and infrastructure of peer review					✓
	Application of emerging technologies in peer review in various contexts					✓
Survey			✓	✓	✓	
Sector view collection		✓	✓	✓	✓	✓
Workshops	'Purpose of research assessment' with policymakers and academics in research assessment	✓				
	'Peer review' with publishers, academics and funders					✓
	'Emerging technology' with technology and data specialists from higher education and industry					✓

Box ES.1: Definitions of the proposed six 'A's as reasons for research assessment

Analysis	To understand why, how and whether research is effective, and how it can be better supported.
Advocacy	To demonstrate the benefits of supporting research, and enhance the understanding of research and its processes among policymakers and the public.
Allocation	To determine how to distribute funding across the research system.
Accountability	To evidence that money and other resources have been used efficiently and effectively, and to hold stakeholders to account.
Acclaim	To compare and recognise the value of higher education institutions and the research conducted within them.
Adaptation	To steer change in organisational structures, behaviours and cultures, and research activities and priorities.

As the research landscape changes, the reasons for performing national research assessment are likely to continue to develop. Participants in the workshop on the reasons for research assessment noted that within the funding community in particular, additional emphasis was now placed on analysis (in the use of research assessment to inform higher education and funding strategies), and that for institutional stakeholders, acclaim has become increasingly important (in the ranking of universities and departments according to the research conducted within them). Given that the six 'A's are dynamic and interrelated elements for research assessment, they are likely to continue to evolve, and the weight and importance of each 'A' as a reason for assessment may continue to shift over time.

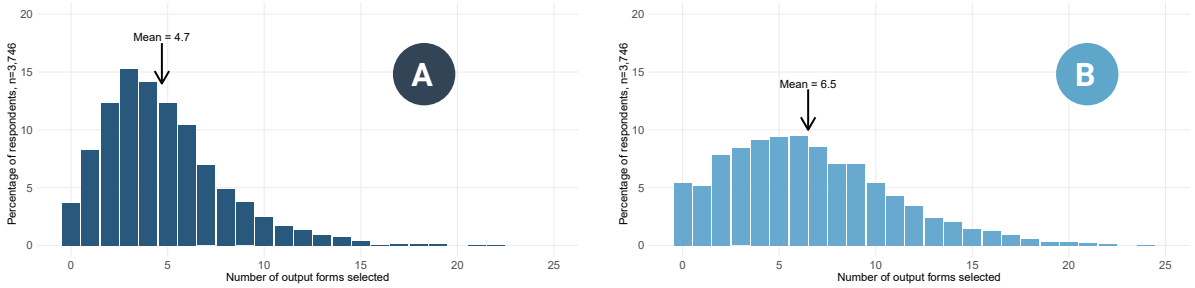
ES.3 How do researchers expect the forms of output they are producing to change in the next 5 to 10 years?

Key findings:

- Researchers currently produce a diversity of output forms.
- Researchers expect that they will produce a greater diversity of outputs in the future.
- Researchers expect to continue to produce journal articles and conference contributions, and that they will remain the dominant forms in many disciplines in the future.
- Many researchers expect to start to produce more diverse forms of output aimed at a wider audience.
- Researchers' decisions on which forms of output to produce are influenced by factors such as career progression and personal preference, as well as institutional incentives and funder requirements.
- Researchers from different disciplines currently produce different output forms, and researchers' expectations suggest that these differences will continue in the future.

The survey presented researchers with a list of forms of output (e.g. journal articles, books, conference proceedings, visualisations and code) and asked them which forms of output they were currently producing and expect to produce in the next 5 to 10 years. It is important to note that this captured the presence or absence of the creation of different

Figure ES.2: Number of different forms of output that researchers produce now (A) and expect to produce in the next 5 to 10 years (B)



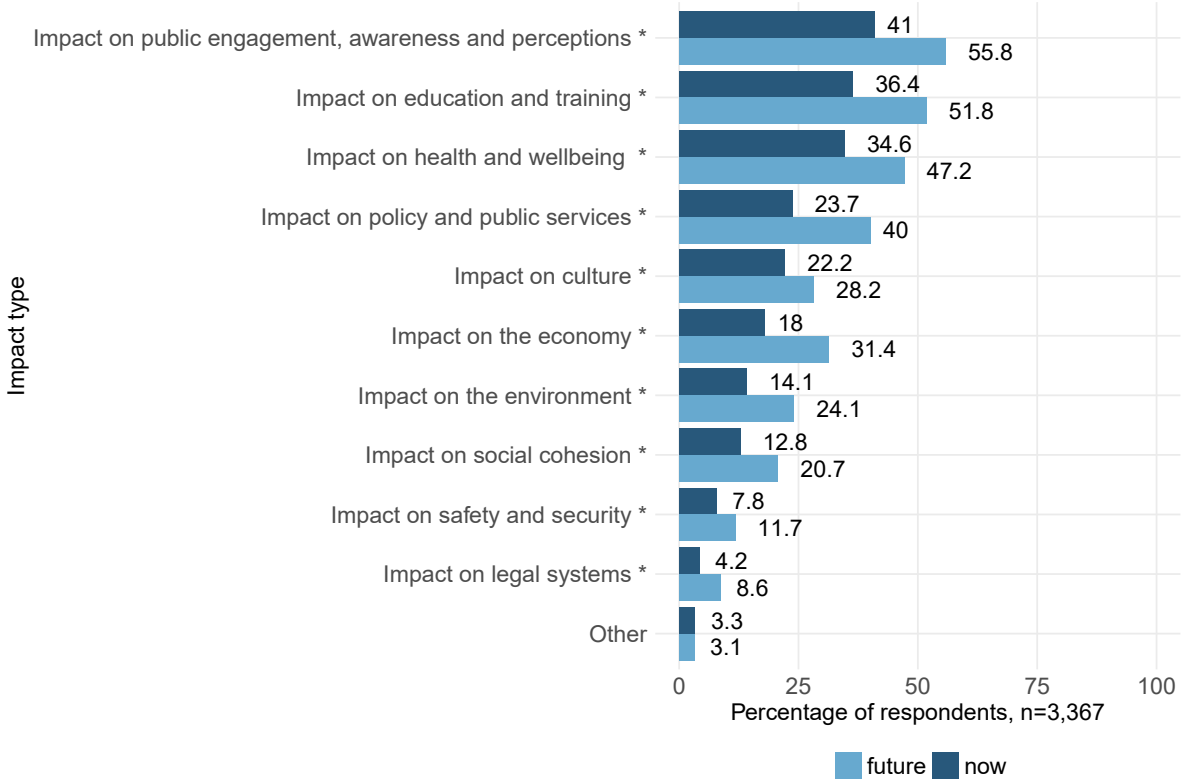
output forms by an individual researcher, rather than the volume of each output form that they produce. The number of forms of outputs produced by researchers is expected to increase, from the current average of 4.7 (Figure ES.2A) to 6.5 in the next 5 to 10 year period (Figure ES.2B).

The majority of researchers expect to continue to produce journal articles and conference contributions, which remain the dominant forms in many disciplines in the future. Currently, the only other forms of output produced by more than 50 per cent of respondents were chapters in books and authored books in arts and humanities. Individual researchers also expect to start to produce more diverse forms of output aimed at a wider audience. The forms of output with the greatest expected percentage increase in the number of researchers producing them over the next 5 to 10 years are books (authored books, chapters in book and edited books), non-confidential research reports for external bodies and openly published peer reviews.

The changes are driven in particular by an expectation of individual career progression, which brings with it the opportunity or requirement to produce different output forms (e.g. books). Other factors influencing the changes in output forms included desire to reach new audiences and create societal impact, changes controlled by external bodies (e.g. funding, open access requirements, REF) and wider changes that may influence the research landscape (e.g. societal changes and new technology).

There are significant differences in the forms of outputs being produced by researchers from different disciplines. For example, fewer arts and humanities researchers produce journal articles than researchers in other disciplines; while more researchers in the social sciences and arts and humanities produce book types (i.e. chapters in books, authored books, book reviews and edited books), social media, blogs, podcasts and working papers. More researchers in medicine, health and life sciences, and physical sciences, engineering and mathematics, produce peer review, code, research datasets, and databases and preprints than researchers from the social sciences and arts and humanities. Some outputs are also highly specific to certain disciplines, for example analysis plans are mainly produced in the disciplines of medicine, health and life sciences, and software is mainly produced in physical sciences, engineering and mathematics. Although there are some differences between career stages, these are relatively minor compared to discipline-level differences. These differences are expected to continue in the future.

Figure ES.3: Types of societal impact that respondents are producing now and expecting to produce in the next 5 to 10 years



ES.4 How do researchers expect the types of societal impact their research produces to change in the next 5 to 10 years?

Key Findings:

- More researchers expect that there will be societal impacts from their research in the future, although the balance of types of impact is expected to remain largely the same.
- Societal impact types differ across disciplines, and this is not expected to change.
- Researchers expect that they will continue to focus the majority of their efforts in the future on producing outputs.
- Respondents had differing views as to whether the importance placed on societal impact should increase or decrease in the future, and the reasons for this change.

Some 77% of respondents currently expect their research to have societal impact, compared to 86% who expect their research to have societal impact in the future. Researchers also expect their research to lead to more types of societal impact in the future, with the mean number of types of societal impact produced from their research increasing from 2.2 to 3.2. Across respondents, the types of societal impact they expected to have did not alter, with only impact on culture and impact on the economy switching over in prevalence between now and the future (Figure ES.3). Societal impact type differs across disciplines, and this is expected to continue (Figure ES.4).

Figure ES.4: Types of societal impact that respondents from each discipline are producing now and expecting to produce in the next 5 to 10 years (percentage)

	Medicine, health and life sciences n=1,252		Physical sciences, engineering and mathematics n=812		Social sciences n=639		Arts and humanities n=529	
Impact type	Now	Future	Now	Future	Now	Future	Now	Future
Impact on public engagement, awareness and perceptions	**38**	**54**	**29**	**44**	**51**	**66**	**52**	**65**
Impact on education and training	**33**	**50**	**30**	**46**	**43**	**55**	**45**	**61**
Impact on health and wellbeing	**63**	**79**	**19**	**33**	**18**	**28**	**10**	**16**
Impact on policy and public services	**22**	**40**	**11**	**26**	**47**	**65**	**15**	**29**
Impact on culture	**7**	**13**	**7**	**12**	**30**	**37**	**68**	**75**
Impact on the economy	**11**	**27**	**30**	**50**	**21**	**31**	10	15
Impact on the environment	**8**	**17**	**28**	**44**	**15**	**25**	**4**	**8**
Impact on social cohesion	**6**	**13**	**2**	**6**	**31**	**43**	**21**	**33**
Impact on safety and security	**5**	**7**	**16**	**24**	**8**	**11**	2	3
Impact on legal systems	**2**	**6**	**2**	**6**	**12**	**20**	3	6

Percentages are shown in bold where there is a significant difference between now and in the future. Impact types are shown shaded in grey if there is a significant difference across disciplines now, and in bold if there is a significant difference expected in the future. Each cell is shaded from white to dark red according to the percentage of respondents reporting producing or expecting to produce each type of impact. The darker the red, the higher the percentage.

When asked about the distribution of balance of effort between producing research outputs and societal impact, researchers expect the majority of effort to remain on outputs in the future, but with a slight increase in effort spent producing impacts, mainly due to the continued emphasis on the impact agenda and its implications for funding at an individual and institutional level.

ES.5 How do researchers expect the research environment they are in to change in the next 5 to 10 years?

Key Findings:

- Researchers think that collaborating with other academics is the most important driver of change.
- There are significant differences across disciplines in the perceived importance of most of the drivers, although the three most important drivers are consistent.
- Overall, most drivers were seen as more important by PhD students and early-career researchers than by mid-career and established researchers, particularly open science.
- There are a range of views from researchers on how the research environment needs to adapt to change.
- Changes to support and drive developments need to happen at both an institutional and a sector level.

Researchers identified a large number of drivers as important for influencing the changes happening in the research system (Figure ES.5). Academic drivers such as the need to collaborate, in general and internationally, were seen as more important than drivers related to societal impact.

Across disciplines, the three most important drivers of change in the research system were consistently identified as collaborating with other academic researchers, collaborating globally with other academic researchers and the focus on multidisciplinary research. However, there were significant differences in the importance of most of the drivers further down the list. For example, open

Figure ES.5: How respondents perceive the importance of potential drivers of change in the research environment

science was ranked 4th by respondents in medicine, health and life sciences, and 5th by respondents in physical sciences, engineering and mathematics; but it was ranked 10th by respondents in social sciences and 14th by those in arts and humanities. The importance of being mobile as a researcher was ranked 4th by respondents in physical sciences, engineering and mathematics, but was less highly ranked by respondents from other disciplines. The importance of collaborating with non-academic partners (outside of industry) was ranked 4th by respondents in social sciences and arts and humanities, but 14th by respondents in physical

sciences, engineering and mathematics. There are also differences across career stages, where most drivers were seen as more important by PhD students and early-career researchers than by mid-career and established researchers, this contrast was particularly pronounced for open science.

Researchers were asked about how the research environment needs to adapt to the changes they foresee in the outputs and societal impacts they produce. The range of topics discussed in the survey free text of how researchers would like the environment to change is presented in Box ES.2. To address these changes there is a need for support at an institutional and a sector level: respondents' suggestions in relation to this are provided in Box ES.3.

Box ES.2: Factors identified by participants that will shape the research landscape over the next 5 to 10 years

- Societal impact: both to increase and decrease the emphasis on this factor.
- Reducing pressure and incentives to produce a large number of research outputs in selective journals.
- Incentivising researchers to produce higher quality and new forms of output to engage a more diverse audience.
- Focusing on dissemination and engagement as routes to societal impact.
- Increasing collaborative research.
- Balancing basic and applied research.
- Making research accessible through open science and open access.
- Increasing support for interdisciplinary research

Box ES.3: Types of support suggested by survey respondents

- Funding to develop research that has societal impact.
- Valuing societal impact and engagement within HEI reward and recognition systems.
- Adjusting workload models and the creation of new roles to take into account work to develop societal impact.
- Changes to policy to address concerns about a culture of audit and the impact of the United Kingdom's changing relationship with the EU.
- Training to develop expertise in engagement, societal impact and new digital methodologies.
- Changes to the academic publishing system to increase openness and improve peer review.
- IT and infrastructure to support openness and collaboration on a global scale.

ES.6 How could UK national research assessment learn from advances in other applications of peer review?

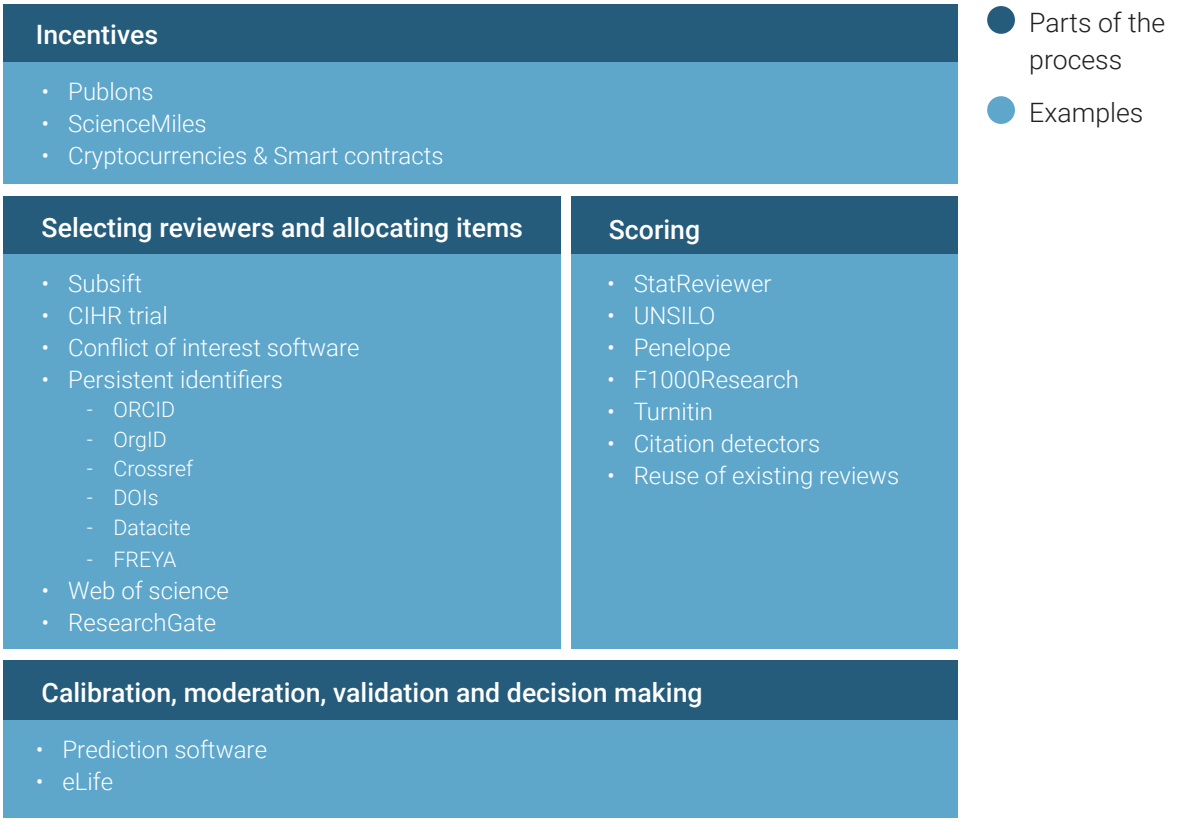
Key findings:

- Peer review is the predominant method for research assessment in the United Kingdom, and there is no expectation that this will change.
- Technological approaches are expected to further support peer review in the future.
- Cultural shifts, as well as technological shifts, are both needed and happening.

Peer review is the predominant method for research assessment in the United Kingdom. It is used across many contexts, such as grant applications, journal publications, *ex-post* assessment and conference contributions, and while it has both strengths and weaknesses, there was no expectation from workshop participants that its predominance in research assessment will change.

However, there is an expectation that technological approaches, which already underpin many aspects of peer review, may further support peer review in the future. Attendees at the workshops on peer review and emerging technologies identified a number of technologies and approaches already being developed which span the entire pathway of peer review, from selecting reviewers and allocating items, to scoring, to calibration, moderation, validation and decision making, and incentives (Figure ES.6).

Figure ES.6: The peer review process and examples of technologies that can support the different stages



Although there are a variety of technologies potentially available to support the peer review process, it was noted that they are not necessarily aligned with all the underlying issues of peer review systems. For example, some of the issues that participants in the workshops on peer review and emerging technology felt most needed addressing, such as equality and diversity and the rewarding of reviewers, would not be exclusively solved by advances in technology, as currently imagined. A challenge for the sector is to not just be driven by technological advances, but to take advantage of the technology that does provide benefits. Additionally, improvements to peer review are likely to require cultural changes, such as the rise of open science, as well as technological changes, and may require additional approaches such as training and incentives.

ES.7 Reflections on how national research assessment may need to adapt to changes in the research landscape

Key considerations for the future:

- Research assessment needs to continue to consider the diversity of outputs produced by academic research.
- It is important to consider the needs of different disciplines when undertaking a nationwide assessment.
- Drivers that researchers perceive to be important are generally within the academic system.
- National research assessment is an important driver of behaviour for the sector.

Across these questions no disruptive changes that would indicate a large or immediate shift in the research landscape have been identified. Instead there are likely to continue to be gradual changes as current drivers within the system develop alongside developments in the external environments (e.g. technological developments). National research assessment is therefore likely to need to continue to remain engaged with the sector and respond to changes as they arise or can be anticipated.

In particular, research assessment needs to continue to consider the diversity of outputs produced by academic research. Currently the vast majority of outputs submitted to the REF represent a small number of output types, largely journal articles.[4] However, researchers want and expect to produce a greater diversity of types of output. If the increased diversity of output forms is considered valuable to the system then it may be necessary to consider suitable ways to encourage their submission. It will also be important to ensure appropriate capacity to both assess and ensure confidence in the assessment of these outputs.

Across outputs, societal impacts and drivers, there were more significant differences in the survey responses between disciplines than between career stages. This reinforces the importance of considering the needs of different disciplines when making decisions about and undertaking national research assessment.

While the majority of drivers were considered to be important in driving changes in the system, those that were seen as most important were more related to academic impact rather than societal impact. In particular, the top five drivers for change were (1) the need to collaborate with other academic researchers; (2) the need to collaborate globally with other academic researchers; (3) the need to focus on multidisciplinary research; (4) the

4 For example, in REF2014 81% of outputs submitted were journal articles. https://results.ref.ac.uk/(S(41wezbilcaxf3dcoiveaq3zo))/DownloadSubmissions/ByForm/REF2

need to focus on research integrity; and (5) a drive towards open science.

It is important to remember that national research assessment is an important driver of behaviour and practice in the sector at an individual and institution level, as well as a system level. For example, universities increasingly use the results of research assessment exercises to promote their work, enhance their reputation, and inform strategic approaches such as recruitment. When tweaking or changing assessments it is important to consider the potential effects or consequences. Continued research is needed to understand the incentives and effects and ensure that they encourage a positive research environment.

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Abbreviations

AI	Artificial intelligence
ARMA UK	Association of Research Managers and Administrators UK
BRIC	Brazil, Russia, India and China
BRICKS	Brazil, Russia, India, China, South Korea, South Africa
DOI	Digital object identifier
EAST	East Anglia
ECR	Early-career researcher
EMID	East Midlands
EOSC	European Open Science Cloud
ER	Established researcher
ERA	Excellence in Research Assessment (Australia)
ERC	European Research Council
EU	European Union
GPA	Grade point average
HEFCE	Higher Education Funding Council for England (now called Research England)
HEFCW	Higher Education Funding Council for Wales
HEI	Higher education institution
HESA	Higher Education Statistics Agency
IT	Information technology
LOND	Greater London
MCR	Mid-career researcher

NA	Not available
NEAS	North East
NIHR	National Institute for Health Research
NWES	North West
OAMJ	Open access mega journal
OECD	Organisation for Economic Co-operation and Development
PBRF	Performance Based Research Fund (Norway)
PERIS	Strategic Plan for Research and Innovation in Health (Catalonia, Spain)
PhD	Doctor of Philosophy
PID	Persistent identifiers
QR	Quality related
R&D	Research and development
RAE	Research Assessment Exercise
RCT	Randomised controlled trial
REA	Rapid evidence assessment
REF	Research Excellence Framework
SARIS	Health Research and Innovation Assessment System (Spain)
SEAS	South East
SFC	Scottish Funding Council
SWES	South West
UK	United Kingdom
UKRI	UK Research and Innovation
UKRIO	UK Research Integrity Office
UOA	Unit of assessment
US	United States
WFC	Weighted fractional count
WMID	West Midlands
YORH	Yorkshire and the Humber

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We would also like to thank workshop participants and the research community who informed our research. Lastly, we thank Dr Susan Guthrie and Dr Catherine Lichten from RAND Europe for their quality assurance roles.

1 Introduction

1.1. Introduction and aims of the study

Research England[5] commissioned RAND Europe to conduct a scoping study to explore how the research landscape and research assessment may be affected by trends in the international environment, technological advances and public policy developments in the next 5 to 10 years. This study is based on perspectives from the sector around the direction of travel that is expected, rather than that desired by researchers and other members of the sector. This study considers changes in the next 5 to 10 years for three elements of national research assessment: why national research assessment is carried out, what is assessed, and how technology might affect the processes of national research assessment.

1.2. How the research environment is changing

Recent studies have looked at possible future scenarios to describe how the research landscape may shift (Elsevier & Ipsos MORI 2019; Elsevier n.d.; Rhoods & Babor 2018). Some future scenarios explored in these reports include the 'brave open world' scenario, characterised by the rise of the open access agenda; the 'tech titans' scenario, which centres around the growing influence and dominance of technology; and the 'eastern ascendance' scenario, characterised by the rise of China as a research power (Elsevier n.d.). Rhoods & Babor have explored changes that may occur in the publishing industry, including the widespread use of emerging technologies such as artificial intelligence, machine learning and automation; developments in geopolitics (globalisation and nationalism); and socio-economic shifts, including the growing distrust of experts (Rhoods & Babor 2018). Some of these major trends, as well as other trends affecting the research system, are described in more detail below.

1.2.1. The role of emerging research nations

The international research landscape is changing as the global role and dominance of emerging nations shift, especially in fields that are highly relevant to industry. A report published by Nature Index, *Nature's Database of Author Affiliation Information*, focused on China's growth as a research nation in terms of research and development (R&D) investment, research output, citation share and international collaboration with top research

5 Formerly the Higher Education Funding Council for England (HEFCE).

countries such as the United States and the United Kingdom. According to the report, China's total expenditure on R&D grew at an average rate of 20% per year from 2005–2015, which was a time when austerity affected most European countries. China's weighted fractional count (WFC)[6] of articles is higher than any other country, especially in chemistry, which accounts for 61% of China's total WFC of articles (Zhou 2015).

Another report compared India's scientific productivity in terms of publications and citation-based indicators to a selection of advanced OECD countries[7] and other BRICKS countries (Brazil, Russia, India, China, South Korea and South Africa). The report found that publications have grown significantly in India and South Korea, as well as in China (Bhattacharya & Kaul 2015), and that the publication share of OECD countries is falling, while that of BRICKS countries is growing, even when China is excluded from the BRICKS country group (Bhattacharya & Kaul 2015).

1.2.2. The growing importance of international research collaborations

A second global trend affecting the international landscape has been the growing importance of international research collaborations in producing high-quality and high-impact research, referred to in the literature as the 'fourth age of research' (Adams 2013; 2017). Globally, the number of international collaborations has been growing. A study looking at internationally co-authored papers in Web of Science from 2000 to 2015 found that the number of internationally collaborative papers grew from 10.7% of the total scientific output in 2000 to 21.3% in 2015 (Ribeiro et al. 2018). While the number of scientific outputs is growing internationally, the proportion of domestic outputs, or papers that list only authors from the country of publication, has fallen in the United States, the United Kingdom and western European countries over the past three decades (Adams 2013; 2017). A recent report by Elsevier found that the upward trend in UK research productivity may be due to a greater number of international collaborations, which tend to have a greater citation impact than outputs by a single author or by collaborations within a single country (Elsevier n.d.). International collaboration is also important to the productivity of individual researchers – a survey of researchers in Europe found that the average productivity of 'internationalists', or researchers involved in international collaborations, is consistently higher than the productivity of 'locals' or researchers not involved in international collaborations, in all fields and countries included in the study (Kwiek 2015).

1.2.3. Increasing academic and industrial collaborations

A third related trend is the growing international importance of higher education institution (HEI) and industry connections, and commercialisation (Abreu & Grinevich 2013; Cervantes & Meissner 2014; Tijssen et al. 2017). A recent study found that around 5.4% of all publications in the United Kingdom list an author affiliative address referring to a business rather than a university, and that university–industry co-authored publications

6 Weighted fractional count (WFC) is a measure of the number of articles published in a group of highly selective science journals (chosen by an independent group of active researchers), reported by Nature Index. WFC assigns fractional counts in the case of multiple authors in order to avoid counting the same article multiple times, and is weighted to account for the high volume of publications in astrophysics and astronomy. For more information see *A Guide to the Nature Index* (Nature Index 2018).

7 These were: France, Germany, Japan, the United Kingdom and the United States of America.

and other interactions with industry have become increasingly important (Tijssen et al. 2017). The focus on societal impact and building connections between HEIs and industry has led to the proliferation of new professional roles within academia, including the 'knowledge broker' role and other para-academic roles that look for ways to match research to impact opportunities (Lightowler & Knight 2013). This emerging class of professionals is part of a wider shift in roles within academia that is leading to non-research staff increasingly taking on professional activities, such as administrative and management tasks, that were previously assigned to academic researchers. This change may alter the skills that academics are expected to have (Kehm 2015).

1.2.4. Focusing on the societal impact of research

There has also been an increased focus on the wider societal impacts of research. For example, in the United Kingdom, the 2014 Research Excellence Framework (REF) introduced the use of case studies to assess the wider societal impact of research. The REF is reflective of broader trends towards an accountability culture (Weingart 2013), which have also been apparent in the increased use of proxy measures of research productivity and quality in research management, such as bibliometrics and altmetrics. Quantitative metrics can contribute to the discussion about research productivity and quality; however, recent work has highlighted limitations in representation, coverage and robustness to manipulation (Wilsdon et al. 2015). Both within the United Kingdom and globally there are ongoing efforts to move away from the use of heuristic measures related to journal prestige to instead focus on the development of 'responsible' research metrics (San Francisco Declaration on Research Assessment 2012; Universities UK 2019; Wilsdon et al. 2015).

1.2.5. The impact of emerging technologies on research

New and emerging technologies have not only had an impact on how research is assessed, but also on how it is conducted. For example, Web 2.0[8] and smart devices have dramatically increased the quantity and granularity of data that can be collected and analysed, which has contributed to ethical concerns about public and private data (Hesse-Biber & Johnson 2013). Similarly, big data and cloud computing now allow researchers to collect, store, analyse and share large quantities of data throughout the research process rather than just when results are peer reviewed and published, which needs to be balanced against concerns around data quality, metadata and reproducibility (Rousidis et al. 2014). Disruptive technologies[9] also have the potential to dramatically change how research is conducted, including by automating or partially automating parts of the research process. For example, research protocols can be written into 'stone' with distributed ledger technologies such as blockchain and smart contracts, which can automatically collect, encrypt and analyse data based on pre-specified instructions, potentially making research less susceptible to error and reducing the risk of intentional misrepresentation (van Rossum 2017).

1.2.6. The rise of open science

Within the United Kingdom and internationally, open science has the potential to change the

8 Web 2.0 refers to the move from a static web in which content is developed by a limited number of developers, to a more collaborative, responsive and interactive web in which users create content on an ongoing basis.

9 A disruptive technology is technology that displaces an established technology and shocks industry, or a product that creates a new industry ("What Is Disruptive Technology? - Definition from WhatIs.Com" n.d.).

research landscape in the next 5 to 10 years. Open science refers to a broad range of changes to increase transparency, accountability and collaboration in the research system, including open access to publications, openly available research data, open scientific codes and tools, open scholarly communications, open evaluation and peer review, and the widening participation in research through activities such as citizen science (Bonney et al. 2014; Fecher & Friesike 2014).[10] These changes are being driven by a variety of factors, including concerns around the replicability and reproducibility of published science (Siebert et al. 2015), and a desire to encourage a culture of transparency and to incentivise 'good' science as opposed to only innovative research or novel findings (Nosek et al. 2015). Open science practices also allow more datasets to be reused, particularly those that are expensive and hard to collect (Piwowar & Vision 2013), which can potentially improve the efficiency of the research system in terms of how research funds are spent. Similarly, open access ensures that research outputs are available to the tax-paying public, which increases the accountability of the research system (Neylon 2013). Open access has been an area of particular growth, with activity taking place in this space (Cervantes & Meissner 2014; Brown et al. 2015) since the 1970s. Activity increased around the turn of the century with the launch of open access journals and databases such as PubMed Central in 2000, Google Scholar in 2004 and PLoS ONE in 2006.[11] The open access agenda has gained momentum over the past decade: in 2011, PLoS ONE became the largest peer reviewed journal in the world in terms of the number of publications that year, and in 2014, the four UK research funding bodies announced an open access policy for REF2021 (Symplectic 2019). The UK Research and Innovation (UKRI) and the European Commission have signed Plan S, which will mandate immediate open access for all cOAlition S[12] funded projects by 2020 (Schiltz 2018),[13] and many third sector research funders in the United Kingdom have also moved towards open access requirements (Brown et al. 2015).

Open access trends have already led to significant changes in how research is conducted (Neylon 2013), and may lead to more significant changes in the future, possibly disrupting the traditional publishing model (Risnes 2018; Van Noorden 2013). For example, a survey of academics found that social media has already allowed for more open scholarly communications as researchers connect with one another, engage the public and discuss their work online through a process of 'conversational scholarship' (Lupton 2014). Researchers have also found that online repositories have changed their workflows by allowing for the publication of raw data, analysis plans and findings throughout the research process (Assante et al. 2015). The availability of these new types of output in repositories and other platforms online creates the potential for their evaluation by funders (Barbaro et al. 2014; Scanlon 2014); for researchers to receive commentary throughout the research process, rather than just at the end (Van Noorden 2014); and for data to be reused and validated (Piwowar & Vision 2013).

10 See the European Commission's Open Science Policy Platform for more information (European Commission 2019a)

11 PLOS ONE is an open access peer reviewed journal with a belief that 'all rigorous science needs to be published and discoverable, widely disseminated and freely accessible to all.' See PLOS ONE for more information (PLOS ONE 2019).

12 'Plan S is an initiative for open access publishing that was launched in September 2018. The plan is supported by cOAlition S, an international consortium of research funders. Plan S requires that, from 2020, scientific publications that result from research funded by public grants must be published in compliant open access journals or platforms' (cOAlition S 2018).

13 This is now delayed until 2021 (www.nature.com/article/d41586-019-01717-2).

Open science has led to an increase in the quantity of published outputs and new ways of managing quality. Online journals are no longer restricted by physical space and can now accept more articles for publication, which has led to the growth of open access mega journals (OAMJs). This removes the need to consider utility, contribution or novelty as factors in the publication process. A recent literature review of OAMJs highlighted the diversity of opinions around them, ranging from viewing OAMJ's as the future of scientific communication to viewing them as 'career suicide' or an 'academic dumping ground' for research that was not accepted into highly selective traditional journals (Spezi et al. 2017). Regardless, open access journals have led to new kinds of research being published and new incentive structures within the research system (Nosek et al. 2015). A recent commentary highlighted that open access has reduced the risk associated with conducting replication studies, finding null or inconclusive results and finding results that contradict a widely held status quo, while also making it easier for new researchers to 'break into' a system in which publishing decisions are not based on previous publishing history or perceived prestige (Risnes 2018). As this area continues to develop, research assessment and reward systems may shift to reflect open science trends and the changing role of selective academic journals; there have already been developments in this direction through, for example, open peer review (Hodonu-Wusu 2018) and altmetrics (Haustein 2016).

1.2.7. The changing role and practice of peer review

Another trend in the academic publishing system has been the increasing acknowledgement of risks to the peer review system. Traditional peer review may have the potential for bias and abuse because of the differential power between researchers and reviewers. It has been criticised for its inability to reliably detect fraudulent research (Tennant et al. 2017) and the lack of incentives for reviewers to provide timely feedback (Jan 2018). Peer review is central to the research system, but is reliant on the cooperation of senior researchers. It is likely to be under increasing pressure in terms of the supply of reviewers as the number of outputs available online grows (Sabater-Mir et al. n.d.). These challenges to the traditional peer review system have led to a number of new models of peer review being put into place, including open peer review, 'peer review lite'[14] and peer review that is decoupled from the publishing process (Tennant et al. 2017).

Different actors within the research landscape have different experiences of the changes to the research system. Early-career researchers, who are typically on temporary short-term contracts, have particularly precarious positions which can affect their experiences (Brechelmacher et al. 2015; Sigl 2016). Some literature has argued that the pressure to focus heavily on public engagement may be damaging to early-career researchers in particular, who may be unable to compete with academics that have been able to focus more heavily on research and publication than their younger peers (Watermeyer 2015). Recent literature has also argued that the movement towards open access may negatively affect early-career researchers, who may face career consequences from publishing in open access mega journals rather than traditional peer reviewed journals that convey prestige (Spezi et al. 2017).

14 'Peer review lite' refers to review processes that only assess whether a study was conducted according to a scientific process and whether conclusions are based on the results, rather than reviewing for potential contribution of an article or output.

Research takes place in a wider social and political ecosystem that needs to be considered in terms of how the research landscape may evolve. The UK system has experienced, and is continuing to experience, social, political and legislative flux in a range of areas, particularly regarding the United Kingdom's upcoming exit from the EU. Questions remain about the medium- and long-term effects these wider changes will have on research investment, mobility and standards (Webb 2016). In particular, there is uncertainty around the United Kingdom's position in the global network of international research collaborations, the future potential for researcher mobility and exchange, and future access to research funding from Horizon 2020 and subsequent EU Framework Programmes (Adams 2017). A recent report looking at 47 large UK universities between 2009 and 2015 found that 24% of all university–industry co-authored publications were through collaborations with companies in EU member states (Tijssen et al. 2017), which points to the potential impact that the United Kingdom's exit from the EU may have on the research system.

1.3. National research assessment in the United Kingdom

Research conducted around the world is assessed at many levels: at an individual level by institutions when considering researchers for new positions or promotions, at a programme level by funders when reviewing a portfolio or allocating awards and grants to individuals, and at a national level by national funders or governments. Research assessment measures different aspects of research depending on the aims of the assessment. These aspects can include the volume of research produced, the quality of research produced, the impact of research produced and the environment in which research is produced. A range of methods are used to assess and report research activity and outcomes, including bibliometrics and altmetrics, economic analyses, peer review, surveys, and case studies (Guthrie et al. 2013). Research can be assessed prospectively on its potential, for example when reviewing grant applications, or retrospectively, like in national exercises such as the United Kingdom's REF or the Australian Excellence in Research Assessment (ERA). This review focuses on the retrospective (*ex post*) assessments conducted at a national level.

National research assessment refers to exercises that monitor research outputs across a country. These exercises are carried out periodically in a number of countries worldwide. There are a range of reasons for carrying them out (discussed in Chapter 2), which include the allocation of funding and the ability to demonstrate the value of providing the funding.

National research assessment was first conducted in the United Kingdom in 1986 in an effort to 'adopt a more selective approach in allocation of research support among universities in order to ensure that resources are used to the best advantage' (Johnes & Taylor 1992). Following the 1989 Research Selectivity Exercise (RSE), the Research Assessment Exercise (RAE) was then carried out approximately every three to five years (1992, 1996, 2001 and 2008), and was replaced by the REF in 2014, which introduced for the first time an assessment of the wider impact of research as an element of assessment.

The REF is undertaken by the United Kingdom's four higher education funding bodies: Research England, the Higher Education Funding Council for Wales (HEFCW), the Scottish Funding Council (SFC) and the Department for the

Economy of Northern Ireland.[15] It has three main purposes:

1. Inform the selective allocation of research funding from the funding body to higher education institutions.
2. Provide accountability for public investment in research and produce evidence of the benefits of this investment.
3. Provide information that allows for cross-HEI and cross-discipline benchmarking.

The next exercise will be in 2021 and, as with REF 2014, panels of experts from within and beyond the sector will assess the quality of outputs, the quality of impacts and the research environment.

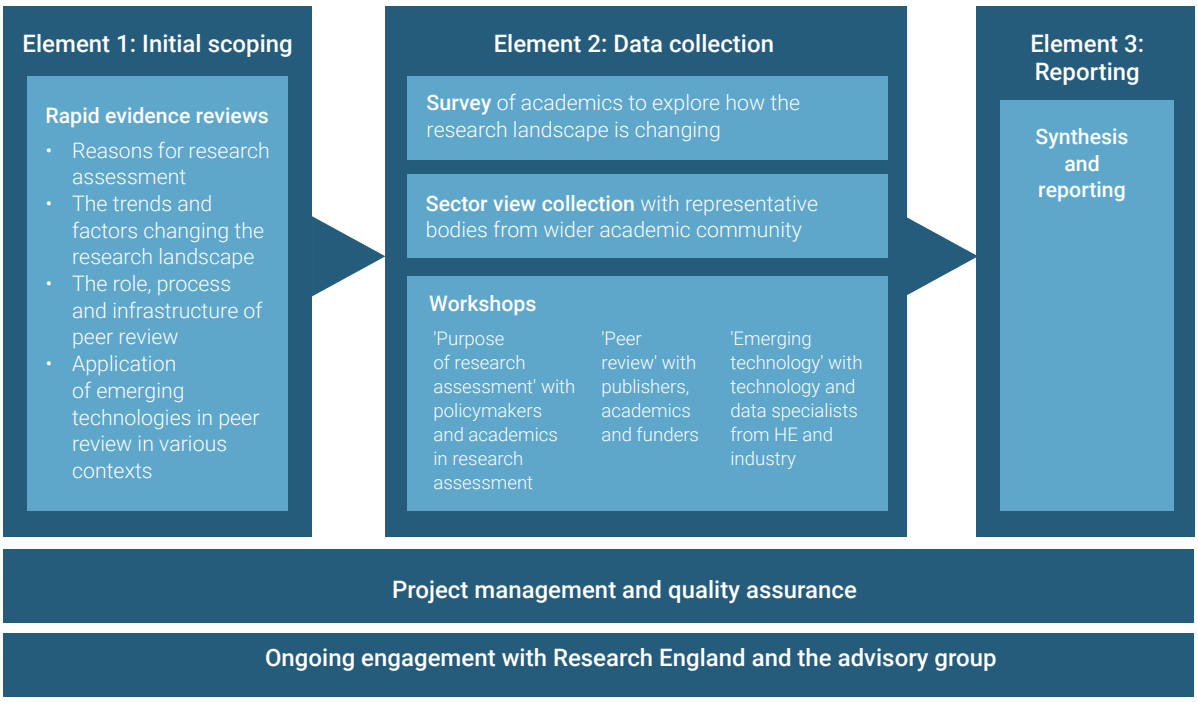
1.4. Overview of methodology

This study considers the current system and possible changes to the research environment in the next 5 to 10 years in relation to the following questions:

- Why do we assess research and how might that change in the next 5 to 10 years?
- How do researchers expect the forms of output they are producing to change in the next 5 to 10 years?
- How do researchers expect the types of societal impact their research produces to change in the next 5 to 10 years?
- How do researchers expect the research environment they are in to change in the next 5 to 10 years?
- How could national research assessment exercises learn from developments in peer review?

Our methodological approach to this study is broadly summarised in Figure 1.1 and Table 1.1 below, with additional detailed methodology provided in Annex A.

Figure 1.1: Methodology used in this study



15 Formerly the Department for Employment and Learning (DEL).

Table 1.1: Methods used to address the key questions

		Questions				
		Why do we assess research and how might that change in the next 5 to 10 years?	How do researchers expect the forms of output they are producing to change in the next 5 to 10 years?	How do researchers expect the types of societal impact their research produces to change in the next 5 to 10 years?	How do researchers expect the research environment they are in to change in the next 5 to 10 years?	How could national research assessment exercises learn from developments in peer review?
Rapid evidence assessments	Reasons for research assessment	✓				
	The trends and factors changing the research landscape		✓	✓	✓	
	The role, process and infrastructure of peer review					✓
	Application of emerging technologies in peer review in various contexts					✓
Survey			✓	✓	✓	
Sector view collection		✓	✓	✓	✓	✓
Workshops	'Purpose of research assessment' with policymakers and academics in research assessment	✓				
	'Peer review' with publishers, academics and funders					✓
	'Emerging technology' with technology and data specialists from higher education and industry					✓

1.4.1. Rapid evidence assessments

Four rapid evidence assessments (REAs) of literature and commentary on national research assessment were performed as part of this study to understand the existing evidence, views and perspectives on (1) why different countries perform research assessment exercises; (2) the trends and factors changing the research landscape; (3) the role and purpose of peer review; and (4) how emerging technologies may affect the way research is assessed. Initial searches were performed using Web of Science and Google Scholar, with results limited to the past five years. Results were then screened by title and abstract for relevance, and data were extracted and analysed from relevant literature. This search was supplemented by a second, more targeted search based on the prior knowledge and expertise of the project team (and suggestions made by the advisory group[16] and from attendees at the workshops) and involved a snowball methodology whereby appropriate references were pulled from reviewed documents.

1.4.2. Workshops

The results of the evidence reviews were used to inform three separate workshops on the purpose of research assessment, the use of peer review across the research system and the development of emerging technologies. During the workshops, stakeholders provided perspectives on developments in research assessment and the research environment. The first workshop (the purpose of research assessment) included representatives from the government and national funding bodies, organisations that fund research, and the higher education sector. The second workshop (the role and purpose of peer review) included representatives from academia, publishers and research funders. The third workshop (emerging technologies for research assessment) included participants from the higher education sector, publishers and experts in emerging technologies.

1.4.3. Survey and sector view collection

A large-scale survey of academic researchers in England was conducted to capture researchers' expectations of how research outputs, research impacts and the research environment more broadly would change over the next decade. Participants' field of study, career stage, institutional affiliation and gender were also captured as part of this survey.[17] In order to have representation across disciplines, geography and type of university, 24 HEIs were sampled and invited to participate. Nineteen universities agreed to participate,[18] and the survey was distributed to their researchers over a four-week period. So as not to be restrictive, the survey was also publicised on social media to invite researchers from the wider community to participate (Figure 1.2).

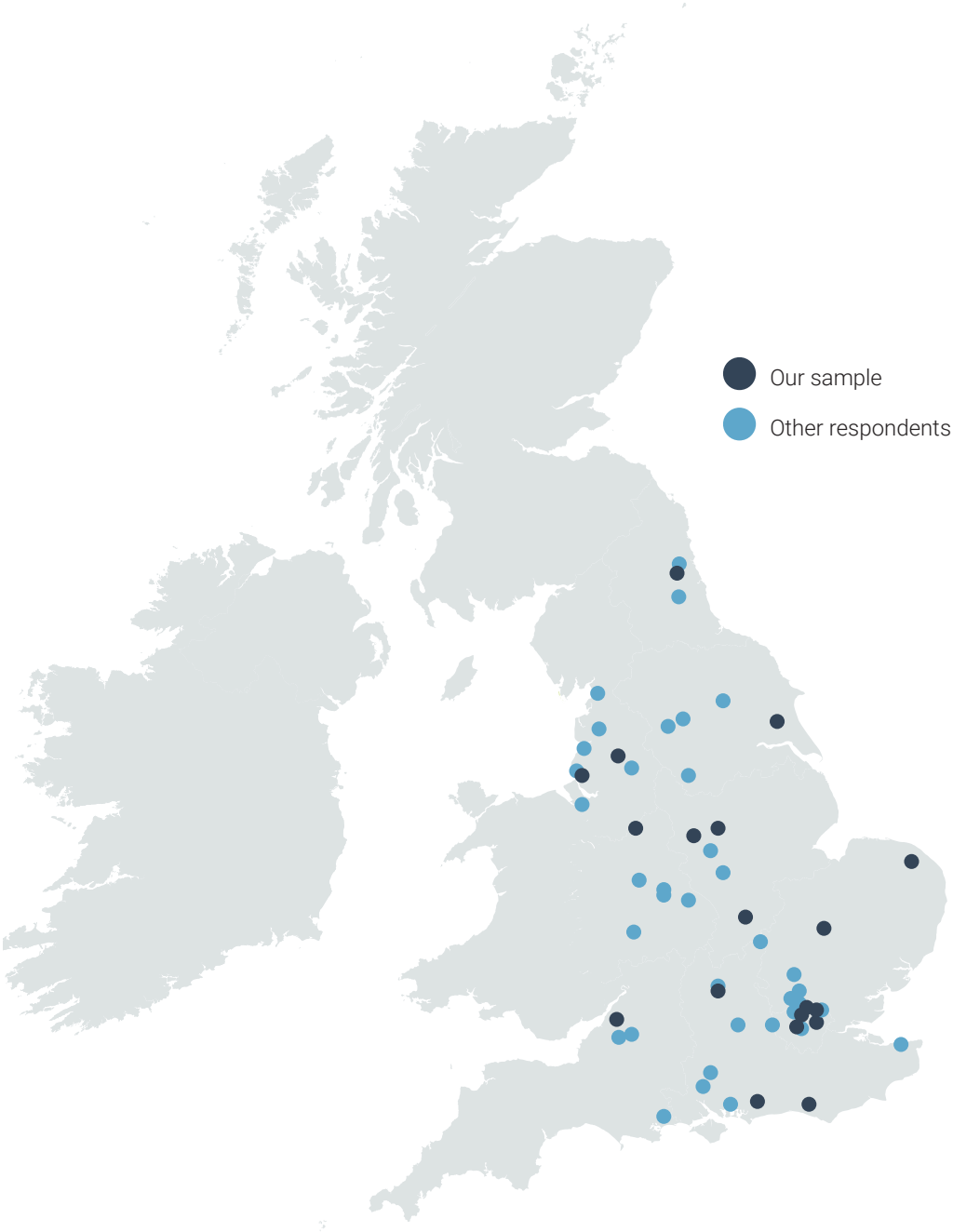
The survey received 3,768 responses. A response was defined as a respondent who

16 The advisory group was selected by Research England and included the following members: Dr Gemma Derrick. Professor Mark D'Inverno, Dr Emily Gale, Dr Daniel Hook, Professor Alis Oancea, Professor Mike Thelwall, Professor Jane Winters and Professor Sarah De Rijcke.

17 These characteristics were used to ensure the data were representative of the sector, rather than to analyse the data by these variables.

18 The 19 universities that agreed to participate were: the University of Bolton, the University of Chichester, the University of Liverpool, the University of Derby, the University of Nottingham, the University of Oxford, the University of Durham, Goldsmiths College, Keele University, Kingston University, Newcastle University, Queen Mary University of London, the Royal College of Music, the University of Brighton, the University of Bristol, the University of Cambridge, the University of East Anglia, the University of Hull and University College London.

Figure 1.2: Locations of researchers responding to the study



answered at least one question related to outputs, impacts or the research environment. Respondents were asked to assign themselves to REF 2021 units of assessment (UOA), and main panels were used as a proxy for disciplines by which to interrogate the analysis (Main Panel A: medicine, health and life sciences; Main Panel B: physical sciences, engineering and mathematics; Main Panel C: social sciences; and Main Panel D: arts and humanities). Responses were received from all UOAs, with at least 500 from each of the four main disciplinary categories (Table 1.2). Respondents were also asked to assign

Table 1.2: Distribution of respondents to the survey by discipline and career stage

Discipline[1]	Number of respondents
Medicine, health and life sciences	1,409
Physical sciences, engineering and mathematics	955
Social sciences	664
Arts and humanities	582
Interdisciplinary	126
Unknown	32

Career stage	Number of respondents
PhD Student	896
Early-career researcher	1,045
Mid-career researcher	804
Established researcher	955
Retired or emeritus researcher	47
Unknown	21

[1]Respondents assigned themselves to REF 2021 units of assessment. REF main panels were used as a proxy for disciplines by which to interrogate the analysis. Main panel A: medicine, health and life sciences; Main Panel B: physical sciences, engineering and mathematics; Main Panel C: social sciences; and Main Panel D: arts and humanities.

themselves to a career stage, and over 800 responses from each of the four main career stages were received: PhD student, early-career researcher, mid-career researcher and established researcher (Table 1.2).

Quantitative analysis of the survey results was conducted in R and consisted of both descriptive statistics and statistical testing.[19] Qualitative analysis was carried out in QRS NVivo 12 Plus and Excel software.

A further 12 representative bodies[20] from the wider academic community were also surveyed to provide views of how they thought research outputs, impacts and the research environment would change over the next 5 to 10 years, and to comment on factors that may be driving these changes, how research assessment might adapt and how specific groups would be affected. Responses were received from four representative bodies.[21]

1.4.4. Synthesis and analysis

Following data collection, an internal team workshop was held to synthesise the data collected and identify key findings and themes across the three phases. Analysis focused on the changes to research produced as a result of changes emerging in the research environment across the United Kingdom, and how research assessment can be supported by technological and cultural developments. Key findings for each phase, as well as for the overall project, were identified, and a narrative was developed that was presented to the advisory group and Research England for their

19 R is a statistical programming language https://cran.r-project.org/

20 The 12 representative bodies invited to participate were the Higher Education Race Action Group; the Association of Research Managers and Administrators (ARMA); Universities UK; GuildHE; Advance HE; the Scottish Library and Information Council; Research Libraries UK; the UK Research Integrity Office (UKRIO); the Royal Society; the British Academy; the Society of College, National and University Libraries (SCONUL); and Jisc.

21 These were: the Association of Research Managers and Administrators (ARMA) UK, JISC, the Royal Society, and the Chair of REF 2021 Interdisciplinary Research Advisory Panel.

input and feedback. This input and feedback was incorporated into the final report.

1.4.5. Caveats and limitations

All research methods have limitations. By using a mixed-methods approach the aim was to build on some of the strengths of each individual method, and limit the impact of the weaknesses on the study. Using a range of methods allowed for the gathering of wide-ranging evidence that could be triangulated to form robust conclusions. Despite this, it is still worth noting the limitations of the individual methods, particularly when considering a study that looks to anticipate the future. Within the three REAs, available literature is often more focused on the past than on the future. Workshops, although valuable for the depth of discussion they allow, provide only a snapshot of opinions and may not reflect the wider views of the sector. A range of representative bodies were approached for views to ensure a wide representation of stakeholders as part of the sector view collection, but only responses from one third were received. The survey, which had respondents from across career stages, types of HEI, discipline and other attributes, is not necessarily representative of all views, and some views may be over or under-represented. The survey was also designed to be short and appealing to researchers to complete, and therefore was limited in the depth of data that could be collected. It is also important to note that the survey asked researchers what they were currently producing and what they expected to produce. Therefore, the results may include details of what they aspire or plan to achieve, rather than solely what they will. Research was focused on the changing landscape for research assessment in the broadest sense, i.e. assessing research at any stage, and it was not intended as an *ex-post* assessment of the REF. However, it was difficult for survey respondents (researchers) to make this distinction, which may be reflected in their answers. The upcoming REF in 2021, and the pressure it brings, may affect what people are currently doing vs. what they aspire to do.

1.5. Outline of the report

This report is structured around the three phases of the study. Chapter 2 discusses the reasons for conducting national research assessment, how these are likely to change in the next 5 to 10 years, and how these are viewed by the sector. Chapters 3, 4 and 5 consider how researchers expect the outputs from research, the impacts of research, and the research environment to change in the next 5 to 10 years. Chapter 6 reports on how national research assessment exercises learn from developments in peer review. Finally Chapter 7 concludes with how national research assessment may need to adapt to changes in the research landscape.

2 Why do we assess research and how might that change in the next 5 to 10 years?

This chapter describes the reasons for and purpose of conducting research assessment at a national level. It is primarily based on the results of desk research synthesised by the project team. It includes reflections from discussions at the first workshop with funders and researchers that focused on research assessment and aimed to explore how the purpose and process of research assessment may change in the future, the role of peer review in the process of research assessment, and how technology may impact the process of research assessment.

The key findings are:

- The reasons for doing research assessment can be summarised by six 'A's: analysis, advocacy, allocation, accountability, acclaim and adaptation.
- The reasons for assessing research are understood and interpreted differently by different stakeholders.
- The rationale for, and emphasis of, research assessment is likely to evolve in the future.

2.1. The reasons for doing research assessment can be summarised by six 'A's

National research assessment exercises have become common over the past couple of decades in many countries, including the United Kingdom, Italy, Australia and the Netherlands. The reasons for performing research assessment have previously been categorised into the four 'A's: accountability, advocacy, analysis and allocation (Guthrie et al. 2013; Morgan Jones & Grant 2013). This chapter builds heavily on this work, from Morgan Jones & Grant (2013) and Guthrie et al. 2013, which introduce the concept of the four 'A's for research assessment, draws on the work of the field, in particular Adam et al. (2018), and expands these to include an additional two 'A's: acclaim and adaptation. Definitions are provided in Box 1.1, with further detail in the sections below.

2.1.1. Analysis

Definition: To understand why, how and whether research is effective, and how it can be better supported.

Analysis is used to assess how research is performing in order to understand the research process, the research system and its outcomes, and propose ways of improvement, if needed. It is also used to stimulate continuous progress in research productivity (Abramo and D'Angelo 2015; Franceschini and Maisano 2017; Guthrie et al. 2013; Molas-Gallart 2015). For example, the National Institute for Health Research (NIHR) developed a research assessment framework consisting of a metrics dashboard to monitor the performance of research it

Box 1.1: Definitions of the proposed six 'A's as reasons for research assessment

Analysis	To understand why, how and whether research is effective, and how it can be better supported.
Advocacy	To demonstrate the benefits of supporting research, and enhance the understanding of research and its processes among policymakers and the public.
Allocation	To determine how to distribute funding across the research system.
Accountability	To evidence that money and other resources have been used efficiently and effectively, and to hold stakeholders to account.
Acclaim	To compare and recognise the value of higher education institutions and the research conducted within them.
Adaptation	To steer change in organisational structures, behaviours and cultures, and research activities and priorities.

Source: RAND Europe analysis.

funds (El Turabi et al. 2011). This framework allows frequent data collection on performance indicators designed to monitor the NIHR research administration process. It contributes to identifying efficiencies and increasing effectiveness, and the information can be used for strategic decision making and analysis (Guthrie et al. 2013; NIHR n.d.).

Some consider analysis to be the underpinning 'A' for all other 'A's (Adam et al. 2018) as it provides an understanding of how research works, including an understanding of the barriers and enablers to expanding knowledge and delivering impact. This allows for the identification of dysfunctions within a research programme, as well as opportunities to increase the value of research during its funding, planning and implementation (Adam et al. 2018). Analysis enables research assessment to be formative as well as summative. It plays a significant part in how institutions and funders understand the quality of research and how they enable the use of data to inform their approaches to developing their research capacity at an organisational and national level. For example, in Spain the Health Research and Innovation Assessment System (SARIS) identified limitations of research funded under the Strategic Plan for Research and Innovation in Health (PERIS) programme, such as length of the grant and the grant's eligibility criteria. These identified limitations will be used for continuous improvements of the scheme (Adam et al. 2018). In another example, following REF 2014, the Higher Education Funding Council for England (now Research England) commissioned a study that looked at shared characteristics between research units whose submissions scored highly in the areas of research and impact in order to develop strategic approaches to delivering excellent research (Manville et al. 2015b). This has been replicated in a number of institutions and used to inform internal strategies.

RAND Europe has led a series of studies using payback case studies to trace research and its impact from the past (10 to 25 years ago) to understand the factors that support the outcomes and impacts of research (Wooding et al. 2005; 2011; 2013). Following studies in the fields of arthritis, cardiovascular and mental health, RAND Europe conducted a

cross-cutting analysis highlighting factors that could help researchers and funders maximise opportunities for impact (Guthrie et al. 2016). These include skills beyond research, engagement with non-academic stakeholders, funding clinical over basic research, inclusion of impact on society as a criterion for funding decisions, understanding that larger studies do not necessarily deliver greater outcomes, the importance of international collaboration, variety across the portfolio, and an understanding that impact will not be delivered by all research funded.

Representatives from funding agencies that attended the workshop on the reasons for research assessment felt that analysis enabled funders to design more strategic research funding, and that research assessment exercises provide evidence and visibility of what funders are doing, as well as a long-term vision of the research landscape. In the United Kingdom, charitable and public funders, as well as institutions have used the impact case studies produced for assessment in REF 2014 to understand what factors lead to impact and hence to inform their strategies. A synthetic analysis of the 6,679 impact case studies submitted to the REF highlighted the range of pathways to impact as well as the different types of impact seen across the disciplines and presented by different types of HEI (Kings College London & Digital Science 2015). This deeper understanding of how impact occurs aims to enable policymakers and institutions to better support research that may have a greater impact on society, and assist researchers to focus their time and effort on what works (Morgan Jones et al. 2017).

2.1.2. Advocacy

Definition: To demonstrate the benefits of supporting research, and enhance the understanding of research and its processes among policymakers and the public.

National research assessments provide evidence for advocacy by capturing the theoretical, economic and social value of research. This is valuable at a national level for government departments and funders to justify investment and support, and underpins the national case for research investment (Adam et al. 2018). Charitable organisations, among others, use this information to engage the public with the outcomes and wider impact of research. The advocacy function of research assessment is particularly important in supporting policymakers during times of change, such as budgetary cycles or wider economic challenges that require complex investment decisions to be made or wider policy engagement with the public to be undertaken (Adam et al. 2018). Other organisations that use the outcomes of research assessment for advocacy include charitable funders, who often need to appeal to the public to support their cause.

The database of impact case studies published from REF 2014 has been used to present the wider value of UK research, and therefore of research funding, to broader society. A number of analyses have been undertaken, which include:

- Highlighting research funded by a specific funding organisation, e.g. NIHR (Kamenetzky et al. 2016).
- Demonstrating the impact of research on a particular geography e.g. BRIC countries, (Brazil, Russia, India and China) (Kings College London & Digital Science 2015).
- Demonstrating impact from a particular field of research, such as community-based health sciences (Greenhalgh & Fahy 2015) or international development (Hinrichs et al. 2015).

Some institutions have also reused the case study narratives to attract staff and students to their institutions by giving anecdotal examples

of the relevance of their research and how it benefits society.

A recent review of research assessment frameworks worldwide found that 22 out of 25 frameworks provided evidence for advocacy (Deeming et al. 2017). In developing countries, research assessment was also used to identify high-quality research activities in order to inform policies that aimed to build sustainable national science systems and research structures, and contribute to enhancing scientific research (Glänzel & Zhang 2018).

2.1.3. Allocation

Definition: To determine how to distribute funding across the research system.

Some national research assessment exercises are used to determine where to allocate future investment in order to make the best use possible of limited funds and improve or sustain returns from the public funding of research (Calver et al. 2013; Guthrie et al. 2013).[22] An allocation approach to research assessment is considered to incentivise research excellence through economic rewards (Adam et al. 2018). The different ways in which countries use research assessment to allocate funding at a national level are presented in Table 2.1.

Table 2.1: Examples of research assessment exercises linked to funding allocation

Country	National funding allocation mechanisms	References
United Kingdom	Quality of research is assessed in terms of output, impact and environment, and funding is allocated taking into account the volume of high-quality research and cost. The UK was the first system to include an assessment of the non-academic impact of research as one of the measures used to determine funding allocation. Specifically, by assessing the reach and significance of the impact of research on society beyond academia.	(Atkinson 2014; Johnston & Reeves 2017; Rebora & Turri 2013; Manville et al. 2015a)
Italy	Resource allocation is based on a number of factors, including the quality of research assessment, which is measured using both a metrics and a peer review component. However, there is a limit on the amount of state funding a university can receive determined by the Ministry of Education, University and Research.	(Rebora & Turri 2013; Franceschini & Maisano 2017; Ancaiani et al. 2015)
Norway	The Performance Based Research Fund (PBRF) system in Norway is used to allocate block funding to HEIs and accounts for 70% of an institution's funds. The PBRF uses the Norwegian Publication Indicator, which consists of a system of weights that makes field-specific publishing traditions comparable across fields.	(Aagaard et al. 2015; Zacharewicz et al. 2018)

22 Research assessment exercises are generally performed by researchers. Therefore, funding allocation as a result of research assessment exercises is in line with the Haldane principle which states that the research questions to be explored should be dictated by researchers and not politicians.

Country	National funding allocation mechanisms	References
New Zealand	Research assessment in New Zealand is done at an individual level. Bibliometrics are used to assess every researcher working in New Zealand's tertiary educational establishments on a six-year cycle. Each researcher receives a ranking (A, B, C and R), which is provided to the institutions. The outcomes are weighted by quality and subject area, and aligned with the resources required for each field. Results are then aggregated by institution and used in combination with external income and research degree completions to distribute research funding.	(McGilvray 2014; Smart 2009)
Hong Kong	Hong Kong uses the framework for research assessment exercise to inform the distribution of part of the University Grants Committee block funding.	(Currie 2008; Parks et al. 2017)

Research evaluation exercises can affect the allocation of research funds both between and within universities (Johnston & Reeves 2017; Jonkers & Zacharewicz, n.d.). For example, the REF assesses the quality of research in terms of outputs, impact and environment in different fields across all submitting institutions (REF 2019a). UK funding bodies[23] use results from REF 2014, which detail the volume of high-quality research and the relative costs of research, to allocate annual funding in the form of quality related (QR) funding[24] or the Research Excellence Grant[25] to institutions across the United Kingdom (HEFCE 2017; Scottish Funding Council n.d.). Institutions then decide how they distribute the funding internally (Johnston & Reeves 2017). For example, following REF 2014 the University of Nottingham divided its annual QR funding between the different schools based on their performance in the REF, whereas Coventry University invested in future development and did not use REF results to inform its allocation of QR (Wellcome, n.d.).

Not all countries use research assessment exercises to allocate funding, for example Sweden and the Netherlands do not use this practice (Deeming et al. 2017; Sivertsen 2018). In Sweden, there was an attempt in 2009 to include a performance-based resource allocation system based on research production and citation rates, as well as on the ability to attract external funding (Karlsson 2017). However, the system was not implemented by the government due to cost and concerns from academics that it would interfere with institutional autonomy (Sivertsen 2018).

2.1.4. Accountability

Definition: To evidence that money and other resources have been used efficiently and effectively, and to hold stakeholders to account.

A common aim of research evaluation is to make research more accountable to taxpayers, donors, governments and society in general (Adam et al. 2018; Deeming et al. 2017; Penfield et al. 2014). The increased need for

23 These are Research England (previously HEFCE), the Higher Education Funding Council for Wales, the Scottish Funding Council, and the Department for the Economy in Northern Ireland.

24 In the case of England, Wales and Northern Ireland.

25 In the case of Scotland.

accountability comes from pressures to justify, or in some cases reduce public spending, which has led to a greater emphasis on transparency, efficiency, value and a return on investment to the public, private and charitable sectors in research. For example, the Australian government describes ERA as 'one of the primary mechanisms that government, public and private sectors have to account for their expenditure on the higher education research sector' (Australian Research Council 2018). An independent review of the ERA framework found that it contributed to increasing the social rate of return from research – i.e. the costs and benefits to society of investment in research, generated cost savings, increased university revenue and enhanced economic activity (ACIL Allen Consulting 2013).

Accountability in research is generally performance oriented (Deeming et al. 2017; Kwok 2013; Marques et al. 2017; Pajić 2015). There are a series of measures used in different settings to quantify research performance (e.g. number of publications, citation index, funding received and impact factor of publications) and inform an understanding of the value-for-money of funded research (Holland et al. 2016).[26] Qualitative evidence can also be presented, for example case studies as part of the impact element of the REF and the pilot for ERA.

In recent years there has been an increase in the need for governments and researchers to show evidence of the economic and social value generated through research, which some have termed a 'new social contract for research' (Molas-Gallart 2015). This moves beyond the assumption that research is only valuable if it generates economic returns for industry to value the societal or public benefit, as well as knowledge creation (Bozeman & Sarewitz 2011).

2.1.5. Acclaim

Definition: To compare and recognise the value of HEIs and the research conducted within them.

Acclaim involves research assessment being undertaken to compare and recognise the value of research at an individual, departmental, institutional or national level. Acclaim can result in prestige, reputation or reward at these different levels. For an individual it could be recognition and promotion, and at an institutional or national level it could be through comparisons or rankings (Mingers, n.d.; Kwok 2013).

Ranking can be a factor in raising standards across institutions (Martin-Sardesai et al. 2017) or consolidating already high standards (Manville et al. 2015b; Rebora & Turri 2013). Participants from the workshop on the reasons for research assessment felt that acclaim had become increasingly important given the role that league tables play in attracting students, researchers and funders to international research and the higher education system.

However, there are also some negative consequences to a focus on acclaim, and the use of research assessment exercises as a means for ranking is said to have led to the

26 The use of bibliometrics and peer review in national research assessment exercises vary per country and discipline. For example, the ERA in 2010 used a bibliometric approach for the hard sciences, using a citation index referring to world and Australian benchmarks to evaluate the outputs of researchers (Abramo & D'Angelo 2015).
On the contrary, the Italian 2001-2003 exercise was entirely based on peer review. However, for the 2004-2010 Italian Research Quality Evaluation the system was changed to use a combination of peer review and bibliometrics, with universities required to submit the best three research outputs for each researcher (Abramo & D'Angelo 2015). The UK REF makes use primarily of peer review, but metrics are supplied to some panels to help inform their judgement (Wilsdon et al. 2015).

reconfiguration of some institutions in terms of mission and internal systems (Holland et al. 2016; Li 2016; Martin-Sardesai et al. 2017). For example, a study looking at organisational change in an Australian university found that the university had made significant changes in anticipation of the upcoming research assessment exercise, including appointing a new vice-chancellor with UK experience of government research assessment, and changes to mission and vision (Martin-Sardesai et al. 2017). This change and its implications are discussed under the final 'A', Adaptation.

The unit of assessment[27] profiles for REF 2014 allowed institutions to show at a more granular level what they were 'best' at, and demonstrate success across the country (Wolff 2015). Participants from the workshop on the reasons for research assessment raised concerns that the search for acclaim may lead to improvements in the quality of research nationally to such a level that research assessment can no longer provide a distinction among excellent research, which participants felt would limit the value of the process. For example, over 70% of impact case studies submitted to REF 2014 were graded as three or four stars[28] (Manville et al. 2015b). Another participant raised concerns that there is a risk that the drive for 'good' rankings could encourage perverse practices in the management of research institutions in order to deliver strong results. Participants agreed that in a world where acclaim is gaining importance, research assessment should ensure that it captures structures and processes that encourage research integrity and good practice.

In New Zealand, where the research assessment exercise is performed at an individual level, a researcher can apply to receive their own rating (McGilvray 2014). Although this was expected to stimulate higher quality research among researchers, there is evidence that it discourages universities from recruiting early-career researchers who will not have established research records. Additionally, individual-focused research assessment may result in 'citation clubs', where a group of researchers consistently cite each other's work to increase their citation index (Holland et al. 2016).

2.1.6. Adaptation

Definition: To steer change in organisational structures, behaviours and cultures, and research activities and priorities.

Research assessment exercises can provide a structure to incentivise change in individual and organisational performance (Marques et al. 2017; Kwok 2013). For example, analysis of research assessment exercises has been used for (1) guiding the research agenda; (2) increasing research productivity; (3) promoting impactful research; and (4) encouraging collaborative and interdisciplinary work.[29]

Research assessment exercises allow the identification of the strengths and weaknesses of different disciplines and geographic areas, with the aim of supporting the development of research policy and management strategies

27 In the REF, submissions are made in discipline-based 'units of assessments' (REF 2019a).

28 The level definitions used for assessing impact as part of REF 2014 were as follows: Four stars were awarded for outstanding impacts in terms of their reach and significance. Three stars were awarded for very considerable impacts in terms of their reach and significance. Two stars were awarded for considered impacts and one star for recognisable but modest impacts. Some were deemed as unclassified when the impact was of little or no reach and significance, or the impact was ineligible or not underpinned by excellent research produced by the submitted unit (REF 2019a).

29 Interdisciplinary work includes multidisciplinary, interdisciplinary, transdisciplinary and cross-disciplinary.

at both the governmental and institutional level (Franceschini & Maisano 2017; Glänzel & Zhang 2018; Rebora & Turri 2013). An example of guiding the research agenda is the Dutch Standard Evaluation Protocol (SEP), which evaluates both the quality and relevance of research to society, and then assesses the research strategies of the different research groups to improve their performance (Association of Universities in the Netherlands et al. 2014).

Research assessment exercises can also be used to increase research productivity by measuring research outputs in terms of quality and quantity (Calver et al. 2013; Mingers, n.d.; Pajić 2015). For example, in Australia and New Zealand there is evidence to suggest that the overall quality of research has increased since the introduction of national assessments (McGilvray 2014). Additionally, a study looking at the evolution of research assessment methodologies in Lithuania found that the introduction of formal assessments of scientific publications encouraged researchers to communicate their results in international scientific journals, and stimulated Lithuanian scientific journals to seek inclusion in international databases, as well as improve their quality (Maskeliūnas et al. 2015).

As mentioned under accountability, in recent years there has been an increase in the need for government and researchers to measure and provide evidence on the value or benefit of research to society (Hill 2016). Methods to assess this include econometric approaches to quantify the relationship between investment in research and economic benefits; approaches focused on knowledge exchange interactions; and the use of qualitative methods, such as the case studies used in REF 2014 (Hill 2016). Submissions for the REF 2014 also included an 'impact template', which consisted of a narrative statement describing the unit's strategy to deliver impact.

An evaluation of impact assessment in REF 2014 found that the inclusion of impact as a criterion for assessment (using the case studies and the strategic template) has changed practice at an individual and institutional level (Manville et al. 2015c; Manville et al. 2015d). Changes observed in institutional practice include setting out an impact strategy for the institution or department, building impact plans into research projects, implementing systems to capture and store evidence of impact on an ongoing basis, including impact as a criterion for promotion, and creating positions such as impact officers (Manville et al. 2015c). In addition, the evaluation found evidence that the assessment of impact as part of REF 2014, along with other policies (such as the Research Councils UK 'Pathways to impact' – now part of UKRI) and the broader 'impact agenda', has led to perceived benefits at the level of individual researchers. For example, identifying and understanding impact, the value of reviewing and affirming relationships with research users, and the promotion or recognition of individuals (Manvilleet al. 2015c). Academics have also perceived a shift in the focus of research away from 'blue skies' and towards more applied research where impact is more easily demonstrated, for the purposes of assessment (Manville et al. 2015c). This is also reflected in an initial evaluation of the impact case studies, which found that the average time between conducting the research and achieving impact was 3 to 9 years, compared to an average of 15 to 20 years previously detailed in the literature (Kings College London & Digital Science 2015). However, this shift may be an artefact of the assessment, rather than a shift in the research conducted.

Through incorporating the societal impact of research as a criterion for assessments, research collaborations have also increased. In Australia and New Zealand, the incorporation of societal impact as a criterion has contributed

to collaborations between researchers from multiple disciplines, from the natural sciences to the humanities, with the aim of assessing societal problems holistically (McGilvray 2014). In the United Kingdom, research assessment has been found to encourage researchers to collaborate with researchers outside of their institution (Martin 2011). In Finland performance-related funding has been used to increase international collaboration (Geuna & Martin 2003).

It is important to note that there may be unintended effects of adaptation that may create perverse incentives in the sector. For example, a shift from basic to applied research has been seen at an individual, institution and sector level in the United Kingdom, in part due to the inclusion of impact as an assessment criterion for the REF (Manville, et al. 2015c). It is not yet clear how far the research agenda in the United Kingdom should shift for the benefit of knowledge creation and society, or what would be 'too far'.

While adaptation as a result of research assessment exercises can happen at an organisational level, there is also the opportunity for adaptation at a local level within projects. For example, as a result of collecting data and evidence of impact, researchers can steer projects in a particular direction to ensure that they are having the desired outcomes and impacts; this has been termed as 'adjustment' (Hill 2017).

The six 'A's are interrelated rather than independent elements. For example, through analysis of 'what works', funders and other stakeholders develop their understanding of what behaviours they seek to promote to achieve the outcomes desired by their strategy. They can influence this by adaptation and incentives, such as how funding is allocated.

2.2. The reasons for assessing research are understood and interpreted differently by different audiences

The purposes for research assessment are both implicit and explicit, and national systems across the world have different purposes. Research assessment can be used either to distribute institutional research funding based on performance, or to provide strategic information not linked to funding. An international landscape study of research and innovation systems found that 10 out of the 20 countries included in the study have at least a component of research assessment built into their national funding system (Kolarz et al. 2019).[30] However, other countries did not have national research assessment exercises linked to funding. For example, in China, research assessment aims to achieve world class status (i.e. acclaim), and only a select group of high-performing universities are included in each assessment. Some countries use alternatives to national research assessment exercises to ensure high-quality research is being conducted within their institutions. For example, in the United States, the Carnegie Ranking of HEIs assesses institutions to classify the country's HEIs.

The primary purpose of the Research Assessment Exercise (RAE) in the United Kingdom was to produce quality profiles for each submission of research activity made by institutions in order to determine how the four UK funding bodies would allocate funding (Research Assessment Exercise 2009).

30 Countries with performance-based research funding that were included in the study: Belgium, Czech Republic, Estonia, Finland, Italy, New Zealand, Norway, Portugal, Sweden and the United Kingdom.

Although allocation remains a key purpose of research assessment in the United Kingdom, the latest REF (REF 2014) had the following key purposes:

- To inform the selective allocation of funding for research.
- To provide accountability for public investment in research and produce evidence of the benefits of this investment.
- To provide benchmarking information and establish reputational yardsticks for use in the higher education sector and for public information (acclaim) (REF 2011).

Although these are the explicit purposes of the REF, the 2016 Stern review identified six purposes for the exercise (BEIS 2016), which have been aligned with the six 'A's for this study:

- Support the allocation of QR funding.
- Produce evidence for strategic decision making on national research priorities (advocacy).
- Provide an accountability mechanism for public investment in research.
- Create performance-based incentives for HEIs and individual academics (adaptation).
- Contribute information to HEIs to inform decisions on resource allocation (analysis).
- Provide a benchmark that may be especially important for less known universities (acclaim).

Reports, such as the Witty review, called for the inclusion of the impact element in national research assessment in order to encourage economic growth from the world leading research that occurs across the United Kingdom (Witty 2013). There could, therefore, be an argument that the explicit nature of the reasons behind assessment has changed over time as the legitimacy of the aims has developed. In a 2019 pilot study to examine the feasibility of evaluating perceptions and attitudes towards the REF, interviewees were asked about what they viewed as the main purpose of the REF (Weinstein et al. 2019).[31] Respondents felt that the REF had broader purposes than the established three (allocation, accountability and benchmarking) (Weinstein et al. 2019). Most interviewees commented on how the REF impacts and influences HEI activity in the United Kingdom and globally in instrumental ways (adaptation), while also acting as a 'quality assurance' system. Many interviewees also acknowledged that the REF had evolved over time to include purposes beyond allocation and accountability. However, they did not provide a clear view on what the main purposes now were.

The view that national research assessment has evolved from its original purpose was shared by participants of the workshop on the purpose of research assessment,[32] who felt that allocation used to be the dominant explicit reason for *ex-post* research assessment through the RAE. However, with the introduction of the impact element a decade ago (REF 2011), the focus has explicitly diversified to value accountability and advocacy, which are needed to underpin the case for public investment in research. Academics completing the survey[33] for the

31 Interviewees for this study included research managers from Cardiff University, the University of Sheffield, the University of Sussex and the University of Lincoln.

32 Participants from the workshop were representatives of the UK government funding bodies and academic experts in the topic of research assessment.

33 Survey participants were asked to rank the six purposes of the REF on a scale of 0 to 6 according to the extent to which the REF achieves the purposes identified in the Stern review. Participants were recruited from four universities: Cardiff University, the University of Sheffield, the University of Sussex and Lincoln University.

2019 review on the REF, described above, agreed that although the three stated purposes of the REF remained (accountability, allocation and benchmarking), accountability had emerged as what should be the main purpose of the REF.

2.3. The rationale for, and emphasis of, research assessment is likely to evolve in the future

As the research landscape changes, the reasons for performing national research assessment are likely to develop. Given that the six 'A's are dynamic and interrelated elements for research assessment, they are likely to continue to evolve, and the weight and importance of each 'A' as a purpose for assessment may continue to shift over time.

In the United Kingdom, research assessment has always been about measuring and improving quality. In 2014, an impact assessment was included which expanded the meaning of quality, beyond academic outputs to include societal benefit beyond academia as an outcome (HEFCE 2009).

Participants of the workshop on the purposes of research assessment felt that the debate had now shifted more towards the use of research assessment to inform strategies (analysis) and focus on acclaim, with universities ranked according to the research they conduct, and using their REF results in the recruitment of staff and students (BEIS 2016; Manville et al. 2015a). The combination of scores for the outputs and impact elements allow HEIs to demonstrate the value of research, as well as to demonstrate to students and their parents the type of environment that an institution creates for its students. The evaluation of the impact element of REF 2014 found that expanding the definition of quality to include the impact on wider society has enabled reward and recognition at an individual, departmental and institutional level for those already undertaking this breadth of activity, which may previously have been overlooked or undervalued (Manville et al. 2015c).

The rise in the role and prominence of analysis may be partly due to the availability of data and the technological capabilities to work with ever-growing datasets. A challenge that faces the sector today, therefore, is to ensure that decisions are data informed, rather than data driven, with sufficient interpretation of the results and an understanding of the data input and its limitations.

The diversification of purposes was previously noted by the 2016 Stern review, detailed above. The review found that although members of the academy still considered the main purpose of the exercise to be allocation of public funds for research, there were other relevant purposes, including informing institutional strategies (i.e. analysis) (BEIS 2016). This may affect the weighting or emphasis placed on different purposes over time. For example, one workshop participant argued that as the public are more engaged in research through public and patient involvement and engagement, their awareness and understanding would increase, which may reduce the drive for accountability to the public.

3 How do researchers expect the forms of output they are producing to change in the next 5 to 10 years?

To understand what forms of outputs and impacts researchers' feel their research is currently leading to, how they expect this to evolve in the next 5 to 10 years, and how this is influenced by the research landscape a large- scale survey of academic researchers in England was conducted. This chapter focusses on the findings on the current and expected outputs of research. It draws on the findings from the large-scale survey of academic researchers in England, as well the rapid evidence assessments and responses to the sector view collection. Additional detail on the methods underpinning this are described in Annex A.

The key findings are:

- Researchers currently produce a diversity of output forms.
- Researchers expect that they will produce a greater diversity of outputs in the future.
- Researchers expect to continue to produce journal articles and conference contributions, and that they will remain the dominant forms in many disciplines in the future.
- Many researchers expect to start to produce more diverse forms of output aimed at a wider audience.
- Researchers' decisions on which forms of output to produce are influenced by factors such as career progression and personal preference, as well as institutional incentives and funder requirements.
- Researchers from different disciplines currently produce different output forms, and researchers' expectations suggest that these differences will continue in the future.

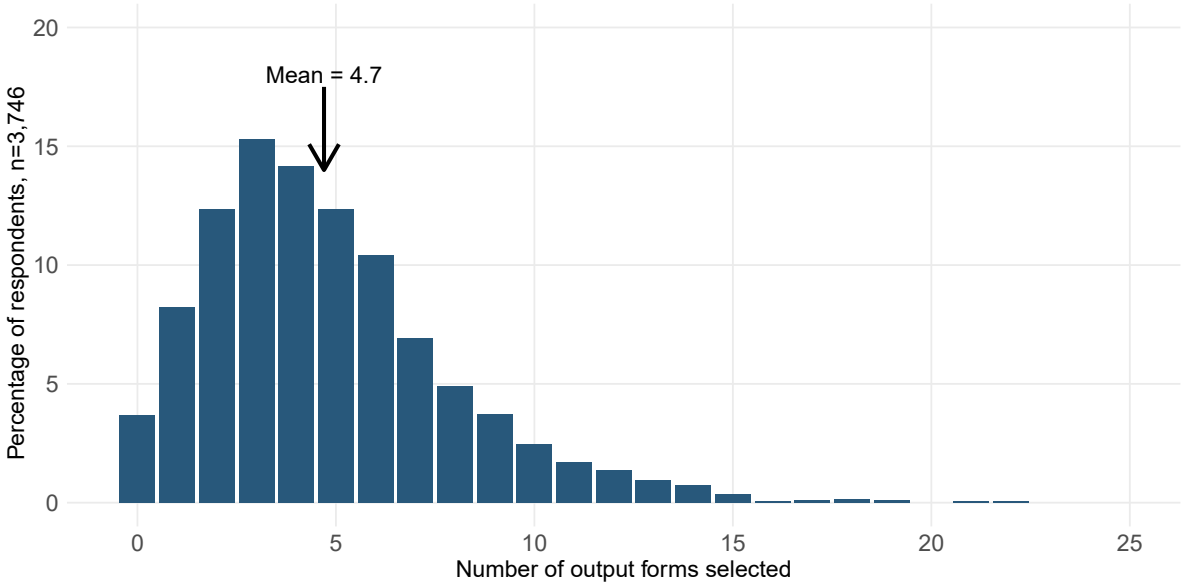
3.1. Researchers currently produce a diversity of output forms

Respondents to the survey were asked to select the forms of output they currently produce and those they plan to produce in the next 5 to 10 years.[34] On average, respondents currently produce 4.7 different forms of output (Figure 3.1).

The most common output forms that respondents currently produce are journal articles and conference contributions, which were identified by 85% and 70% of respondents, respectively (Figure 3.2). No other forms of output are currently produced by more than 50% of respondents across disciplines. When looking at a discipline level in the field of arts

34 Researchers were provided with a list of 32 different output forms (labelled as types). This list was based on the output forms that can be submitted to REF 2021, supplemented with other output forms found within the literature or suggested by the advisory group.

Figure 3.1: Number of output forms currently produced



and humanities, 60% of respondents reported producing chapters in books, and 51% reported producing authored books (detailed below in Figure 3.5). More detail on the disciplinary differences is presented in Section 3.6.

3.2. Researchers expect that they will produce a greater diversity of outputs in the future

When asked to report the output forms respondents are planning to produce in the next 5 to 10 years, on average, respondents selected 6.5 forms of output (Figure 3.3), an average of 2.2 more different output forms than respondents reported currently producing. While there is generally a shift towards the production of more diversity of outputs per person (65% of respondents expect to produce more forms of output in the future), this is not uniform across all respondents. Some 18% of respondents expect to produce fewer forms of output than they currently produce.

The open text section of the survey asked respondents to comment on why they expect their research outputs to change or remain the same, and provides a possible explanation for why respondents reported a wider or narrower range of forms of output in the future. Nearly one quarter (24.3%) of respondents who provided a free text answer (261 of 1,072 responses) cited career progression as the reason for their output forms changing in the future. Many felt that producing a greater range of outputs was associated with developing as a researcher – from being a PhD student or an early-career researcher to more senior research roles. These respondents reflected that they currently need to focus on journal articles until they are at a more advanced stage in their career, but that once they have progressed they will have the time and space to produce outputs besides journal articles. Those who reported a reduction in the range of outputs they expect to produce in the future were often respondents who were retiring or leaving academia. Some 61% of respondents reporting zero output forms were currently PhD students, but only 33% of

Figure 3.2: The percentage of respondents currently producing each form of output

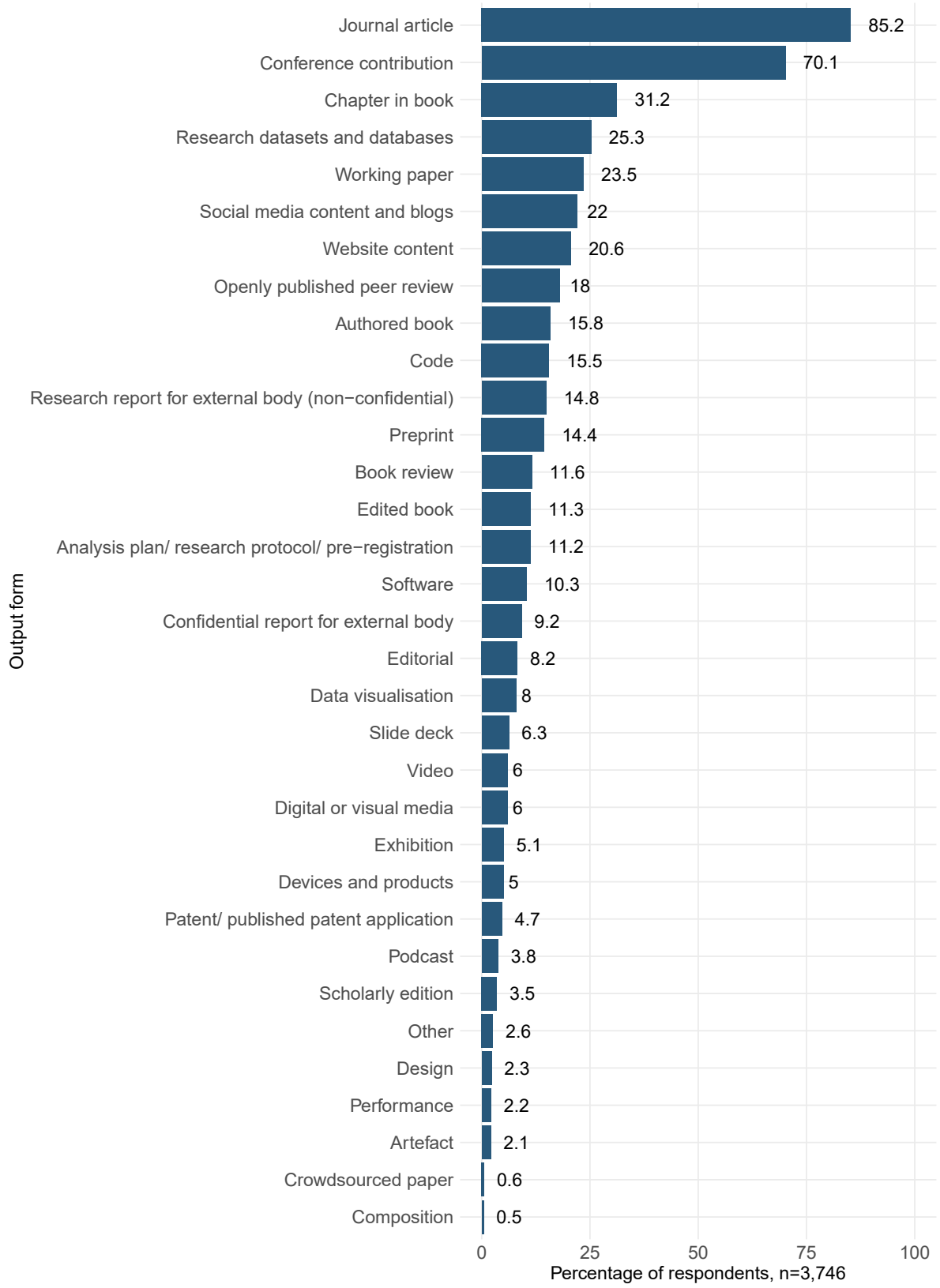
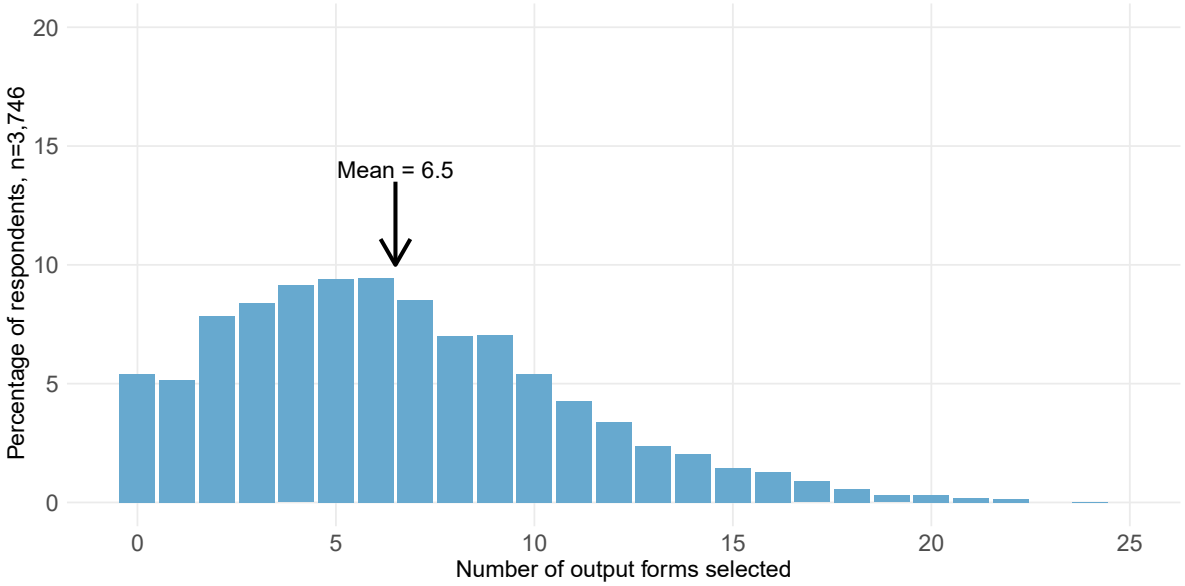


Figure 3.3: Number of output forms that researchers plan to produce in the next 5 to 10 years



those expecting zero output forms in the future were PhD students. This supports the idea that some of the expected increase in outputs is likely driven by PhD students who will be starting to produce outputs, and some of the expected decrease in outputs is likely driven by those who will be leaving academia.

3.3. Researchers expect to continue to produce journal articles and conference contributions, and that they will remain the dominant forms in many disciplines in the future

The top three most frequent output forms, both now and in the future, were ranked as journal articles, conference contributions and chapters in a book (Table 3.1). Significantly[35] more respondents expect to produce most output forms in the future than are currently producing them now (Figure 3.4), with authored books increasing the most from 15.8% to 36.7%. Conference contributions, working papers, code and slide decks had no change between now and the future; journal articles had a slight but significant decrease; and the proportion reporting chapters in a book increased significantly by 18.6% (Figure 3.4).

Authored books, website content, openly published peer review, research report for external body (non-confidential) and edited books all move up the ranking, indicating that they are expected to become relatively more common in terms of the proportion of researchers that will produce them in the future. Working papers and code are some of the few output forms with no expected changes between now and the future. It is not clear why respondents did not expect these output forms to increase. However, in the open text responses about 4% of respondents mentioned that they expect to produce more software or code in the

35 Where results are described as significant this means that a statistical test has been run and the results were statistically significant, with $p<0.05$. Further details on statistical testing can be found in Section A4.2 of the Annex A.

Table 3.1: Top 10 most frequently reported output forms being produced now and expected to be produced in 5 to 10 years' time

Ranking	Most frequently reported output forms now	Most frequently reported output forms in 5 to 10 years' time
1	Journal article	Journal article
2	Conference contribution	Conference contribution
3	Chapter in book	Chapter in book
4	Research datasets and databases	Authored book
5	Working paper	Research datasets and databases
6	Social media content and blogs	Website content
7	Website content	Openly published peer review
8	Openly published peer review	Social media content and blogs
9	Authored book	Research report for external body (non-confidential)
10	Code	Edited book

Colour denotes consistency between the rankings for now and future.

next 5 to 10 years (38 out of 1,072), and about 3% mentioned that they would ideally produce more software or code (21 out of 640).

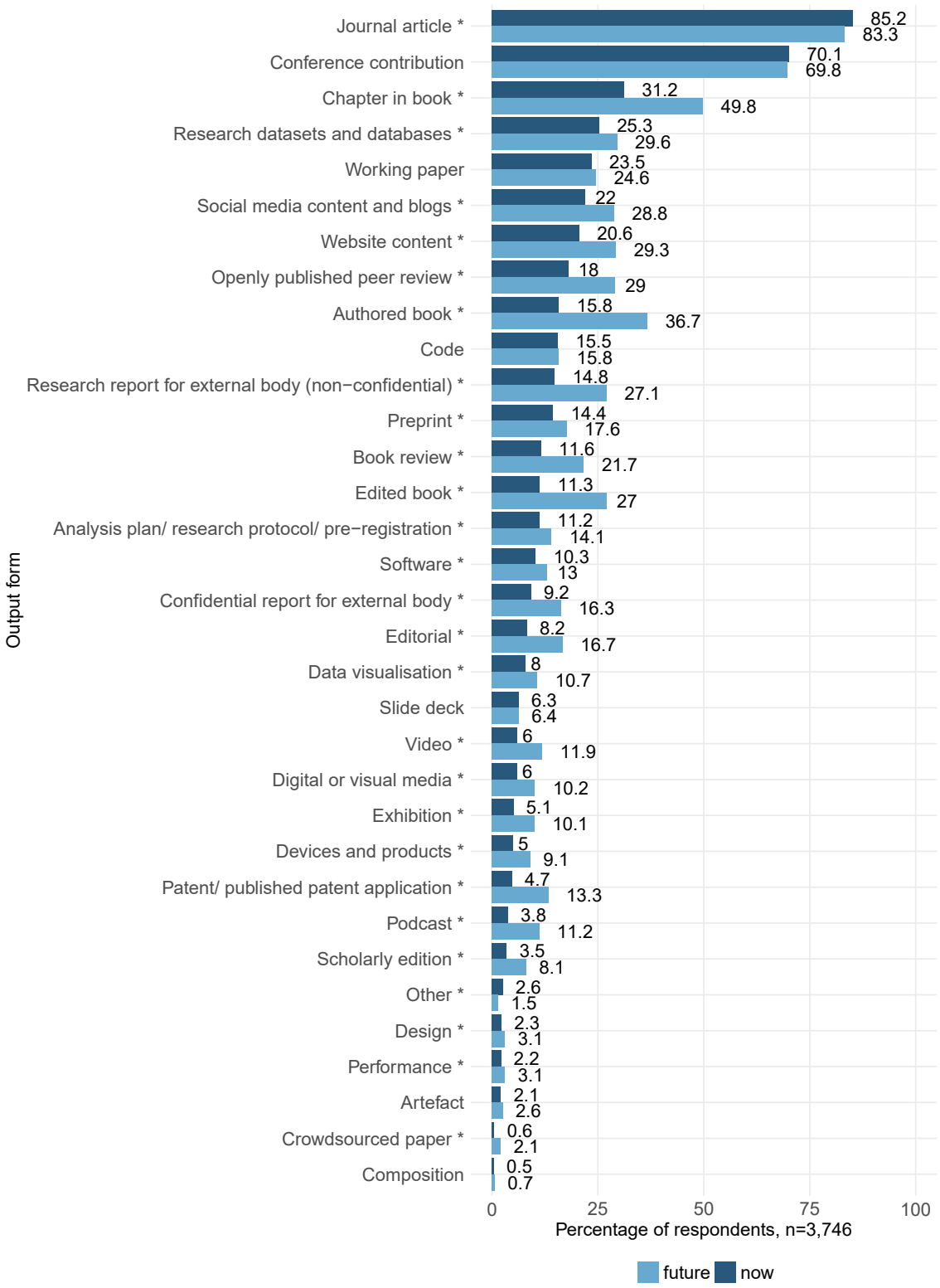
Respondents were also asked whether they expected a change in the form of outputs they are expecting to produce in the next 5 to 10 years, and the reasons behind their expectations. Although this question asked about output forms, researchers commented more about the quantity of different output forms (i.e. whether they would produce that output more or less), rather than whether they were producing them or not. In general, researchers reported increases in outputs that they will be producing rather than decreases, although there were divergent views as to whether the production of some common forms of output would increase or decrease in the future (Table 3.2).

Table 3.2: Respondents who expect a change in the forms of output they produce in the next 5 to 10 years (n=1,072)

Output forms commonly reported in the quantitative element of the survey	Respondents expecting increase (%)	Respondents expecting decrease (%)
Books for an academic audience	70 (6.5%)	23 (2.1%)
Journal articles	57 (5.3%)	47 (4.4%)
Book chapters	19 (1.8%)	0 (0%)
Monographs	14 (1.3%)	12 (1.1%)
Conference contributions	8 (0.7%)	2 (0.2%)
Books for the public or for practitioners	5 (0.5%)	0 (0%)

Books for an academic audience: This category includes mentions of books, where the type of book was not specified. In these instances it was assumed that the respondent was referring to scholarly books rather than books aimed at a public or practitioner audience.

Figure 3.4: The different forms of output respondents are producing now and expect to produce in the next 5 to 10 years



Researchers were provided with a list of 32 different output forms (labelled as types). This list was based on the output forms that can be submitted to REF 2021, supplemented with other output forms found within the literature or suggested by the advisory group.

The stars on the labels indicate a statistically significant difference ($p<0.05$) between now and the future.

Table 3.3 Respondents who would ideally like to produce more or fewer books, monographs and journal articles (n=640)

Output form	Respondents who would ideally produce more of output form (%)	Respondents who would ideally produce less of output form (%)
Books and monographs	103 (16.1%)	10 (1.6%)
Journal articles	18 (2.8%)	115 (18%)

The expected increase in output forms reported may be due to respondents reflecting on their own career ambitions, rather than expected changes in the research landscape. Although career progression was identified as the reason for expecting to produce a particular form of output by about 24% of respondents overall (261 out of 1,072), it was identified as the reason for a third of those who expected increases in any of the common output forms listed in Table 3.2 (44 out of 139); and a third of those who expected increases in journal articles (19 out of 57); and 27% of those who expected increases in books and scholarly books (19 out of 70).

Respondents were also asked if, in an ideal world, they would produce different forms of outputs than they currently do. Nearly one quarter of respondents (712 out of 3,010) said that in an ideal world they would choose to produce different forms of output from what they are currently producing or expect to produce in the future. In the open text question that asked respondents to explain what their ideal outputs would be and why, the most frequently cited forms of output were books and monographs. The most frequently cited form of output that respondents would ideally produce fewer of were journal articles (Table 3.3).

Although respondents commonly mentioned that they expected to produce more journal articles in the future, they also commonly mentioned that they would ideally produce less of this type of output. The responses indicate that while many respondents expected to produce more journal articles as they advance in their careers because such outputs are valued by the academic system in terms of recruitment and career progression, they felt that ideally the system would value a more diverse set of outputs. Out of those who reported they would ideally like to produce fewer journal articles (n=115), more than 20% said that they are unable to produce fewer journal articles because it would hinder their career progression (n=23) and because of the current publishing and peer review model (n=25). Respondents noted that in an ideal world they would not want journal articles to be considered one of the most 'important' outputs, and that they would ideally like the time and space to write more books and monographs rather than focusing only on outputs they perceived were valued and rewarded through national research assessments such as the REF. Some responses perceived journal articles to be more valuable for research assessment (n=16) because they can be produced quicker and in greater volume than other forms of research output. These comments also reflected that respondents felt that this was not always the most appropriate way to publish research. Respondents highlighted institutional pressures to produce more than one output per research project to provide a pool of outputs for assessment and demonstrate success measured in hiring and promotion decisions, which value productivity as well as quality. Many respondents also commented on the need for a wider range

of outputs to be valued and evaluated within the research system, or to create a better measure of research quality than metrics that measure the quantity of journal outputs. Some respondents wanted to reduce the 'publish or perish' mentality in academia.

The expected increase in books may be due to the high proportion of respondents answering this question based on developments that they expect in their career, which was identified as the reason driving changes in future outputs by about 24% (261 out of 1,072) of respondents to the open text question on why respondents expected different forms of output. Of those who reported that they expected an increase in books and scholarly books (n=70), career progression increases to over 25% (n=19), and was the only reason identified by more than 5% of respondents who expected to produce more books and scholarly books. A common argument was that as an individual's career advanced, so would the body of research they had developed, which would allow them to focus on writing books and monographs instead of outputs from individual grants. When asked about what outputs they would ideally produce, many respondents also mentioned institutional constraints in terms of having the time and resources to write books (n=17).

3.4. Many researchers expect to start to produce more diverse forms of output aimed at a wider audience

The top three forms of output with the greatest percentage increase in the next 5 to 10 years are different types of books (Table 3.4), which, as mentioned above, may be due to expected career progression.

Table 3.4: Top 10 output forms with greatest percentage increase in the number of respondents who plan to produce them in the next 5 to 10 years

Ranking	Output forms
1	Authored book
2	Chapter in book
3	Edited book
4	Research report for external body (non-confidential)
5	Openly published peer review
6	Book review
7	Website content
8	Patent/ published patent application
9	Editorial
10	Podcast

Overall, based on researchers' expectations there is likely to be an increase in the diversity of output forms that each researcher plans to produce. There may be a slight decrease in the proportion of researchers producing journal articles, along with increases in the proportion of researchers producing other forms of output. The open text responses largely mirror these findings (Table 3.5 and Table 3.6).[36]

Table 3.5: Broad categories of less common output forms that respondents expect to increase producing

Category of output	Number of respondents (n=1,072) (%)
Outputs with wider audience	286 (26.7%)
Open science outputs	236 (22%)
Outputs using non-traditional mediums	97 (9%)

36 Table 3.5 uses the same data as Table 3.6, but closely related categories have also been grouped together in order to provide a more accurate representation of the number of respondents who expect broad categories of outputs to increase (as many of these respondents will have mentioned more than one type of output within each grouping).

Table 3.6: Less common output forms that respondents expect to increase producing

Output form	Number of respondents (n=1,072) (%)
More impactful or new forms of output (no specific form mentioned)	65 (6%)
Online and digital outputs	111 (10.4%)
Public-facing outputs	111 (10.4%)
Social media posts	60 (5.6%)
Blogs	34 (3.2%)
Podcasts and radio	25 (2.3%)
Website content	22 (2.1%)
Open access publications	111 (10.4%)
Open data or datasets	57 (5.3%)
Open science outputs	54 (5%)
Pre-prints	53 (4.9%)
Open code or software	38 (3.5%)
Open peer review	21 (2%)
Open methodologies or pre-registrations	18 (1.7%)
Open access books and monographs	12 (1.1%)
Crowdsourced papers	2 (0.2%)
Videos	44 (4.1%)
Visual media	25 (2.3%)
Interactive or multimedia outputs	21 (2%)
Creative outputs	16 (1.5%)
Data visualisations	14 (1.3%)
Collaborative and interdisciplinary outputs	28 (2.6%)
Patents and products	26 (2.4%)
Reports	18 (1.7%)
Outputs for industry	18 (1.7%)
Shorter-format publications	14 (1.3%)
Policy briefs	12 (1.1%)

This table includes all output forms that were mentioned by at least 1% of respondents to the free text question as forms they expect to increase in the future.

Table 3.7: Respondents who would ideally like to produce more of different output forms

Output form	Number of respondents who would ideally produce more of output form (n=640) (%)
Alternative outputs or more public facing outputs	95 (14.8%)
Open access articles	71 (11.1%)
Popular media (including blogs, podcasts, magazines, newspapers)	70 (10.9%)
Video	53 (8.3%)
Open science outputs	39 (6.1%)
Interdisciplinary and collaborative outputs	34 (5.3%)

All other output forms were identified by less than 5% of the 640 respondents to the free text question as an output type they would ideally produce more of.

Some 640 respondents identified in the free text responses a number of less common outputs that they would ideally like to produce more of in the next 5 to 10 years (Table 3.7). Other than books and monographs (discussed above), the most common answers were more alternative outputs or more public facing outputs, which were identified by about 15% (n=95) of respondents; open access articles, which were identified by over 10% (n=71); and more popular media (including blogs, podcasts, magazines and newspapers), which were identified by over 10% (n=70).

The expectation that researchers will produce more diverse outputs in the future was echoed in the four responses collected as sector views. When asked about how outputs are expected to change in the next 5 to 10 years, organisations mentioned the expectation that outputs will be more accessible in the future and more tailored to non-expert audiences. Organisations mentioned that this may take the form of more innovative formats or a wider range of outputs, such as blogs, videos, infographics, datasets and software. One organisation highlighted that this may reflect the transition to more granular outputs, or outputs with release versions rather than a final output.

Respondents also mentioned that diversification may mean that more outputs are produced per research project, including more granular outputs at different stages of the research (such as hypotheses, datasets, protocols and methods). Although organisations in the research sector expect more diverse outputs, they stressed that the level to which this is achieved is dependent on the importance of article prestige and metrics such as journal impact factor going forwards. If journal articles continue to dominate in terms of how research is evaluated both at an institutional level (e.g. recruitment and promotion decisions) and in the research system (e.g. grant decisions and publishing decisions), the diversity of outputs produced may be limited. This sentiment was largely reflected in the survey data, with respondents expecting to produce more outputs in the

Table 3.8: Reasons provided for why researchers expect to produce new output forms in the future

Reason why new output forms expected	Number of respondents (n=1,072) (%)
Career progression	261 (24.3%)
Reaching new audiences	93 (8.7%)
Creating impact	32 (3%)
Funding opportunities	30 (2.8%)
Promotion, reward and recognition systems	29 (2.7%)
Rise of open access publications	22 (2.1%)
The REF	21(2%)
Changes in academic publishing system	20 (1.9%)
New technology	19 (1.8%)
Improving communication	13 (1.2%)
Improving research	12 (1.1%)
Impact agenda	11 (1%)

future, while also identifying necessary changes in the research landscape that will facilitate the production of more diverse outputs.

3.5. Researchers' decisions on which forms of output to produce are influenced by factors such as career progression and personal preference, as well as institutional incentives and funder requirements

The open text responses in the survey provide some insight as to why researchers choose to produce certain output forms over others. Respondents were asked, 'Do you expect a change in the type of outputs you are producing in the next 5 to 10 years?'[37] and then had the opportunity to answer in an open response, 'If yes, please explain below.' In total, 1,072 respondents provided an open text response to this question. There are a number of internal and external factors and motivations that they think will drive changes in the forms of output they expect to produce in the next 5 to 10 years. Table 3.8 shows the proportion of respondents who mentioned specific reasons for expecting different outputs in the future.

The top three reasons that respondents identified for expecting different outputs in the future were career progression, to reach new audiences and to create impact (Table 3.8). Similarly, when respondents were asked about why they would ideally produce different outputs (n=640), the most common reason identified by nearly 20% was to reach new audiences (n=120), followed by to create impact (identified by over 10%, n=67).

Other factors and motivations that respondents identified as reasons why they expect different

37 The analysis has replaced 'types' with 'forms' when discussing outputs to distinguish it from comments on impact type.

outputs in the future (or why they would ideally produce different outputs in the future) were improving communication and improving research and publishing systems, which includes the rise of open access publications and other changes in the academic publishing system (such as changes to peer review, fewer print publications and changes to subscription models). Respondents reported that longer format output forms such as books and monographs allowed them to explain more nuanced arguments or engage in deeper explorations of their research areas. Respondents also mentioned that producing output forms other than journal articles helps to improve the rigour, transparency and efficiency of the research system. For example, some respondents felt that publishing studies with null results and replication studies (which are less likely to be published as journal articles) allows researchers across the research system to build on one another's work rather than repeat work that has already been done but has not been published. Publishing pre-registrations and open datasets ensure that findings can be replicated by others.

When asked about the forms of output they would produce in an ideal world,[38] over 15% of those who responded to this free text question (97 out of 640) reported that they are either unable to produce the outputs that they would ideally like to because they feel they are not valued at an institutional or research system level (n=56) or that the national research assessment (i.e. the REF) impacts on the range of output forms produced (n=47). Many expressed that other output forms are desirable, but producing them takes time away from writing journal articles, which will be more significant in career progression and future funding opportunities.

As discussed above, the publishing system is viewed as driving some respondents to change their outputs, and it was also seen as a constraint in terms of researchers producing the outputs they would like to publish (n=640). About 8% of respondents said that they are not able to produce the outputs they would like to because of the current publishing and peer review model (n=53). A small number of respondents (about 2%, n=19) also mentioned the role that they expected new technologies to play in the range of research outputs they produce in the future. Some of these respondents mentioned that digital media will allow them to produce more multimedia, video and interactive outputs, while others commented that new technologies such as artificial intelligence (AI) and machine learning would change how research is conducted, which would lead to new outputs in the future.

3.6. Researchers from different disciplines currently produce different output forms, and researchers' expectations suggest that these differences will continue in the future

When looking at the forms of output that researchers produce now and expect to in the future, similarities and differences across disciplines[39] are expected to continue over the next 5 to 10 years (Figure 3.5).

38 The survey asked 'In an ideal world, would you choose to produce different forms of output from those you have selected above?' and then had the opportunity to answer in an open text response 'If you answered yes to Question 8, what would they be and why would you choose to produce them instead?' In total, 640 respondents provided an open response to this question.

39 The main panels for REF2021 are used throughout as a proxy for disciplines.

Figure 3.5: Percentage of respondents from each discipline who report producing each form of output now and who expect to do so in the future (in 5 to 10 years)

	Medicine, health and life sciences n=1,404		Physical sciences, engineering and mathematics n=954		Social sciences n=664		Arts and humanities n=582	
Output form	Now	Future	Now	Future	Now	Future	Now	Future
Journal article	88	86	**87**	**84**	86	82	**72**	**78**
Conference contribution	**69**	**73**	71	71	70	68	70	64
Chapter in book	**22**	**43**	**17**	**38**	**43**	**60**	**60**	**71**
Research datasets and databases	**34**	**39**	**25**	**30**	19	22	12	15
Working paper	20	22	23	23	36	36	16	18
Social media content and blogs	**20**	**28**	**13**	**20**	**32**	**38**	**29**	**35**
Website content	**18**	**26**	**20**	**30**	24	28	**23**	**35**
Openly published peer review	**26**	**41**	**19**	**27**	**11**	**21**	**5**	**14**
Authored book	**3**	**16**	**5**	**25**	**23**	**58**	**51**	**80**
Code	15	17	32	31	5	6	2	2
Research report for external body (non-confidential)	**16**	**30**	**13**	**25**	**21**	**36**	**6**	**12**
Preprint	**17**	**23**	25	27	5	7	3	5
Book review	**4**	**11**	**4**	**12**	**17**	**31**	**35**	**51**
Edited book	**4**	**16**	**4**	**16**	**17**	**41**	**31**	**55**
Analysis plan/ research protocol/ pre-registration	**23**	**28**	4	6	5	6	2	2
Software	**7**	**10**	26	31	3	3	1	2
Confidential report for external body	**9**	**18**	**13**	**20**	**9**	**15**	4	7
Editorial	**10**	**21**	**5**	**11**	**10**	**18**	**8**	**14**
Data visualisation	**8**	**11**	12	15	5	8	**2**	**6**
Slide deck	6	6	9	10	7	6	2	2
Video	**5**	**10**	**6**	**11**	**7**	**13**	**7**	**16**
Digital or visual media	**4**	**9**	**4**	**7**	**8**	**12**	**10**	**16**
Exhibition	**2**	**4**	4	5	**5**	**15**	**13**	**27**
Devices and products	**4**	**10**	**10**	**16**	2	2	2	3
Patent/ published patent application	**5**	**17**	**10**	**25**	0	1	1	1
Podcast	**3**	**10**	**1**	**6**	**6**	**14**	**7**	**20**
Scholarly edition	**2**	**5**	**1**	**3**	**4**	**9**	**11**	**23**
Design	1	1	5	6	2	3	1	1
Performance	1	1	1	1	2	3	6	10
Artefact	0	0	2	3	3	3	5	7
Crowdsourced paper	**1**	**2**	**1**	**3**	**0**	**2**	0	1
Composition	0	0	0	1	0	0	2	3

Percentages are shown in bold where there is a significant difference between now and the future (significant differences between now and the future are also shown in Table 3.9). Output forms are shown shaded in grey if there is a significant difference across disciplines now, and in bold if there is a significant difference expected in the future. Each cell is shaded from white to dark red according to the percentage of respondents reporting producing or expecting to produce each type of output. The darker the red, the higher the percentage.

For a number of output forms across all disciplines, the percentage of respondents who expect to produce them in the future is significantly greater than the percentage who report producing them today. Across all disciplines, researchers expect that they will produce more authored books, edited books, chapters in a book, scholarly editions, research reports for external bodies (non-confidential), social media content and blogs, digital or visual media, openly published peer review, podcasts, videos, editorials, and book reviews in the future. The five output forms which do not have a significant difference between now and the future across the sample (code, working paper, slide deck, artefact and composition) also do not have a significant difference between now and the future within any of the disciplines. Design and performance also do not have significant differences between now

and the future (likely due to small numbers of respondents who selected these options). Some output forms only present significant differences between now and the future for some disciplines (Table 3.9).

Table 3.9: Significant differences in outputs produced now and expected to be produced in the future, across disciplines

Output type	Medicine, health and life sciences	Physical sciences, engineering and mathematics	Social sciences	Arts and humanities
Journal article		↓		↑
Conference contribution	↑			
Chapter in book	↑	↑	↑	↑
Research datasets and databases	↑	↑		
Working paper				
Social media content and blogs	↑	↑	↑	↑
Website content	↑	↑		↑
Openly published peer review	↑	↑	↑	↑
Authored book	↑	↑	↑	↑
Code				
Research report for external body (non-confidential)	↑	↑	↑	↑
Preprint	↑			
Book review	↑	↑	↑	↑
Edited book	↑	↑	↑	↑
Analysis plan/research protocol/pre-registration	↑			
Software	↑			
Confidential report for external body	↑	↑	↑	
Editorial	↑	↑	↑	↑
Data visualisation	↑			
Slide deck				
Video	↑	↑	↑	↑
Digital or visual media	↑	↑	↑	↑
Exhibition	↑		↑	↑
Devices and products	↑	↑		
Patent/published patent application	↑	↑		
Podcast	↑	↑	↑	↑
Scholarly edition	↑	↑	↑	↑
Design				
Performance				
Artefact				
Crowdsourced paper	↑	↑	↑	
Composition				

Key: upwards arrow= significant increase expected in the future; downward arrow =significant decrease expected in the future; no arrow = no significant change expected in the future.

As outlined above, there are significant differences across disciplines in terms of what outputs they produce and expect to produce in the future. All but three output forms (conference contribution, website content and video) have a significant difference across disciplines now, and all but one (crowdsourced paper) have a significant difference for those expecting to produce them in the future. In particular, there are currently fewer arts and humanities researchers producing journal articles than researchers in other disciplines, while more social sciences and arts and humanities researchers produce book types (i.e. chapters in books, authored books, book reviews, and edited books), social media, blogs, podcasts and working papers. Openly published peer review, code, research datasets and databases and preprints are more common outputs for researchers in medicine, health and life sciences, as well as physical sciences, engineering and mathematics. Some outputs are also highly specific to certain disciplines, for example analysis plans are mainly produced in medicine, health and life sciences, and software is mainly produced in physical sciences, engineering and mathematics.

There are also some significant differences between career stages within disciplines. Figure 3.6 shows the percentage of respondents from each discipline and career stage that report producing the top 10 forms of output now, and that expect to produce them in the future. Percentages are shown in bold where there is a significant difference within the discipline and time period (i.e. now or the future) across the career stage. There is a significant difference in the proportion of researchers who report producing journal articles and chapters in books across career stages within each discipline, with the exception of physical sciences, engineering and mathematics, and arts and humanities in relation to journal articles, and social sciences and arts and humanities in relation to chapters in books. There is a significant difference for research datasets and databases across career stages within medicine, health and life sciences, as well as physical sciences, engineering and mathematics, but this is not the case for social sciences and arts and humanities. Further differences can be seen in Figure 3.6.

Variation is also seen in some responses reported by career stage (Figure 3.7 and Table 3.10): eight output forms do not have a difference within each career stage in terms of the number of respondents reporting producing them now and in the future (Table 3.10). Eleven output forms have significant differences between now and the future for all career stages (website content, openly published peer review, research report for external body (non-confidential), book review, confidential report for external body, editorial, video, digital or visual media, exhibition, patent/published patent application, and podcast) (Table 3.10). Some output forms only have significant differences for some career stages (Table 3.10). In general, fewer PhD students are producing each output type than respondents from other career stages, with the exception of working papers, code, data visualisations and design. In particular, code and data visualisations are mostly produced by PhD students and early-career researchers.

Overall, although there are significant differences across career stages for many output forms, there are more output forms with significant differences when looking across disciplines (see Figure 3.8), which suggests that disciplinary conventions have a greater bearing than career stage on the forms of output produced.

Figure 3.6: Percentage of respondents reporting producing the top 10 overall forms of output now and expecting to produce them in the future: Differences across career stages within disciplines

	Medicine, health and life sciences								Physical sciences, engineering and mathematics							
	Now				Future				Now				Future			
	PhD	ECR	MCR	ER	PhD	ECR	MCR	ER	PhD	ECR	MCR	ER	PhD	ECR	MCR	ER
Journal article	**69.5**	**91.4**	**95.8**	**96.3**	**78.2**	**85.7**	**88.2**	**91.4**	**71.4**	**93.5**	**93.2**	**94.7**	78.3	85.6	85.7	86.7
Conference contribution	58.2	73.6	74.8	71.6	**64.0**	**79.3**	**74.4**	**74.9**	63.8	79.4	73.9	70.8	67.0	75.5	73.3	70.8
Chapter in book	**5.5**	**17.6**	**29.7**	**34.6**	**31.7**	**45.8**	**46.0**	**49.2**	**2.9**	**14.8**	**21.1**	**34.5**	**22.8**	**47.7**	**36.6**	**48.2**
Research datasets and databases	**22.5**	**38.0**	**39.6**	**37.6**	**28.6**	**44.2**	**44.7**	**40.4**	**15.9**	**27.1**	**29.8**	**28.8**	**20.3**	**37.9**	**33.5**	**31.9**
Working paper	22.5	19.7	19.5	18.3	**28.9**	**20.2**	**22.0**	**17.7**	**27.9**	**23.5**	**21.1**	**18.1**	29.0	22.4	23.0	19.0
Social media content and blogs	14.5	23.8	19.8	21.1	25.2	31.8	29.1	25.4	10.5	17.7	14.9	11.5	18.1	23.1	23.6	15.9
Website content	**9.8**	**16.9**	**21.7**	**26.0**	**16.6**	**26.1**	**32.9**	**31.2**	**9.8**	**26.7**	**24.2**	**23.5**	**19.6**	**38.3**	**32.9**	**31.9**
Openly published peer review	**12.6**	**24.2**	**35.1**	**31.8**	37.2	42.0	46.3	37.9	15.6	19.5	26.1	20.4	23.2	30.0	31.7	27.4
Authored book	**0.9**	**1.4**	**4.5**	**7.3**	14.2	13.8	20.8	17.1	**0.4**	**3.2**	**3.7**	**13.7**	**9.8**	**23.8**	**29.8**	**41.2**
Code	**20.0**	**19.0**	**13.4**	**8.9**	**19.1**	**21.9**	**14.4**	**10.1**	**36.6**	**40.1**	**29.2**	**19.0**	**34.4**	**36.8**	**31.1**	**21.7**
	Social sciences								**Arts and humanities**							
	Now				**Future**				**Now**				**Future**			
	PhD	ECR	MCR	ER	PhD	ECR	MCR	ER	PhD	ECR	MCR	ER	PhD	ECR	MCR	ER
Journal article	**68.3**	**88.6**	**91.3**	**95.2**	**73.4**	**79.5**	**85.7**	**88.2**	**55.7**	**87.3**	**73.4**	**71.8**	81.1	70.4	78.4	81.8
Conference contribution	68.3	73.5	68.3	69.9	59.7	71.1	65.8	73.1	74.6	73.2	69.1	67.1	59.0	62.7	62.6	70.6
Chapter in book	**19.4**	**36.7**	**54.0**	**57.0**	66.2	50.6	62.1	63.4	**21.3**	**65.5**	**70.5**	**74.7**	72.1	70.4	71.2	72.4
Research datasets and databases	15.8	24.1	15.5	18.8	18.7	22.3	18.0	26.3	12.3	13.4	10.1	11.8	11.5	15.5	15.1	16.5
Working paper	36.7	38.6	31.1	34.4	43.2	39.2	27.3	35.5	**26.2**	**17.6**	**10.1**	**11.8**	25.4	19.7	12.2	17.1
Social media content and blogs	30.9	37.3	31.1	29.6	36.7	43.4	41.0	33.9	34.4	32.4	28.1	24.1	36.9	43.0	38.8	26.5
Website content	14.4	25.3	27.3	27.4	18.7	31.3	31.7	31.2	21.3	24.6	25.2	21.8	30.3	41.5	38.8	31.8
Openly published peer review	4.3	13.9	11.2	12.4	25.2	24.1	16.8	18.8	4.1	5.6	7.9	4.7	15.6	18.3	12.2	11.2
Authored book	**5.8**	**19.9**	**27.3**	**36.0**	**54.7**	**48.2**	**63.4**	**64.5**	**9.0**	**55.6**	**61.9**	**67.6**	82.8	79.6	81.3	77.6
Code	6.5	8.4	3.7	2.7	4.3	11.4	4.3	3.8	1.6	4.2	2.2	1.8	2.5	2.8	2.2	1.2

Percentages are shown in bold where there is a significant difference across career stages within disciplines and between now and in the future. Each cell is shaded from white to dark red according to the percentage of respondents reporting producing or expecting to produce each type of output. The darker the red, the higher the percentage.

Figure 3.7: Percentage of respondents from each career stage reporting producing forms of output now and expecting to produce them in the future

	PhD Student n=893		Early-career researcher n=1,043		Mid-career researcher n=803		Established researcher n=953	
Output form	Now	Future	Now	Future	Now	Future	Now	Future
Journal article	**68**	**78**	**91**	**83**	**90**	**85**	91	88
Conference contribution	64	63	75	74	72	70	70	73
Chapter in book	**10**	**41**	**27**	**51**	**41**	**52**	**47**	**57**
Research datasets and databases	18	22	**29**	**35**	27	31	27	31
Working paper	28	31	24	25	21	21	21	22
Social media content and blogs	**19**	**26**	**26**	**33**	**23**	**32**	21	25
Website content	**12**	**20**	**22**	**33**	**24**	**33**	**25**	**32**
Openly published peer review	**11**	**28**	**19**	**32**	**23**	**31**	**20**	**27**
Authored book	**3**	**29**	**13**	**32**	**20**	**42**	**27**	**45**
Code	20	19	20	21	13	13	9	10
Research report for external body (non-confidential)	**7**	**21**	**14**	**29**	**19**	**30**	**20**	**30**
Preprint	**9**	**14**	**16**	**20**	17	19	15	18
Book review	**7**	**18**	**12**	**20**	**15**	**25**	**13**	**24**
Edited book	**2**	**16**	**8**	**26**	**14**	**32**	**22**	**35**
Analysis plan/ research protocol/ pre-registration	10	13	**13**	**17**	12	16	10	12
Software	**9**	**12**	**13**	**16**	10	13	10	11
Confidential report for external body	**3**	**10**	**8**	**16**	**11**	**18**	**15**	**22**
Editorial	**2**	**7**	**6**	**16**	**10**	**21**	**16**	**24**
Data visualisation	11	13	**9**	**13**	8	11	5	7
Slide deck	4	5	7	7	7	7	7	7
Video	**3**	**8**	**4**	**12**	**9**	**15**	**9**	**14**
Digital or visual media	**4**	**7**	**6**	**11**	**8**	**13**	**7**	**11**
Exhibition	**4**	**8**	**5**	**10**	**6**	**12**	**6**	**11**
Devices and products	**2**	**8**	**4**	**9**	**5**	**10**	8	10
Patent/ published patent application	**2**	**12**	**5**	**17**	**4**	**12**	**7**	**13**
Podcast	**2**	**9**	**4**	**12**	**4**	**12**	**5**	**13**
Scholarly edition	**1**	**8**	**3**	**8**	**4**	**8**	6	9
Design	3	5	2	3	2	3	2	2
Performance	1	2	2	3	3	4	2	3
Artefact	1	2	2	3	3	3	3	2
Crowdsourced paper	**1**	**2**	**1**	**3**	0	1	1	2
Composition	0	1	0	1	1	1	0	1

Percentages are shown in bold where there is a significant difference between now and the future (significant differences between now and the future are also shown in Table 3.10). Output forms are shown shaded in grey if there is a significant difference across career stages now, and in bold if there is a significant difference across career stages expected in the future. Each cell is shaded from white to dark red according to the percentage of respondents reporting producing or expecting to produce each type of output. The darker the red, the higher the percentage.

Table 3.10: Significant differences in outputs produced now and expected to be produced in the future, across career stages

Output Type	PhD	ECR	MCR	ER
Journal article	↑	↓	↓	
Conference contribution				
Chapter in book	↑	↑	↑	↑
Research datasets and databases		↑		
Working paper				
Social media content and blogs	↑	↑	↑	
Website content	↑	↑	↑	↑
Openly published peer review	↑	↑	↑	↑
Authored book	↑	↑	↑	↑
Code				
Research report for external body (non-confidential)	↑	↑	↑	↑
Preprint	↑	↑		
Book review	↑	↑	↑	↑
Edited book	↑	↑	↑	↑
Analysis plan/ research protocol/ pre-registration		↑		
Software	↑	↑		
Confidential report for external body	↑	↑	↑	↑
Editorial	↑	↑	↑	↑
Data visualisation		↑		
Slide deck				
Video	↑	↑	↑	↑
Digital or visual media	↑	↑	↑	↑
Exhibition	↑	↑	↑	↑
Devices and products	↑	↑	↑	
Patent/ published patent application	↑	↑	↑	↑
Podcast	↑	↑	↑	↑
Scholarly edition	↑	↑	↑	
Design				
Performance				
Artefact				
Crowdsourced paper	↑	↑		
Composition				

Key: ECR = early-career researcher; MCR = mid-career researcher; ER = established researcher; upwards arrow= significant increase expected in the future; downward arrow =significant decrease expected in the future; no arrow = no significant change expected in the future.

Figure 3.8: Percentage of respondents reporting producing the top 10 forms of output now and expecting to produce them in the future: Differences across disciplines within career stages

	PhD student								Early-career researcher							
	Now				Future				Now				Future			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Journal article	**69.5**	**71.4**	**68.3**	**55.7**	**78.2**	**78.3**	**73.4**	**81.1**	**91.4**	**93.5**	**88.6**	**87.3**	**85.7**	**85.6**	**79.5**	**70.4**
Conference contribution	58.2	63.8	68.3	74.6	**64.0**	**67.0**	**59.7**	**59.0**	73.6	79.4	73.5	73.2	**79.3**	**75.5**	**71.1**	**62.7**
Chapter in book	**5.5**	**2.9**	**19.4**	**21.3**	**31.7**	**22.8**	**66.2**	**72.1**	**17.6**	**14.8**	**36.7**	**65.5**	**45.8**	**47.7**	**50.6**	**70.4**
Research datasets and databases	**22.5**	**15.9**	**15.8**	**12.3**	**28.6**	**20.3**	**18.7**	**11.5**	**38.0**	**27.1**	**24.1**	**13.4**	**44.2**	**37.9**	**22.3**	**15.5**
Working paper	**22.5**	**27.9**	**36.7**	**26.2**	**28.9**	**29.0**	**43.2**	**25.4**	**19.7**	**23.5**	**38.6**	**17.6**	**20.2**	**22.4**	**39.2**	**19.7**
Social media content and blogs	**14.5**	**10.5**	**30.9**	**34.4**	**25.2**	**18.1**	**36.7**	**36.9**	**23.8**	**17.7**	**37.3**	**32.4**	**31.8**	**23.1**	**43.4**	**43.0**
Website content	**9.8**	**9.8**	**14.4**	**21.3**	**16.6**	**19.6**	**18.7**	**30.3**	**16.9**	**26.7**	**25.3**	**24.6**	**26.1**	**38.3**	**31.3**	**41.5**
Openly published peer review	**12.6**	**15.6**	**4.3**	**4.1**	**37.2**	**23.2**	**25.2**	**15.6**	**24.2**	**19.5**	**13.9**	**5.6**	**42.0**	**30.0**	**24.1**	**18.3**
Authored book	**0.9**	**0.4**	**5.8**	**9.0**	**14.2**	**9.8**	**54.7**	**82.8**	**1.4**	**3.2**	**19.9**	**55.6**	**13.8**	**23.8**	**48.2**	**79.6**
Code	**20.0**	**36.6**	**6.5**	**1.6**	**19.1**	**34.4**	**4.3**	**2.5**	**19.0**	**40.1**	**8.4**	**4.2**	**21.9**	**36.8**	**11.4**	**2.8**
	Mid-career researcher								**Established researcher**							
	Now				**Future**				**Now**				**Future**			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Journal article	**95.8**	**93.2**	**91.3**	**73.4**	**88.2**	**85.7**	**85.7**	**78.4**	**96.3**	**94.7**	**95.2**	**71.8**	**91.4**	**86.7**	**88.2**	**81.8**
Conference contribution	74.8	73.9	68.3	69.1	**74.4**	**73.3**	**65.8**	**62.6**	71.6	70.8	69.9	67.1	74.9	70.8	73.1	70.6
Chapter in book	**29.7**	**21.1**	**54.0**	**70.5**	**46.0**	**36.6**	**62.1**	**71.2**	**34.6**	**34.5**	**57.0**	**74.7**	**49.2**	**48.2**	**63.4**	**72.4**
Research datasets and databases	**39.6**	**29.8**	**15.5**	**10.1**	**44.7**	**33.5**	**18.0**	**15.1**	**37.6**	**28.8**	**18.8**	**11.8**	**40.4**	**31.9**	**26.3**	**16.5**
Working paper	**19.5**	**21.1**	**31.1**	**10.1**	**22.0**	**23.0**	**27.3**	**12.2**	**18.3**	**18.1**	**34.4**	**11.8**	**17.7**	**19.0**	**35.5**	**17.1**
Social media content and blogs	**19.8**	**14.9**	**31.1**	**28.1**	**29.1**	**23.6**	**41.0**	**38.8**	**21.1**	**11.5**	**29.6**	**24.1**	**25.4**	**15.9**	**33.9**	**26.5**
Website content	21.7	24.2	27.3	25.2	32.9	32.9	31.7	38.8	26.0	23.5	27.4	21.8	31.2	31.9	31.2	31.8
Openly published peer review	**35.1**	**26.1**	**11.2**	**7.9**	**46.3**	**31.7**	**16.8**	**12.2**	**31.8**	**20.4**	**12.4**	**4.7**	**37.9**	**27.4**	**18.8**	**11.2**
Authored book	**4.5**	**3.7**	**27.3**	**61.9**	**20.8**	**29.8**	**63.4**	**81.3**	**7.3**	**13.7**	**36.0**	**67.6**	**17.1**	**41.2**	**64.5**	**77.6**
Code	**13.4**	**29.2**	**3.7**	**2.2**	**14.4**	**31.1**	**4.3**	**2.2**	**8.9**	**19.0**	**2.7**	**1.8**	**10.1**	**21.7**	**3.8**	**1.2**

Percentages are shown in bold where there is a significant difference between now and in the future. Each cell is shaded from white to dark red according to the percentage of respondents reporting producing or expecting to produce each type of output. The darker the red, the higher the percentage.

Key: Main panel A = medicine, health and life sciences; B = physical sciences, engineering and mathematics; C = social sciences; and D = arts and humanities.

4 How do researchers expect the types of societal impact their research produces to change in the next 5 to 10 years?

To understand what forms of outputs and types of societal impacts researchers' feel their research is currently leading to, how they expect this to evolve in the next 5 to– 10 years, and how this is influenced by the research landscape a large- scale survey of academic researchers in England was conducted This chapter focusses on the findings related to the current and expected wider societal impacts of research and researchers' perceptions of the key drivers of expected changes in impact. It also draws on the rapid evidence assessments, responses to the sector view collection and evidence from the workshops. Additional detail on the methods underpinning this are described in Annex A.

The key findings are:

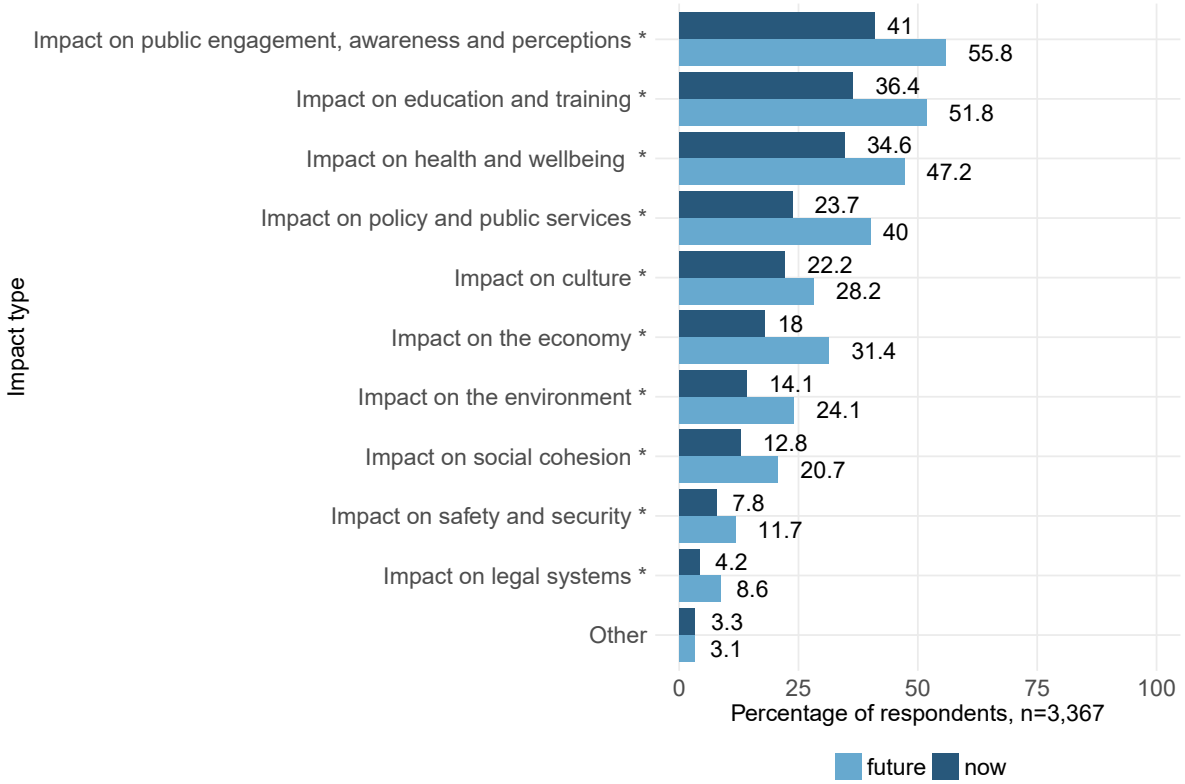
- More researchers expect that there will be societal impacts from their research in the future, although the balance of types of impact is expected to remain largely the same.
- Societal impact types differ across disciplines, and this is not expected to change.
- Researchers expect that they will continue to focus the majority of their efforts in the future on producing outputs.
- Respondents had differing views as to whether the importance placed on societal impact should increase or decrease in the future, and the reasons for this change.

4.1. More researchers expect that there will be societal impacts from their research in the future, although the balance of types of impact is expected to remain largely the same

Respondents were asked to select the types of impact their research currently produces and those they expect it to produce in the next 5 to 10 years. Some 77% of respondents currently expect their research to have societal impact, compared to 86% who expect their research to have societal impact in the future. Most respondents expect that their research will lead to more different types of impact in the future (Figure 4.1), with the mean number of types of impact per research increasing from 2.2 to 3.2.

The types of impact that researchers expect to produce remain constant, with the exception of the impact of research on culture and on the economy, which switch places in terms of how they are ranked: more respondents expect that research will have an impact on the economy than reported an impact on culture in the next 5 to 10 years. This was backed up in the sector views, where one response highlighted that the types of impact are unlikely to change. However this organisation felt that over time the sector was developing a deeper understanding of the process by which impact can occur and how to imbed it within academic

Figure 4.1: Types of impact that respondents are producing now and expecting to produce in the next 5 to 10 years



Researchers were provided with a list of 10 different impact types. This list was based on the definition of impact from REF 2021, supplemented with knowledge of research impact.

The stars on the labels indicate a statistically significant difference ($p<0.05$) between now and the future.

research, which would enable a more nuanced practice and reporting of impact.

4.2. Societal impact types differ across disciplines, and this is not expected to change

The current and expected impacts that respondents reported by disciplines and career stage (Figure 4.2 and Figure 4.3, respectively) were also explored as part of this study. The biggest differences in terms of respondents' current and expected impact types are seen across disciplines, where there is a significant difference for all impact types (Figure 4.2). For example, impacts on health and wellbeing are reported most by researchers from medicine, health and life sciences; impacts on the economy are reported most by researchers in physical sciences, engineering and mathematics; impacts on policy and public services are reported most by researchers in social sciences; and impacts on culture are reported most by researchers in arts and humanities. Respondents from all disciplines expect to produce more of all impact types in the future, with the exception of those in the field of arts and humanities, where respondents do not expect a significant increase between now and the future in terms of impact on the

Figure 4.2: Types of societal impact that respondents from each discipline are producing now and expecting to produce in the next 5 to 10 years (percentage)

	Medicine, health and life sciences n=1,252		Physical sciences, engineering and mathematics n=812		Social sciences n=639		Arts and humanities n=529	
Impact type	Now	Future	Now	Future	Now	Future	Now	Future
Impact on public engagement, awareness and perceptions	**38**	**54**	**29**	**44**	**51**	**66**	**52**	**65**
Impact on education and training	**33**	**50**	**30**	**46**	**43**	**55**	**45**	**61**
Impact on health and wellbeing	**63**	**79**	**19**	**33**	**18**	**28**	**10**	**16**
Impact on policy and public services	**22**	**40**	**11**	**26**	**47**	**65**	**15**	**29**
Impact on culture	**7**	**13**	**7**	**12**	**30**	**37**	**68**	**75**
Impact on the economy	**11**	**27**	**30**	**50**	**21**	**31**	10	15
Impact on the environment	**8**	**17**	**28**	**44**	**15**	**25**	**4**	**8**
Impact on social cohesion	**6**	**13**	**2**	**6**	**31**	**43**	**21**	**33**
Impact on safety and security	**5**	**7**	**16**	**24**	**8**	**11**	2	3
Impact on legal systems	**2**	**6**	**2**	**6**	**12**	**20**	3	6

Percentages are shown in bold where there is a significant difference between now and in the future. Impact types are shown shaded in grey if there is a significant difference across disciplines now, and in bold if there is a significant difference expected in the future. Each cell is shaded from white to dark red according to the percentage of respondents reporting producing or expecting to produce each type of impact. The darker the red, the higher the percentage.

economy, on safety and security, and on legal systems.

There are notable differences in terms of what impacts respondents from different career stages produce now and expect to produce in the future (Figure 4.3). There is a significant increase in the number of respondents at all career stages expecting to produce impacts of all type between now and the future, with the exception of established researchers, where there is no significant increase between now and the future for impact on culture, impact on safety and security, and impact on legal systems (Figure 4.3). There are significant differences across career stages for the impact that research has currently on public engagement, awareness and perceptions; education and training; policy and public service; the economy; and legal systems. There are also significant differences across career stages for the expected impact that research will have on public engagement, awareness and perceptions; education and training; health and wellbeing; the economy; and the environment. Overall, although there are still differences between career stages in terms of the types of impact respondents produce or expect to produce, there are fewer differences across career stages than across disciplines. This indicates that there are differences between disciplines that exist outside of differences in career stage.

As discussed above, the predominant differences in impact types are between disciplines, rather than across career stages. This can be seen in particular when looking within career stages – there is a significant difference across disciplines, for all career stages and all impact types both now and in next 5 to 10 years, in terms of the number of established researchers who expect to have an impact on education and training in the future (Figure 4.4).

There are also some differences across career stages within disciplines (Figure 4.5), indicating there are differences across career stage that exist outside of disciplinary differences. For example, looking at the current types of impact achieved within medicine, health and

Figure 4.3: Types of societal impact that respondents from each career stage are producing now and expecting to produce in the next 5 to 10 years (percentage)

Impact type	PhD Student n=754		Early-career researcher n=924		Mid-career researcher n=737		Established researcher n=904	
	Now	Future	Now	Future	Now	Future	Now	Future
Impact on public engagement, awareness and perceptions	**26**	**50**	**44**	**60**	**45**	**58**	**47**	**56**
Impact on education and training	**21**	**46**	**34**	**52**	**41**	**55**	**48**	**53**
Impact on health and wellbeing	**25**	**42**	**35**	**50**	**39**	**51**	**38**	**47**
Impact on policy and public services	**14**	**37**	**23**	**42**	**23**	**41**	**33**	**40**
Impact on culture	**17**	**29**	**21**	**27**	**24**	**29**	26	28
Impact on the economy	**9**	**27**	**14**	**30**	**18**	**32**	**29**	**36**
Impact on the environment	**12**	**27**	**15**	**26**	**12**	**20**	**16**	**22**
Impact on social cohesion	**8**	**20**	**13**	**22**	**16**	**23**	**14**	**19**
Impact on safety and security	**6**	**13**	**8**	**13**	**7**	**11**	9	11
Impact on legal systems	**2**	**11**	**4**	**9**	**4**	**7**	7	8

Percentages are shown in bold where there is a significant difference between now and in the future. Impact types are shown shaded in grey if there is a significant difference across career stages now, and in bold if there is a significant difference expected in the future. Each cell is shaded from white to dark red according to the percentage of respondents reporting producing or expecting to produce each type of impact. The darker the red, the higher the percentage.

life sciences; physical sciences, engineering and mathematics; and social sciences, there is a significant difference across career stages for impact on the economy and impact on education and training. For physical sciences, engineering and mathematics and for social sciences, there is a significant difference across career stages for impact on policy and public services. For physical sciences, engineering and mathematics there is a significant difference across career stages for impact on public engagement, awareness and perceptions. For social sciences there is a significant difference across career stages for impact on social cohesion.

There are fewer significant differences across career stages within disciplines in terms of expected impact in 5 to 10 years (Figure 4.5). The differences observed were a significant difference across career stages in physical sciences, engineering and mathematics for expected impact on education and training; a significant difference across career stages in medicine, health and life sciences and arts and humanities for expected impact on culture; a significant difference across career stages in medicine, health and life sciences for expected impact on health and wellbeing; and a significant difference across career stages in physical sciences, engineering and mathematics for expected impact on public engagement, awareness and perceptions.

4.3. Researchers expect that they will continue to focus the majority of their efforts in the future on producing outputs

Respondents were asked about the balance of effort they currently spend on outputs versus impacts, and the balance of effort they expect to spend in 5 to 10 years' time.[40] It is worth

40 To measure this, respondents were provided with a scale from 0-100, where selecting 100 indicated that all of their efforts went into outputs, and selecting 0 indicated that all of their efforts went into impacts.

Figure 4.4: Percentage of respondents reporting producing each type of impact now and expecting to produce each type of impact in the next 5 to 10 years: Differences across disciplines within career stages

	PhD Student								Early-career researcher							
	Now				Future				Now				Future			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Impact on public engagement, awareness and perceptions	**28**	**15**	**34**	**36**	**49**	**33**	**66**	**71**	**40**	**36**	**54**	**55**	**59**	**50**	**68**	**65**
Impact on education and training	**21**	**13**	**24**	**29**	**49**	**34**	**45**	**64**	**31**	**29**	**44**	**40**	**51**	**46**	**58**	**66**
Impact on health and wellbeing	**49**	**13**	**9**	**7**	**71**	**29**	**25**	**16**	**62**	**19**	**18**	**9**	**82**	**34**	**27**	**17**
Impact on policy and public services	**13**	**6**	**28**	**11**	**37**	**25**	**63**	**33**	**22**	**9**	**52**	**15**	**45**	**25**	**66**	**29**
Impact on culture	**7**	**6**	**24**	**57**	**18**	**9**	**39**	**81**	**7**	**8**	**34**	**61**	**12**	**15**	**40**	**77**
Impact on the economy	**5**	**16**	**12**	**5**	**21**	**44**	**26**	**10**	**7**	**29**	**16**	**6**	**25**	**51**	**25**	**18**
Impact on the environment	**7**	**23**	**12**	**3**	**19**	**47**	**27**	**8**	**9**	**28**	**15**	**5**	**21**	**43**	**28**	**10**
Impact on social cohesion	**5**	**2**	**18**	**15**	**13**	**6**	**43**	**32**	**6**	**2**	**40**	**18**	**13**	**5**	**53**	**39**
Impact on safety and security	**4**	**12**	**5**	**1**	**9**	**22**	**16**	**2**	**5**	**16**	**8**	**3**	**8**	**24**	**8**	**1**
Impact on legal systems	**2**	**0**	**6**	**2**	**7**	**6**	**27**	**6**	**1**	**2**	**13**	**3**	**6**	**7**	**22**	**6**
	Mid-career researcher								**Established researcher**							
	Now				**Future**				**Now**				**Future**			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Impact on public engagement, awareness and perceptions	**42**	**31**	**54**	**56**	**57**	**48**	**64**	**65**	**41**	**35**	**58**	**60**	**53**	**46**	**66**	**60**
Impact on education and training	**34**	**41**	**45**	**49**	**51**	**56**	**56**	**66**	**45**	**41**	**52**	**57**	50	53	57	56
Impact on health and wellbeing	**67**	**29**	**20**	**13**	**83**	**39**	**29**	**17**	**71**	**21**	**25**	**10**	**80**	**33**	**32**	**15**
Impact on policy and public services	**21**	**11**	**45**	**13**	**38**	**28**	**66**	**29**	**29**	**19**	**59**	**20**	**39**	**27**	**66**	**25**
Impact on culture	**6**	**7**	**32**	**71**	**11**	**10**	**39**	**77**	**7**	**9**	**30**	**79**	**10**	**14**	**33**	**78**
Impact on the economy	**11**	**34**	**21**	**13**	**29**	**56**	**31**	**18**	**20**	**46**	**32**	**16**	**31**	**54**	**38**	**19**
Impact on the environment	**6**	**31**	**13**	**3**	**13**	**43**	**21**	**10**	**8**	**32**	**20**	**4**	**15**	**44**	**23**	**8**
Impact on social cohesion	**8**	**1**	**34**	**25**	**13**	**5**	**43**	**39**	**6**	**3**	**29**	**25**	**12**	**6**	**36**	**28**
Impact on safety and security	**4**	**18**	**8**	**0**	**7**	**26**	**10**	**1**	**5**	**19**	**10**	**4**	**6**	**24**	**11**	**4**
Impact on legal systems	**2**	**1**	**12**	**1**	**4**	**4**	**15**	**6**	**5**	**3**	**15**	**5**	**5**	**6**	**18**	**6**

Percentages are shown in bold where there is a significant difference within career stage, between now and in the future. Each cell is shaded from white to dark red according to the percentage of respondents reporting producing or expecting to produce each type of impact. The darker the red, the higher the percentage.

Key: Main panel A = medicine, health and life sciences; B = physical sciences, engineering and mathematics; C = social sciences; D = arts and humanities.

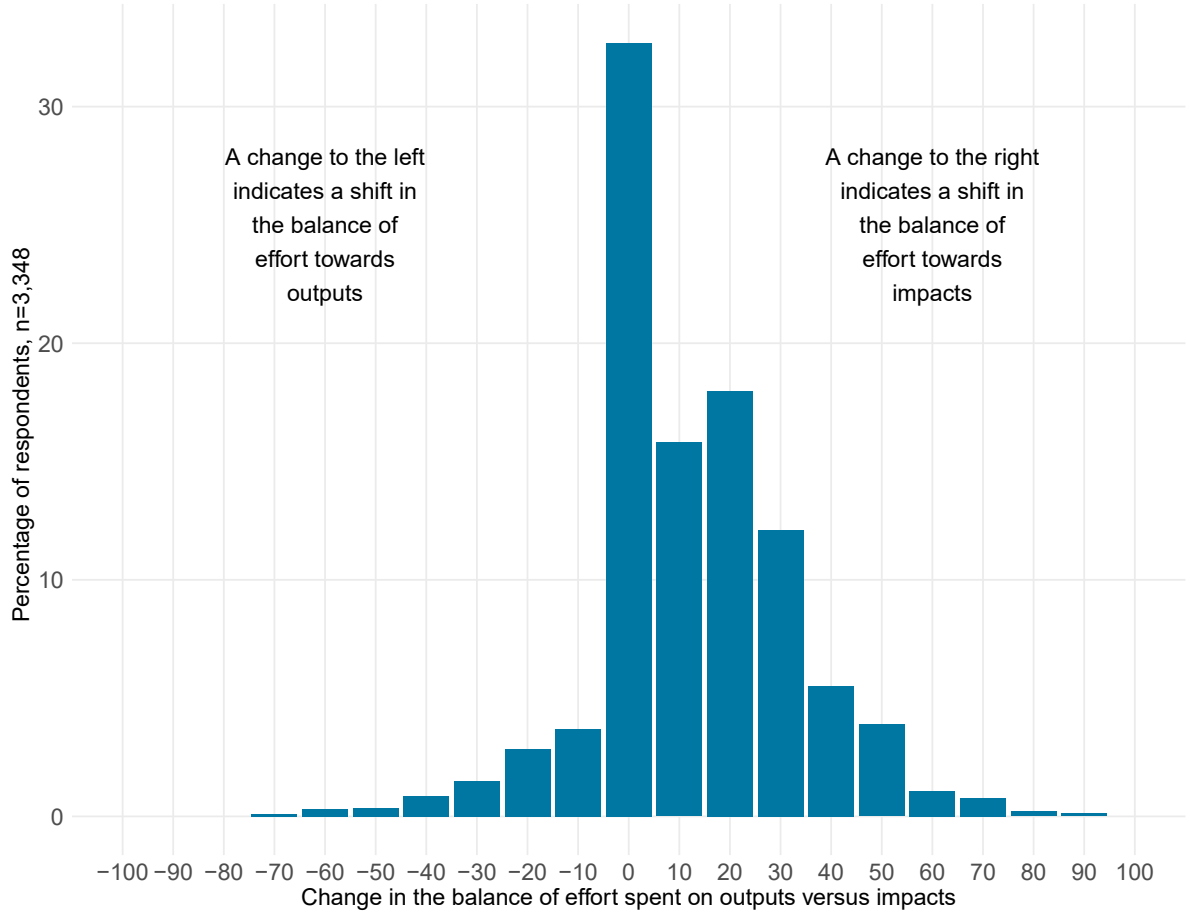
Figure 4.5: Percentage of respondents reporting producing each type of impact now and expecting to produce each type of impact in the next 5 to 10 years: Differences across career stages within disciplines

	Medicine, health and life sciences								Physical sciences, engineering and mathematics							
	Now				Future				Now				Future			
	PhD	ECR	MCR	ER	PhD	ECR	MCR	ER	PhD	ECR	MCR	ER	PhD	ECR	MCR	ER
Impact on public engagement, awareness and perceptions	28	40	42	41	49	59	57	53	**15**	**36**	**31**	**35**	**33**	**50**	**48**	**46**
Impact on education and training	**21**	**31**	**34**	**45**	49	51	51	50	**13**	**29**	**41**	**41**	**34**	**46**	**56**	**53**
Impact on health and wellbeing	**49**	**62**	**67**	**71**	71	82	83	80	13	19	29	21	29	34	39	33
Impact on policy and public services	13	22	21	29	37	45	38	39	**6**	**9**	**11**	**19**	25	25	28	27
Impact on culture	7	7	6	7	**18**	**12**	**11**	**10**	6	8	7	9	9	15	10	14
Impact on the economy	**5**	**7**	**11**	**20**	21	25	29	31	**16**	**29**	**34**	**46**	44	51	56	54
Impact on the environment	7	9	6	8	19	21	13	15	23	28	31	32	47	43	43	44
Impact on social cohesion	5	6	8	6	13	13	13	12	2	2	1	3	6	5	5	6
Impact on safety and security	4	5	4	5	9	8	7	6	12	16	18	19	22	24	26	24
Impact on legal systems	2	1	2	5	7	6	4	5	0	2	1	3	6	7	4	6
	Social sciences								**Arts and humanities**							
	Now				**Future**				**Now**				**Future**			
	PhD	ECR	MCR	ER	PhD	ECR	MCR	ER	PhD	ECR	MCR	ER	PhD	ECR	MCR	ER
Impact on public engagement, awareness and perceptions	34	54	54	58	66	68	64	66	36	55	56	60	71	67	65	60
Impact on education and training	**24**	**44**	**45**	**52**	45	58	56	57	29	40	49	57	64	60	66	56
Impact on health and wellbeing	9	18	20	25	25	27	29	32	7	9	13	10	16	18	17	15
Impact on policy and public services	**28**	**52**	**45**	**59**	63	66	66	66	11	15	13	20	33	32	29	25
Impact on culture	24	34	32	30	39	40	39	33	57	61	71	79	**81**	**67**	**77**	**78**
Impact on the economy	**12**	**16**	**21**	**32**	26	25	31	38	5	6	13	16	10	11	18	19
Impact on the environment	12	15	13	20	27	28	21	23	3	5	3	4	8	6	10	8
Impact on social cohesion	**18**	**40**	**34**	**29**	43	53	43	36	15	18	25	25	32	35	39	28
Impact on safety and security	5	8	8	10	16	8	10	11	1	3	0	4	2	6	1	4
Impact on legal systems	6	13	12	15	27	22	15	18	2	3	1	5	6	5	6	6

Percentages are shown in bold where there is a significant difference between now and in the future. Each cell is shaded from white to dark red according to the percentage of respondents reporting producing or expecting to produce each type of impact. The darker the red, the higher the percentage.

Key: ECR = early-career researcher; MCR = mid-career researcher; ER = established researcher.

Figure 4.6: Change in the balance of efforts spent on producing outputs and impacts between now and 5 to 10 years' time



noting that although this question provides an insight into the changing focus on outputs and impacts, it does not necessarily capture how many respondents would think about the time they spend on outputs and impacts. For example, outputs and impacts are neither separate, linear nor direct, and researchers may not dedicate separate time and effort to each activity independently, or recognise a clear distinction.

On average, researchers indicated that the proportion of effort they currently devote to outputs is 74%, and in 5 to 10 years they expect it to be 61%, which indicates that despite a reduction, still over half of researchers' efforts will be spent on outputs. Figure 4.6 shows the change in balance that is expected between now and 5 to 10 years' time.

The majority of respondents expect a shift in effort towards impact in the future (Table 4.1). However, one third of respondents do not expect it to change, and nearly 10% predict a shift away from impacts and towards outputs.

Table 4.2 and Table 4.3 show the average balance of efforts spent on outputs and impacts across career stages and disciplines, respectively. In general, PhD students and early-career researchers report spending a

Table 4.1: Expected shifts in effort between the production of outputs and impacts

Expected shift in effort	Number of respondents (n=3,348) (%)
Towards impact	1,929 (57.6%)
Remain the same	1,095 (32.7%)
Towards outputs	324 (9.7%)

Table 4.2: Average balance of efforts spent on outputs and impacts across career stages

Career stage	Balance of effort currently spent on outputs versus impacts (%)	Balance of effort expected to be spent on outputs versus impacts in 5 to 10 years' time (%)	Change expected between now and 5 to 10 years' time (%)
PhD students	71	55	16
Early-career researchers	74	60	14
Mid-career researchers	76	64	12
Established researchers	75	65	10

Table 4.3: Average balance of efforts spent on outputs and impacts across disciplines

Discipline	Balance of effort currently spent on outputs versus impacts (%)	Balance of effort expected to be spent on outputs versus impacts in 5 to 10 years' time (%)	Change expected between now and 5 to 10 years' time (%)
Medicine, health and life sciences	73	60	13
Physical sciences, engineering and mathematics	74	63	11
Social sciences	73	60	13
Arts and humanities	77	65	12

lower proportion of effort on outputs versus impacts than mid-career and established researchers, and they expect this to be even lower in the future (Table 4.2). There is less difference between disciplines, with researchers from medicine, health and life sciences; physical sciences; engineering and mathematics; and social sciences being broadly similar in terms of the proportion of effort spent on outputs and impacts now and in the future. Arts and humanities were slightly higher (Table 4.3).

Table 4.4: Reasons respondents gave for expecting different types of impact or an increase in impact in the future

Reason	Number of respondents (n=499) (%)
Change and developments in own research	177 (35.5%)
Career progression	87 (17.4%)
Research topic is becoming more relevant or impactful	86 (17.2%)
Respondent is more actively focusing on impact or public engagement	64 (12.8%)
Societal challenges	62 (12.4%)
Respondents moving towards commercialisation or private sector	38 (7.6%)
Changing outputs	36 (7.2%)
New technology	27 (5.4%)
Funding	26 (5.2%)
Policy changes	24 (4.8%)
Impact agenda	16 (3.2%)

4.4. Respondents had differing views as to whether the importance placed on societal impact should increase or decrease in the future, and the reasons for this change

Respondents were given the opportunity to provide an open text response about whether they thought the impacts of their research would change over the next 5 to 10 years, and their reasons for any change (n=893). Of those who provided a reason, more than half (n=499) said that they expected the impact arising from their research to change or increase, meaning that their research would either lead to new types of impact, different types of impact or a more substantial impact in the future. Over 25% (n=231) said that they expected their impacts to stay the same or decrease, and about 15% (n=159) were unsure as to whether or not their impacts would change. From some respondents who provided a reason it was unclear whether they expected their impacts to change or increase, stay the same or increase, or if they were unsure of their future impacts.

4.4.1. Reasons for expecting different or increased impacts in the future

Respondents who provided open text responses about why they expected their impacts to increase or change in future (499 out of 893) identified a number of factors and motivations that would drive changes to the type of impact or increases in the amount of impact achieved (Table 4.4).

The most common reason respondents cited for why they expected their impacts to increase or change in the future was changes or developments in the research that they were conducting (n=177). This mostly consisted of respondents who said that over time their research will become more developed and closer to the end user, which creates the opportunity for greater or more diverse impacts. This included respondents conducting research they classified as 'fundamental' or 'basic', but that they envisaged would become more applied or would influence the work of other researchers over time. There were also respondents in this category who said that they were planning on moving into slightly different areas of research that had the potential for

new types of impact or for more impact to be created. In some instances, this may reflect where the sector sees the availability of funding to be moving. One organisational response highlighted the alignment of research, and therefore impact, with sustainable development goals and other real world problems.

Another driver identified by respondents who expected their impacts to change or increase was career progression (n=87), for example moving to more senior positions or leaving academia entirely over the next decade. Some of these respondents attributed their expectation for more impact as they progressed in their career to more esteem, expertise and opportunities to collaborate with industry and non-academic partners. Others, particularly those retiring or moving out of academia, focused on the fact that they would have more time and energy to create impact.

Over 15% of respondents who thought that their impact would change or increase in the future said that they expected the topic of their current or planned research to become more relevant in the future (n=86). This was mostly due to big challenges in society that would drive impact (n=62), such as the environment, climate change, reduced health resources, antimicrobial resistance, affordable housing, political systems and democracy.

4.4.2. Reasons for expecting reduced or unchanged impacts in the future

Not all respondents to the open text question thought that their research would have an impact or that their research would lead to new impacts in the future. About 25% (231 out of 893) said that they think their research will lead to the same impacts in the future as it currently does, or that their research will lead to fewer impacts in the future. The most commonly reported reasons are given in Table 4.5.

The most common reason given for why impacts would not change or would decrease was that the research they conducted already had a particular impact, and that this was unlikely to develop further over the next decade (n=64). Another frequent response was that respondents were undertaking 'basic' or 'fundamental' research (n=34) where it was felt that the impact of the research would take longer than 10 years to materialise, that it would not lead to direct societal impacts, or that it has no societal impact and will therefore not lead to different impacts in the future (n=10). Others in arts or humanities perceived that their discipline did not have wider societal impact, or that it only had a set number of types of impact that were already being achieved (n=8). Other respondents said that their research would not have an impact or would not have new impacts because their career stage or the research they conduct was unlikely to change in the next 5 to 10 years to such a degree that it would create new impacts (n=31). These respondents felt that the scope of their research was unlikely to change (either because of the researcher or because of constraints from the sector or their institutions), and that it only allowed for certain impacts. Other reasons that respondents provided for not creating new impacts included career progression (n=12), including those who said that their work would not create impact because their career would still be at an early stage in the next 5 to 10 years, those who were moving to new roles with less potential for impact, and those who were moving out of academia entirely in the next decade.

Over 10% (n=26) of those who did not expect new impacts cited decreased funding. This was closely related to those who cited less 'risky' and basic research in the research landscape as the reason (n=10). A number of respondents also felt that impact or engagement is not possible because there is a lack of interest

Table 4.5: Reasons respondents gave for expecting the same or a reduction in the types of impact in the future

Reason	Number of respondents (n=231) (%)
My research has always had impact	64 (27.7%)
Research is fundamental or basic	34 (14.7%)
Research and career is rigid	31 (13.4%)
Funding	26 (11.3%)
Impact is difficult or impossible because public is not interested	23 (10%)
Impact agenda	21 (9.1%)
Career progression	12 (5.2%)
Societal change	12 (5.2%)
Leaving the EU	10 (4.3%)
Decreased 'risky' or basic research	10 (4.3%)
My research does not have impact	10 (4.3%)
The REF	8 (3.5%)
Arts and humanities research	8 (3.5%)

This table details all reasons identified by at least 3% (n=23) of the respondents.

or understanding in the research conducted beyond academia (n=23). Under 10% (n=21) of respondents who did not expect new impacts cited what some described as the 'artificial engineering' of impact, where research is conducted with a desired societal impact in a short timeframe, which may hinder more 'blue skies' or abstract research in favour of incremental improvements. This was linked to mentions of the importance of the European Research Council (ERC), which they perceived as funding 'riskier' research without a requirement for impact, and a concern over access to this type of funding following the United Kingdom's changing relationship with the EU. Some 5% (n=12) said that societal changes such as increasing levels of public distrust in science would make their research less impactful in the next 5 to 10 years, or that 'information overload' would make it difficult for scientific breakthroughs to be noticed. Some (n=8) also said that they felt as though the REF exercise limits the investment in longer term, less demonstrable impacts that may be more meaningful to society in the long run by creating incentives to produce demonstrable and evidenced impacts from research. Some commented on the time to engage in institutional preparations for the REF exercise, such as mock exercises, which they felt could decrease the amount of time they had to conduct research and create impact.

4.2.3. Reasons why respondents were unsure of whether their impacts would change in the future

Under 20% (159 out of 893) of respondents who provided at least one reason why they did or did not expect their impacts to change reported that they were unsure whether their

Table 4.6: Reasons respondents gave for being unsure of how impacts would change in the future

Reason	Number of respondents (n=159) (%)
Change or developments in research	38 (23.9%)
Career progression	24 (15.1%)
Funding	20 (12.6%)
Policy changes	18 (11.3%)
Societal change	16 (10.1%)
The REF	11 (6.9%)
Impact agenda	11 (6.9%)
Changing outputs	11 (6.9%)
Research is fundamental or basic	11 (6.9%)
Topic becoming more relevant or impactful	10 (6.3%)
Technology	8 (5%)

impacts would change in the next 5 to 10 years (Table 4.6). These factors reflect a level of uncertainty around some of the factors cited above.

The most common reasons for respondents being unsure of how impacts would change in the future were uncertainty in terms of how their research would develop or what the findings of their research would be over the next decade (n=38), uncertainty of how their career would develop (n=24), or uncertainty of how funding opportunities would affect impact (n=20). Other areas of uncertainty included policy changes, such as changes in research and funding policy, policies around the REF and the impact agenda, as well as other measurements such as the Teaching Excellence Framework (TEF) and the Knowledge Exchange Framework (KEF), as well as societal changes. Respondents who mentioned societal changes tended to be unsure of how issues within society (such as housing prices, the environment and democracy) would develop or how they would be resolved, which had the potential to make their research either more relevant, or conversely, outdated (n=16).

5 How do researchers expect the research environment they are in to change in the next 5 to 10 years?

To understand what types of outputs and impacts researchers' feel their research is currently leading to, how they expect this to evolve in the next 5 to 10 years, and how this is influenced by the research landscape a large-scale survey of academic researchers in England was conducted. This chapter focusses on the findings related to how researchers expect the research environment to change over the next decade. It also draws on the rapid evidence assessments and responses to the sector view collection. Additional detail on the methods underpinning this are described in Annex A.

The key findings are:

- Researchers think that collaborating with other academics is the most important driver of change.
- There are significant differences across disciplines in the perceived importance of most of the drivers, although the three most important drivers are consistent.
- Overall, most drivers were seen as more important by PhD students and early-career researchers than by mid-career and established researchers, particularly open science.
- There are a range of views from researchers on how the research environment needs to adapt to change.
- Changes to support and drive developments need to happen at both an institutional and a sector level.

5.1. Researchers think that collaborating with other academics is the most important driver of change

When asked to rate a set of statements in terms of their importance for driving changes in the research environment,[41] over 50% of respondents rated each statement as being important ('somewhat important' or 'very important') in driving changes in the research system (Figure 5.1).[42] More than 75% of respondents considered 12 out of the 20 statements as important ('somewhat important' or 'very important') in driving the changes in the research system. The top five statements that were rated as the most important drivers of change in the research environment were the importance of

41 Respondents were asked 'How important are the following factors in driving the changes you foresee in the next 5 to 10 years?' for a series of statements. All statements were rated by at least 2,900 respondents. The four options provided were: not important, somewhat important, very important and unsure. It was not compulsory to answer the question.

42 For the purposes of analysis, importance is considered as selecting either 'somewhat important' or 'very important', and not important as selecting 'not important'.

Figure 5.1: How respondents perceive the importance of potential drivers of change in the research environment

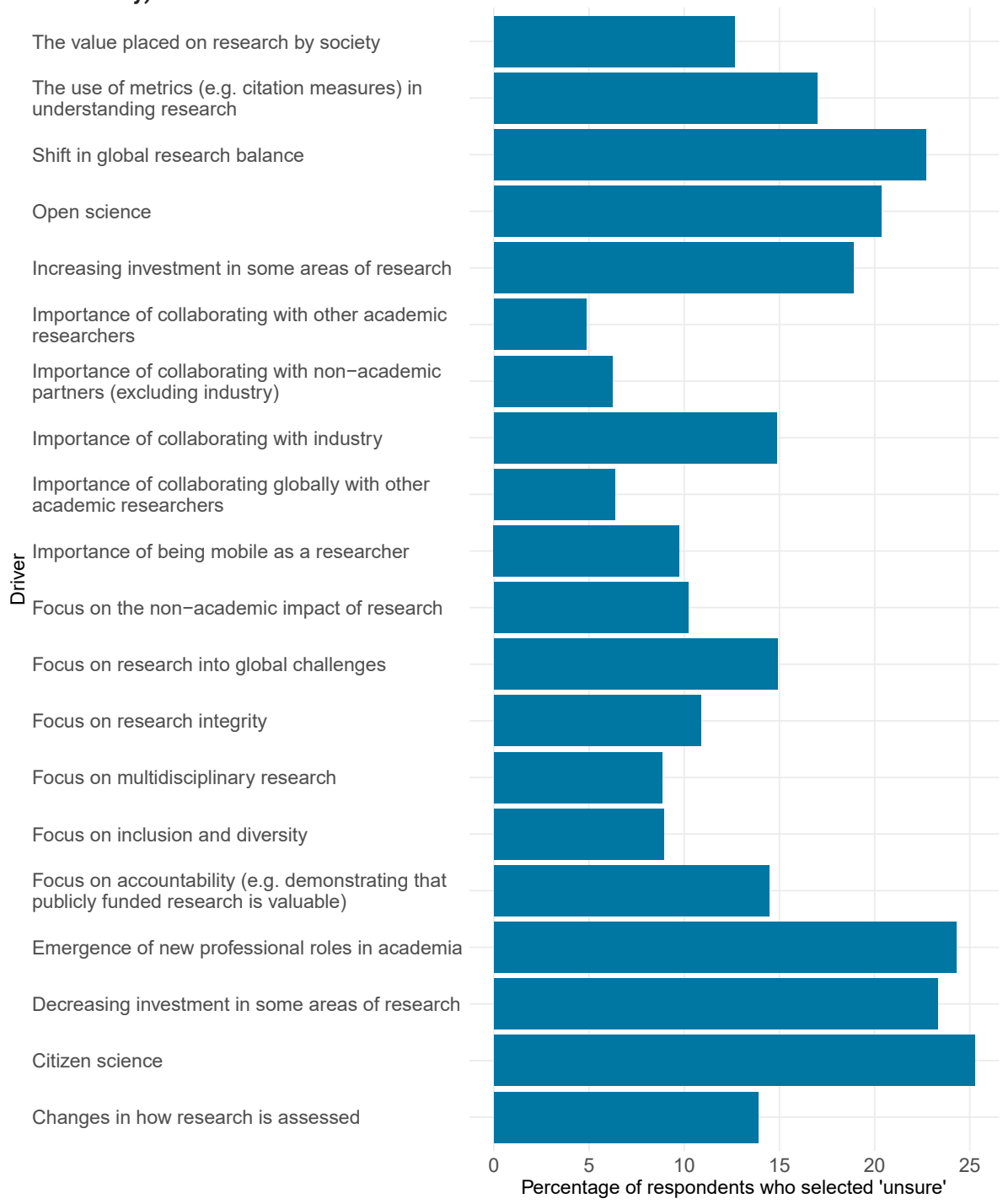
collaborating with other academic researchers, the importance of collaborating globally with other academic researchers, the focus on multidisciplinary research, the focus on research integrity, and open science.

While collaborating and collaborating globally with other academic researchers came at the top of the list, collaborating with non-academic partners (except industry) and collaborating with industry came further down. This may indicate that academic collaborations are seen as a more important driver of change than the push toward non-academic impact.

No statements had more people select 'not important' than 'important', although three statements had more than 20% of respondents select 'not important' in driving the changes. These statements that were seen as the least

important drivers of the research environment in our list of options, were the use of metrics (e.g. citation measures) in understanding research, citizen science, and the emergence of new professional roles in academia. However, when interpreting these data it is important to consider the level of certainty around each driver. Figure 5.2 shows the level of uncertainty, which is reflected by the percentage of respondents who answered each driver with

Figure 5.2: Percentage of respondents who were unsure of importance of drivers of change (level of uncertainty)



'unsure'. The emergence of new professional roles in academia was the statement with the most uncertainty, with over 20% of respondents selecting that they were 'unsure' of how important this was in driving changes in the research system.

5.2. There are significant differences across disciplines in the perceived importance of most of the drivers, although the three most important drivers are consistent

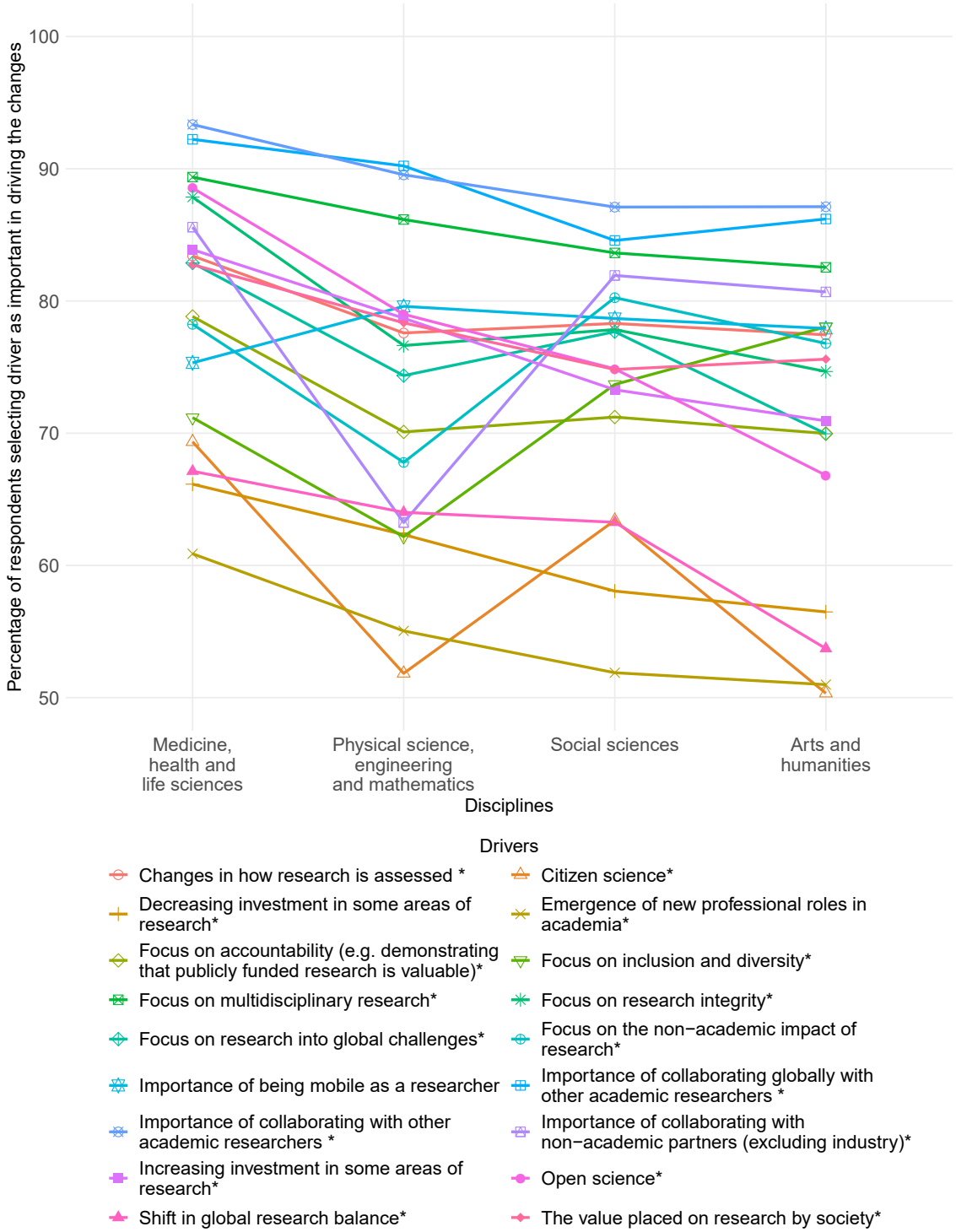
Out of 18 drivers, 17 have a significant difference in the percentage of respondents who rated them as somewhat or very important across disciplines, with the exception being the importance of being mobile as a researcher, which was rated as somewhat/very important by 75-80% of respondents from each discipline (Figure 5.3).

Figure 5.4 shows the top five ranked drivers for each career stage, with each driver shaded a consistent colour. Looking across all disciplines, the importance of collaborating with other academic researchers is generally seen as the most important driver, followed by the importance of collaborating globally with other academic researchers and the focus on multidisciplinary research. For respondents in physical sciences, engineering and mathematics, the importance of collaborating globally with other academic researchers was seen as more important than collaborating with other academic researchers in general terms. This reflects the trends seen across the full dataset.

More notable differences in terms of how drivers of change are ranked are seen further down the list, for example, open science was ranked 4th by respondents in medicine, health and life sciences, and 5th by respondents in physical sciences, engineering and mathematics; but 10th for respondents in social sciences and 14th by those in arts and humanities. The focus on research integrity was seen as one of the most important drivers of change only for respondents in medicine, health and life sciences, while the importance of being mobile as a researcher was seen as one of the most important drivers of change only for respondents in physical sciences, engineering and mathematics. Similarly, the importance of collaborating with non-academic partners (outside of industry) was ranked as the 4th most important driver of change for respondents in social sciences and arts and humanities, but comes 14th for respondents in physical sciences, engineering and mathematics. The focus on the non-academic impact of research was only seen as one of the most important drivers for researchers in social sciences, and the focus on inclusion and diversity was only seen as one of the most important drivers of change for researchers in arts and humanities.

There was no significant difference in terms of how respondents from different career stages within the same discipline rated the importance of different drivers of change (Figure 5.5), with some exceptions. There were significant differences in terms of how respondents from different career stages within medicine, health and life sciences, physical sciences, engineering and mathematics, and social sciences rated the importance of the emergence of new professional roles in academia. There was also a significant difference in how respondents from different career stages in physical sciences, engineering and mathematics, and social sciences rated the importance of citizen science, and how respondents from different career stages within physical sciences, engineering and mathematics rated the importance of open science, the focus on inclusion and diversity,

Figure 5.3: How researchers perceive the importance of drivers of change, across disciplines



*The * on labels represents a significant difference across disciplines.*

Drivers are shown if they were selected as important by at least 50% of respondents from all disciplines.

Figure 5.4: The top five ranked drivers of change in the research system, across disciplines

Ranking	Medicine, health and life sciences	Physical science, engineering and mathematics	Social sciences	Arts and humanities
1	Importance of collaborating with other academic researchers	Importance of collaborating globally with other academic researchers	Importance of collaborating with other academic researchers	Importance of collaborating with other academic researchers
2	Importance of collaborating globally with other academic researchers	Importance of collaborating with other academic researchers	Importance of collaborating globally with other academic researchers	Importance of collaborating globally with other academic researchers
3	Focus on multidisciplinary research	Focus on multidisciplinary research	Focus on multidisciplinary research	Focus on multidisciplinary research
4	Open science	Importance of being mobile as a researcher	Importance of collaborating with non-academic partners (excluding industry)	Importance of collaborating with non-academic partners (excluding industry)
5	Focus on research integrity	Open science	Focus on the non-academic impact of research	Focus on inclusion and diversity

Colours denote different drivers to visualise the consistency or otherwise of responses across different disciplines.

changes in how research is assessed, and the focus on accountability. There were no significant differences in terms of how respondents from different career stages within arts and humanities rated the importance of any of the drivers of change.

5.3. Overall, most drivers were seen as more important by PhD students and early-career researchers than by mid-career and established researchers, particularly open science

The question that asked respondents to rate the importance of different drivers was also analysed by sub-group in order to draw out differences that exist between researchers at

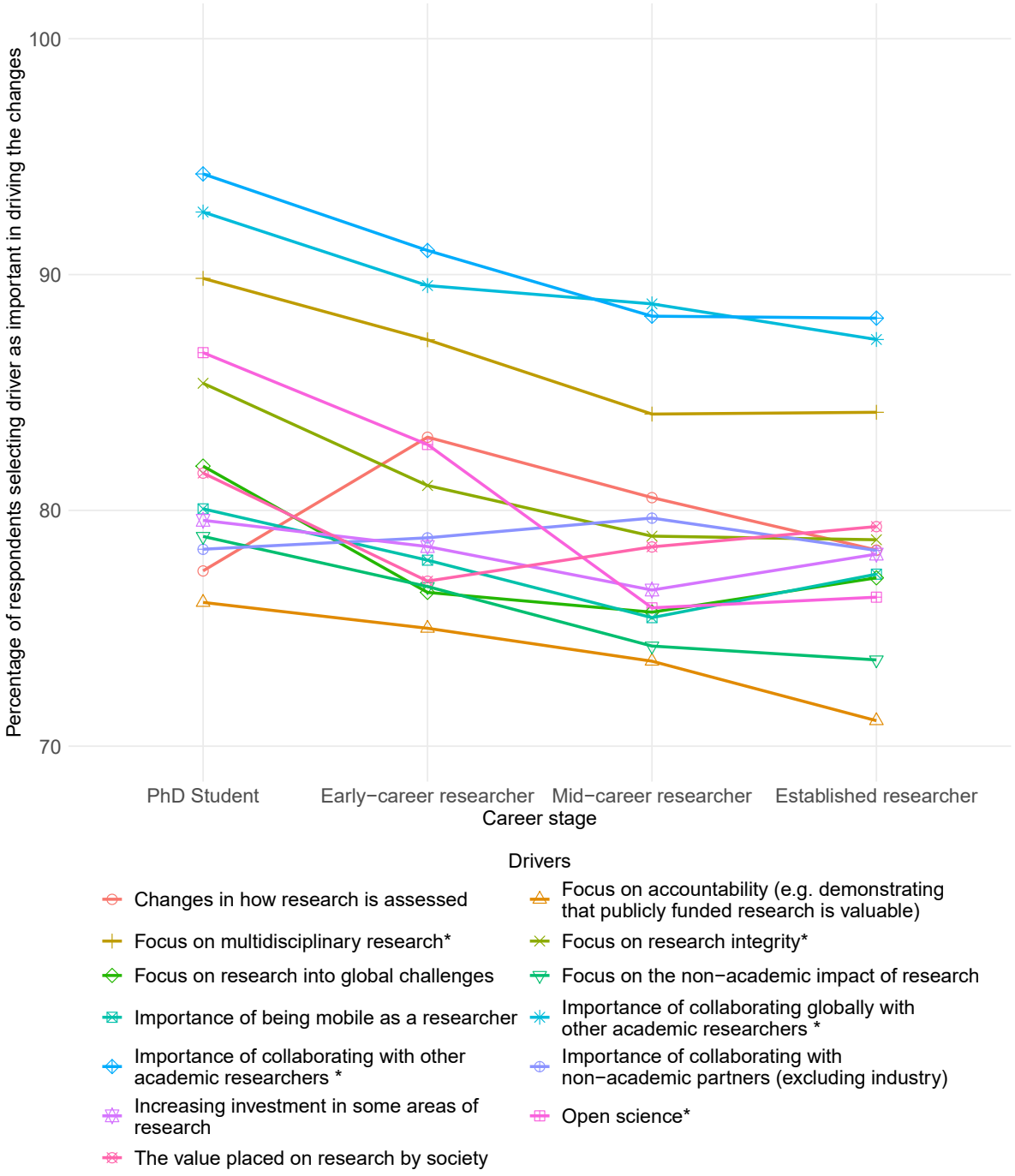
Figure 5.5: Percentage of respondents reporting a driver as important: Differences across career stages within disciplines

	Medicine, health and life sciences				Physical science, engineering and mathematics				Social sciences				Arts and humanities			
	PhD	ECR	MCR	ER	PhD	ECR	MCR	ER	PhD	ECR	MCR	ER	PhD	ECR	MCR	ER
Importance of collaborating with other academic researchers	95	94	91	93	93	90	85	89	95	86	86	85	93	89	87	83
Importance of collaborating globally with other academic researchers	94	92	92	91	93	90	89	90	92	84	83	82	91	85	87	84
Focus on multidisciplinary research	93	91	86	88	88	88	82	84	88	81	82	83	87	81	84	80
Focus on research integrity	91	88	86	86	81	79	73	72	83	76	75	77	86	70	72	74
Open science	94	91	84	86	**87**	**86**	**73**	**68**	87	74	68	74	70	63	68	68
Changes in how research is assessed	81	84	82	86	**76**	**80**	**80**	**74**	77	82	80	74	74	85	78	73
The value placed on research by society	84	81	82	83	80	76	81	78	80	74	71	74	80	72	74	77
Importance of collaborating with non-academic partners (excluding industry)	84	86	83	89	63	66	63	61	86	80	83	81	86	81	86	74
Increasing investment in some areas of research	84	85	80	86	77	78	77	82	78	71	72	72	74	71	74	66
Importance of being mobile as a researcher	76	74	75	76	79	82	76	82	89	77	79	74	83	80	72	78
Focus on research into global challenges	87	82	78	84	80	75	66	75	80	78	78	76	78	62	77	66
Focus on the non-academic impact of research	86	78	73	76	67	70	66	68	90	80	77	78	78	78	82	72
Focus on accountability (e.g. demonstrating that publicly funded research is valuable)	81	82	75	78	**71**	**72**	**72**	**66**	80	71	71	66	71	67	75	67
Importance of collaborating with industry	86	79	80	82	79	78	79	83	75	63	68	59	50	48	50	43
Focus on inclusion and diversity	70	76	70	67	**70**	**67**	**57**	**52**	81	73	72	71	84	77	81	74
Shift in global research balance	63	64	70	70	62	67	65	64	74	59	57	65	57	45	58	56
Decreasing investment in some areas of research	61	63	61	78	55	58	66	73	58	57	55	61	43	59	56	63
Citizen science	72	70	70	66	**60**	**58**	**51**	**38**	**76**	**65**	**59**	**57**	58	46	54	45
The use of metrics (e.g. citation measures) in understanding research	59	61	62	70	57	55	52	56	65	51	56	49	43	47	41	57
Emergence of new professional roles in academia	**67**	**64**	**61**	**52**	**65**	**59**	**57**	**39**	**63**	**54**	**47**	**45**	71	50	46	44

Percentages are shown in bold if there is a significant difference across career stages within a discipline. Each cell is shaded from white to dark red according to the percentage of respondents reporting a driver as important. The darker the red, the higher the percentage.

Key: ECR = early-career researcher; MCR = mid-career researcher; ER = established researcher.

Figure 5.6: How researchers perceive the importance of drivers of change, across career stages



*The * on labels represents a significant difference across career stages.*

Figure 5.7: Top five ranked drivers of changes in the research system, by career stage

Ranking	PhD Student	Early-career researcher	Mid-career researcher	Established researcher
1	Importance of collaborating with other academic researchers	Importance of collaborating with other academic researchers	Importance of collaborating globally with other academic researchers	Importance of collaborating with other academic researchers
2	Importance of collaborating globally with other academic researchers	Importance of collaborating globally with other academic researchers	Importance of collaborating with other academic researchers	Importance of collaborating globally with other academic researchers
3	Focus on multidisciplinary research	Focus on multidisciplinary research	Focus on multidisciplinary research	Focus on multidisciplinary research
4	Open science	Changes in how research is assessed	Changes in how research is assessed	The value placed on research by society
5	Focus on research Integrity	Open science	Importance of collaborating with non-academic partners (excluding industry)	Focus on research integrity

Shading denotes different drivers to visualise the consistency or otherwise of responses across career stages.

different stages of their careers (Figure 5.6).[43] Figure 5.7 summarises the top five ranked drivers for each career stage, with each driver shaded a consistent colour. Looking across career stages the top three most important drivers of the changes in the system are the same: Importance of collaborating with other academic researchers, importance of collaborating globally with other academic researchers, and the focus on multidisciplinary research. For all of the top five drivers of change, PhD students and early-career researchers rated them as more important than mid-career researchers and established researchers, and there are significant differences in rating across the career stages.

Figure 5.8 shows the percentage of respondents from each career stage and discipline reporting a driver as being important. Within each career stage there is no significant

43 Drivers are shown if they were selected as somewhat or very important by at least 70% of respondents from all career stages.

difference across disciplines for the top three drivers of change (importance of collaborating with other academic researchers, importance of collaborating globally with other academic researchers, and focus on multidisciplinary research).

Within each career stage there is a significant difference between disciplines for the importance of collaborating with industry, the importance of collaborating with non-academic partners (excluding industry), and citizen science (Figure 5.8). For PhD students there is a significant difference between disciplines for focus on inclusion and diversity and focus on the non-academic impact of research. For early-career researchers there is a significant difference between disciplines for open science, shift in global research balance and focus on the non-academic impact of research. For mid-career researchers there is a significant difference between disciplines for open science, focus on inclusion and diversity, and focus on research into global challenges. For established researchers there is a significant difference between disciplines for open science, focus on inclusion and diversity, focus on research integrity, focus on research into global challenges, changes in how research is assessed, focus on accountability, focus on the non-academic impact of research, increasing investment in some areas of research, and the use of metrics.

5.4. There are a range of views from researchers on how the research environment needs to adapt to change

When asked to provide open text responses about how the research environment needs to adapt to the changes foreseen in the outputs and impacts researchers produce (if any), survey respondents (n=1,930) revealed a range of views on the preferred direction of travel for the research environment. The main issues are summarised as follows:[44]

- The drive for societal impact is generally seen as positive, although there are many divergent views and desires for change within the impact agenda.
- Dissemination and engagement are seen as important, and are closely tied to the current focus on societal impact.
- The pressure to publish in selective journals is seen as a concern of the current research landscape.
- New forms of output are seen as desirable, but adaptations in the research landscape are needed for them to become more accepted.
- Trends such as increased collaboration and open science will continue to shape the research landscape.

Each of these topics is discussed in the sections below.

5.4.1. The drive for societal impact is generally seen as positive, although there are many divergent views and desires for change within the impact agenda

Survey respondents had diverging views on whether the research environment should focus more on societal impact, or whether this is misguided. Of the responses that mentioned societal impact (606 out of 1,930 respondents), about one third (n=237) said that the focus on societal impact in the research landscape should increase, while over 20% (n=148) said that it should decrease. About a third of all

44 To analyse these open text responses, an inductive and iterative codebook was developed in NVivo. Further details on this are provided in Annex E.

Figure 5.8: Percentage of respondents reporting a driver as important: Differences across disciplines within career stages

	PhD student				Early-career researcher				Mid-career researcher				Established researcher			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Importance of collaborating with other academic researchers	95	93	95	93	94	90	86	89	91	85	86	87	93	89	85	83
Importance of collaborating globally with other academic researchers	94	93	92	91	92	90	84	85	92	89	83	87	91	90	82	84
Focus on multidisciplinary research	93	88	88	87	91	88	81	81	86	82	82	84	88	84	83	80
Focus on research integrity	91	81	83	86	88	79	76	70	86	73	75	72	86	72	77	74
Open science	94	87	87	70	**91**	**86**	**74**	**63**	**84**	**73**	**68**	**68**	**86**	**68**	**74**	**68**
Changes in how research is assessed	81	76	77	74	84	80	82	85	82	80	80	78	**86**	**74**	**74**	**73**
The value placed on research by society	84	80	80	80	81	76	74	72	82	81	71	74	83	78	74	77
Importance of collaborating with non-academic partners (excluding industry)	**84**	**63**	**86**	**86**	**86**	**66**	**80**	**81**	**83**	**63**	**83**	**86**	**89**	**61**	**81**	**74**
Increasing investment in some areas of research	84	77	78	74	85	78	71	71	80	77	72	74	**86**	**82**	**72**	**66**
Importance of being mobile as a researcher	76	79	89	83	74	82	77	80	75	76	79	72	76	82	74	78
Focus on research into global challenges	87	80	80	78	82	75	78	62	**78**	**66**	**78**	**77**	**84**	**75**	**76**	**66**
Focus on the non-academic impact of research	**86**	**67**	**90**	**78**	**78**	**70**	**80**	**78**	73	66	77	82	**76**	**68**	**78**	**72**
Focus on accountability (e.g. demonstrating that publicly funded research is valuable)	81	71	80	71	82	72	71	67	75	72	71	75	**78**	**66**	**66**	**67**
Importance of collaborating with industry	**86**	**79**	**75**	**50**	**79**	**78**	**63**	**48**	**80**	**79**	**68**	**50**	**82**	**83**	**59**	**43**
Focus on inclusion and diversity	**70**	**70**	**81**	**84**	76	67	73	77	**70**	**57**	**72**	**81**	**67**	**52**	**71**	**74**
Shift in global research balance	63	62	74	57	**64**	**67**	**59**	**45**	70	65	57	58	70	64	65	56
Decreasing investment in some areas of research	61	55	58	43	63	58	57	59	61	66	55	56	78	73	61	63
Citizen science	**72**	**60**	**76**	**58**	**70**	**58**	**65**	**46**	**70**	**51**	**59**	**54**	**66**	**38**	**57**	**45**
The use of metrics (e.g. citation measures) in understanding research	59	57	65	43	61	55	51	47	62	52	56	41	**70**	**56**	**49**	**57**
Emergence of new professional roles in academia	67	65	63	71	64	59	54	50	61	57	47	46	52	39	45	44

Percentages are in bold if there is a significant difference across disciplines within a career stage. Each cell is shaded from white to dark red according to the percentage of respondents reporting a driver as important. The darker the red, the higher the percentage.

Key: A = medicine, health and life sciences; B = physical sciences, engineering and mathematics; C = social sciences; D = arts and humanities.

responses that mentioned societal impact (n=221) tended to critique at least some aspects of the current impact agenda. The most common issue discussed by respondents was a concern that the current focus on societal impact leads to more shallow or short-term impacts (n=90), followed by a desire for a clearer definition of societal impact (n=63). Those who wanted a clearer definition of societal impact referred to both the consistency of what constitutes societal impact in general and in specific disciplines, such as in the arts and humanities, which many respondents felt had less clear definitions of social impact. Many respondents also mentioned that societal impact takes time and resources to develop (n=62), and that this is not always recognised in how funding is allotted and in how researchers are required to demonstrate impact. Respondents also commented that societal impact is appropriate for some research and researchers, but not for all (n=51), and that the concept of societal impact should be adapted to accommodate differences between researchers and disciplines.

Many respondents said that there is a need for more institutional and sectoral support to achieve societal impact through research (n=245). Those who indicated that the research landscape should focus more on societal impacts (n=237) in the future tended to also cite a need for increased funding (n=52), with most of these responses highlighting the need to adequately fund impact activities. Respondents who indicated that they would like more focus on societal impact also tended to cite that although societal impacts are now included in processes at the sector level, such as grant applications and research assessments, they are not sufficiently incentivised at an institutional level through mechanisms such as reward and recognition systems (e.g. recruitment and promotion) (n=49). These respondents tended to express that there needs to be a more systematic and deeper focus on societal impact, rather than just 'ticking boxes' in engagement and societal impact activities.

Respondents who said that the focus on societal impact should decrease expressed concerns about the direction that the impact agenda has taken within the research environment. Limitations of assessment included the relevance of measuring impact in some research fields where research does not have a direct application, and the serendipitous nature of impact meaning that it cannot be predicted when the research is commenced. Respondents also felt that by focusing on societal impact as a goal in and of itself, the research agenda and funding may shift away from fundamental or 'blue skies' research, which although has no pre-specified societal objective and involves uncertain impacts, is potentially more meaningful. It was felt that this may increase the perceived loss of academic independence. Others were concerned that the current focus on societal impact underappreciates the intrinsic value of knowledge produced through academic research as it quantifies impacts and focuses on impacts to the economy and the private sector.

Of the respondents who thought that the focus on societal impact should decrease (n=148), many also said that funding should change (n=21), with most of these responses expressing that funding should not be granted based on the potential for societal impact. Many also thought that policy should change (n=13), with many commenting on the recent focus of the UK Research Councils on impact, as well as the desire to decrease the weight of the impact portion of the REF exercise (n=16).

5.4.2. Dissemination and engagement are seen as important, and are closely tied to the current focus on societal impact

The vast majority of respondents who mentioned wider engagement (187 out of 1,930) expressed that an increased focus on

the dissemination of research findings and engagement with interested stakeholders would be beneficial to the wider societal impact of research (n=184). This was closely tied to the desire for an increased focus on societal impact and the desire for more non-traditional outputs that are accessible to a wider audience. Some respondents expressed that although dissemination and engagement already occur, there should be a deeper or more meaningful engagement of stakeholders, rather than 'tokenistic' engagement to tick boxes in grant requirements.

Many respondents cited the need for more institutional and sectoral support for engagement activities (n=190), such as more delegated resources for dissemination and engagement (n=31), particularly after producing grant outputs. These respondents tended to cite the need for recognition that dissemination and engagement takes more time and resources than are currently allotted, and that the time spent on dissemination and engagement is time that cannot be spent elsewhere. Respondents who wanted the focus on dissemination and engagement to increase (n=184) also tended to mention the need for more training (n=13) and more integration of engagement activities into institutional reward and recognition systems (n=12) (described further below).

5.4.3. The pressure to publish in selective journals is seen as a concern of the current research landscape

Many respondents (244 out of 1,930) mentioned the pressure to publish in selective journals, with over 90% of these respondents (n=227) expressing that the pressure to publish a large number of outputs in selective journals should decrease. Respondents said that this pressure comes from both their institutions and the wider system. For example, citation-based metrics and individual publishing records are used by some institutions in hiring, promotion and tenure decisions.

Respondents felt that the quality of outputs should be more valued than the quantity of publications in selective high-profile journals, and that there should be more holistic ways of measuring a researcher's or institution's productivity. Respondents in this category tended to also mention the need for different institutional reward and recognition systems (n=51) that take into account more holistic factors besides the quantity of publications in peer reviewed journals. The need for different funding mechanisms was also identified (n=36), with most responses focusing on the need to reduce the pressure to publish a large number of grant outputs. Many respondents who commented on the need to reduce the pressure to publish in selective journals also mentioned the need for different metrics to measure research quality and productivity (n=20).

Some respondents in these categories expressed that the pressure to publish in selective journals disadvantages researchers conducting interdisciplinary and applied research, and makes it risky for researchers to conduct replication studies or studies that may find null results as these are rarely published in selective journals. This type of research can be highly impactful and is important in terms of assuring that research is replicable and robust, and therefore respondents felt that it should not be disincentivised, particularly in light of the reproducibility issues in the sector.[45] Respondents also commented on the need for

45 In 2005, Ioannidis published an essay to assess the validity of concerns on the fact that most published research findings are false. Simulations showed that for most study designs and settings it was more likely for a research finding to be false than true. To improve the situation he suggested striving for better powered evidence, introducing enhanced research standards to diminish bias between research conducted by different teams, and improve the understanding of statistics (Ioannidis 2005).

increased research that is more focused on the research itself rather than quickly publishing outputs, which can only happen when there is less pressure to produce a high number of publications in selective journals. Respondents coined this 'slow science'. Respondents also expressed concerns that the 'publish or perish' mindset in academia prevents researchers from producing alternative outputs that may reach a wider audience than print publications; however, reaching a wider audience is desirable if impact and engagement are to be prioritised.

5.4.4. New forms of output are seen as desirable, but adaptations in the research landscape are needed for them to become more accepted

Over 10% of survey respondents cited the need to improve the quality of research outputs in the future or to publish more diverse outputs (220 out of 1,930), of these, nearly 50% (n=101) commented on the need for new forms of output in the future. Many respondents who commented on the need for better and new forms of output in the future also commented on the need for new output forms to be recognised in national research assessment (n=31), the need for them to be valued in institutional reward and recognition systems (n=30), and the need for funding and resources for outputs that are not journal articles (n=23).

When thinking about new forms of output, respondents commented that shorter and more plain-language publications may be more accessible to a wider public audience, as well as to important stakeholders such as policymakers and businesses, who are often key audiences to access for research uptake and impact. However, the counter argument from some survey respondents was that targeting outputs to make research findings and outputs more accessible to the public would lead to over-simplifying complex research topics, which they felt would have negative consequences for research in terms of the quality of outputs produced.

5.4.5. Trends such as increased collaboration and open science will continue to shape the research landscape

Respondents cited a number of other developments that they would like to see in the research environment. Under 10% of respondents (148 out of 1,930) commented on collaboration in some way, and all but five of these responses expressed a desire for collaboration to increase rather than decrease. The responses focused on collaboration with other academics (n=72), collaboration with non-academics (n=57) and international collaborations (n=18). Respondents saw the benefits of collaborative research and 'team science' as including bringing diverse perspectives into research, creating higher quality research and ensuring that research is useful in society. Collaboration was seen by some respondents as a challenge because of the competitive nature of academia and traditional authorship norms that make it risky for researchers to contribute to research in which they will be listed as middle authors. Of the respondents who wanted collaborations with other academics to increase (n=72), many commented on the need for funding (n=14), with many of these commenting on the need for funding for collaborative projects, as well as funding for travel. A small minority of respondents (n=4) in the arts and humanities cited the need to decrease the pressure to collaborate with other academics, arguing that lone researchers produce high-quality work in many research fields.

Under 5% of respondents (73 out of 1,930) mentioned the open science agenda, with the majority of these responses (n=64) arguing for a need to focus more on open science and

open access, including following through on Plan S.[46] They argued that making research publications and datasets more accessible would not only increase public engagement with research and help create societal impact, but also help support reproducible science, as replication studies and studies with null results would be available and datasets would be reused more. Of those respondents who wanted the focus on openness to increase, many also mentioned the need for an overhaul of the academic publishing system (n=20) and the need for new funding or funding mechanisms (n=15), with many of these commenting on open access requirements for funders. A small minority of respondents (n=6) expressed concerns about open science, particularly in the arts and humanities, and commented on the need to protect intellectual knowledge and early-career researchers without permanent posts. These researchers were seen as most at risk, as traditional publication records in selective journals are still seen as important for recruitment and career progression.

Many respondents (57 out of 1,930) also mentioned interdisciplinary research, with all but three of these responses citing the need for more interdisciplinary research, which is often well suited to addressing complex societal issues. Respondents expressed that interdisciplinary research is sometimes seen as challenging because of the nature of research funding in the United Kingdom (n=21), which they perceived to be siloed, as well as the decreased potential to publish in selective journal, as described above.

5.5. Changes to support and drive developments need to happen at both an institutional and a sector level

Respondents who provided open text responses (n=1,930) identified a number of institutional and sectoral mechanisms that may support the changes identified above. These mechanisms can be roughly grouped into three broad categories: a strong need for institutions and the wider research sector to support engagement (n=190), a need to support impact activities (n=245), and a need to support the growing workload of academic researchers (n=224). The specific forms of support suggested are provided in Table 5.1.

5.5.1. Increased funding and new ways to allocate funding are needed to encourage impactful research

Nearly 20% of respondents (368 out 1,930) to the open text question mentioned funding as a mechanism that may support changes in the research environment. Respondents cited a number of ways that increased funding, changes in funding allocations and changes in funding policy can improve the research environment, or help guide it in the direction that researchers would like to see.

Among the respondents who mentioned funding (n=368), some cited the need to provide designated funding for impact (n=52) and engagement activities (n=31). They felt many of these activities are currently undertaken by researchers without additional resources, and that specific funding for impact and engagement would incentivise researchers to spend adequate time and

46 Plan S is a mandate that all cOAlition S (an international consortium of research funders) members require that research they fund be published in compliant open access journals and platforms by 2020 (cOAlition S 2018). This deadline has now been shifted to 2021 (www.coalition-s.org/revised-implementation-guidance/).

Table 5.1: Main forms of institutional and sectoral mechanisms to support changes in the research landscape, as suggested by respondents

Type of support	Number of respondents (n=1,930) (%)
Funding to develop research that has societal impact	368 (19.1%)
Valuing societal impact and engagement within HEI reward and recognition systems	180 (9.3%)
Adjusting workload models to take account of work that develops societal impact	139 (7.2%)
Changes to policy to address concerns about a culture of audit and the impact of the UK's changing relationship with the EU	93 (4.8%)
Training to develop expertise in engagement, societal impact and new digital methodologies	91 (4.7%)
Changes to the academic publishing system to increase openness and improve peer review	52 (2.7%)
Infrastructure to support openness and collaboration on a global scale	45 (2.3%)
Creation of new roles to take account of work that develops societal impact	37 (1.9%)
IT to support openness and collaboration on a global scale	17 (0.9%)

resources at the end of a project to create impact and to publish non-traditional outputs that are more accessible to key stakeholders (n=23). Respondents reported that they felt that these activities are not effectively incentivised and sufficiently supported where they were contributing to their institutions' REF submission, as an impact case study. Similarly, some respondents felt that changes to funding schemes could support interdisciplinary research (n=21), which they perceived as currently disadvantaged by funding schemes they viewed as siloed by disciplines.

Conversely, over 5% of respondents who mentioned that changes to funding are needed cited the desire for a decreased focus on societal impact (n=21), mostly because they felt that funding should not be tied to the potential for research to achieve impact. Some respondents felt that researchers are not the most suited actors to carry out these activities, as most academics are not skilled in engagement and impact, and it is expensive for them to try to create impact.

Similarly, many respondents who mentioned funding cited a need for the United Kingdom to develop a longer term research strategy in terms of what research is funded. They felt that the current approach was focused on the short term and encouraged researchers to create

'quick' demonstrable impacts rather than longer term impacts that take time to achieve and evidence and that address major societal issues. Some thought that a UK research strategy should prioritise societal impact and major societal challenges, while others thought that it should be aimed at 'blue skies' research (n=26) or 'riskier' projects (n=16) without set objectives. Many of these respondents identified this as a requirement to maintain the United Kingdom's place in terms of cutting edge research and innovation (n=11). Some mentioned that this shift in funding strategy will be especially important as the United Kingdom leaves the European Union (n=18), with a perception that the ERC currently funds this type of research more frequently than funders within the United Kingdom.

One option identified by respondents was to have a funding stream for engagement and impact that is separate to the funding for conducting the research.[47] This would allow researchers to bring together separate strands of research that all contribute to a larger impact, and to facilitate impacts that are not tied to a single research output. It would also ensure that funding for impact and engagement does not compete with funding for 'blue skies' research, which would continue to be funded.

Other options mentioned by respondents included allocation policies, such as a desire to expand the diversity of who receives funding in the future beyond the 'usual suspects' of HEIs and previous grant holders. To support this, some respondents felt that grant applications should be assessed holistically. There was a perception that the quantity of publications and selectivity of the journals in which they were published was a factor in decision making, even though a number of funders have actively indicated that this is not the case. Similarly, respondents suggested that diverse sources of funding, such as jointly funded projects between public and private sources, and greater diversity in the length of grants would be helpful. Short-term grants with a quick turnaround could allow researchers to take advantage of fleeting opportunities for engagement and impact activities,[48] while long-term grants could allow researchers to more fully develop research ideas with possibly unpredictable but potentially significant societal impacts. Some respondents also called for more opportunities for researchers to join research projects, for example in research centres or centres of excellence, rather than compete for small pots of money. This would allow larger research projects with the same themes, questions and goals to be collaborative, rather than competitive.

Many respondents commented on the need to streamline the grant application process, citing the amount of time it takes researchers to apply for highly competitive grants.[49] By making

47 This is already present through some funders. For example, the Wellcome Trust has developed the Public Engagement Fund for researchers and organisations to use creative approaches to engage the public with health research ('Public Engagement Fund' Wellcome n.d.). Additionally, the Economic and Social Research Council's Festival of Social Science Impact Acceleration Accounts consist of block funding made to research organisations to accelerate impact and allow organisations to respond to impact opportunities ('Impact Acceleration Accounts', Economic and Social Research Council 2019).

48 Previous research by RAND Europe found that focus groups of researchers from Hong Kong were concerned that short-term funding, together with the requirement to publish in order to secure subsequent funding, impacted the type of research questions that could be addressed successfully (Parks et al. 2017).

49 The burden on researchers of grant applications has been previously assessed. For example, an Australian study found that academic researchers spent an average of 38 days preparing a new grant application for the National Health and Medical Research Council (Herbert et al. 2013). Additionally, from an economic perspective it has been estimated that application preparation can account for up to 35% of the application budget (Guthrie et al. 2018).

the application process less cumbersome, many researchers expressed that they would have more time to conduct high-quality research and produce outputs.[50]

5.5.2. New institutional mechanisms for reward and recognition are seen by some as necessary to incentivise high-quality research

Nearly 10% of respondents (180 out of 1,930) commented on what institutions could do to incentivise the behaviour that they wanted to promote through reward and recognition systems. For example, respondents said that if institutions would like their researchers to concentrate more on impact (n=49) and engagement (n=12), these need to be valued within the institution and demonstrated through appropriate incentives in terms of recruitment, promotion and tenure. Some respondents felt that there was a disconnect between the pro-impact rhetoric of institutions and the incentives that prioritise a high quantity of publications in selective journals or first author publications for career progression (n=51).

Other comments discussed the need for longer term contracts and increased job security, especially for early-career researchers. Respondents felt that greater job security would allow early-career researchers to spend more time conducting research rather than applying for future positions, and would allow researchers to engage in longer term projects without the pressure to publish quickly. Some respondents also expressed a desire for more diverse posts, including more jointly funded posts with industry, more part-time research contracts, and more posts that are focused on engagement and impact.

5.5.3. Some researchers are concerned with growing academic workloads

More than 10% of respondents (224 out of 1,930) expressed concern that researchers' workloads are growing,[51] and that time spent in activities such as teaching (n=37), administration (n=39), impact and engagement (n=85), and internal and external audits takes away from time spent on research. To address this, many respondents (n=139) identified the need for revised workload models that consider the non-research activities that researchers are responsible for, or dedicated time to support research workloads. There should also be clearer guidelines on what is expected at an institutional level, for example, respondents expressed that institutions should communicate better with researchers in terms of the amount of time that they should spend on research activities, producing outputs, teaching and creating impact, and engagement, as they felt that it is not possible to dedicate effort to all of these activities at once.

Outside of adjusting workload models, one potential solution to growing workloads identified in the responses was to allocate or outsource different activities (beyond research) to other individuals within the higher education

50 Previous research by RAND Europe found that focus groups of researchers from Hong Kong considered the grant application process to be burdensome and could be streamlined. Researchers felt that increasing the number of applications per year, reducing the length of time it takes to learn the outcome of an application, and reducing the level of declaration currently required could contribute to reducing the burden on applicants (Parks et al. 2017).

51 Large proportions of HEI staff in the UK are exceeding the limit of 48 hours per week imposed by the EU's Working Time Directive (European Commission 2019b). For example, a study from 2010 found that academics in the UK have worked an average of 50 hours per week since the 1960s, when the figure increased from approximately 40 hours (Tight 2010). There is evidence that this increased workload impacts the wellbeing of researchers, who have a lower wellbeing in this respect than workers in other industries (Kinman & Wray 2013). A 2013 survey showed that 79% of HEI workers reported 'always' or 'often' having to work very intensively, and 50% reported feeling pressured to work long hours (always or often) (Kinman & Wray 2013).

setting (mentioned by 16 of those who expressed concern about workloads, and by 37 respondents in total). Some suggested that this would allow specialisation so that individuals could focus on the areas in which they excel (mentioned by 13 of those who expressed concern about workloads, and 31 respondents in total). It was also suggested that universities may consider hiring impact and engagement officers with specific training in this area. These officers would be allocated a certain amount of time to each department or researcher to help create and monitor societal impact, for example the collection of evidence of impact. However, one concern from an organisational response was that these positions are time-bounded and may vanish post-REF, which would lose the knowledge from the sector and result in a transient workforce if short-term strategies are adopted. Some respondents felt that impact should be integrated into regular research activities so that it was not seen as an add-on, but as an integral part of the research process.

Respondents commented that an individual's focus on the range of activities conducted as an academic may vary depending on the researcher's specific discipline, over the course of a researcher's career, and with differences in natural aptitude.

5.5.4. Some researchers feel that national policy changes are needed in order to address concerns about the culture of audit and the United Kingdom's changing relationship with the EU

About 5% (93 out of 1,930) of respondents made suggestions around national policy in the open text responses. Many were critical of the 'audit culture' in the United Kingdom (n=20), particularly regarding the time and resources it takes to conduct national research assessment exercises and the knock on implications for internal audits. For example, respondents reported that many institutions conduct mock REF exercises that take time and resources to conduct, and that limit the available time that researchers have to conduct research.

Some respondents also made suggestions for how national policy could address concerns around the United Kingdom's changing relationship with the EU (37 out of 1,930). Respondents particularly identified the need to support and retain researcher mobility, and the importance of maintaining funding for 'blue skies' research and early-career researchers.

5.5.5. Additional training could fill gaps in researchers' expertise in engagement, impact and new digital methodologies

Approximately 5% of respondents (91 out of 1,930) identified training as a mechanism that can support changes in the research environment. Some respondents highlighted the need for more training in impact (n=38) and engagement (n=23), as this is an area where researchers, and early-career researchers in particular, lack expertise. In particular they commented that training should include more clarity on what constitutes a societal impact in different fields, social media use, publications for a lay audience, and event management, as well as softer skills such as communication and collaboration with non-academics, especially policymakers and industry.[52] Some respondents also identified a need to receive training in new digital methodologies such as data visualisation, artificial intelligence and coding. This aligns with responses from sectoral organisations, where respondents suggested that new roles within academia

52 This echoes the comments from consultation responses suggesting that HEIs may adapt their strategy around impact to create more connections with external stakeholders, to build skills around impact and engagement.

may be developed, both to respond to short-term impact and engagement strategies and to support researchers in incorporating new technology-enabled methods in their research. Roles mentioned included software engineers and statistical support roles.

Some respondents also cited a need for a review of how PhD students are trained in the changing research landscape, particularly in areas such as collaboration, impact and engagement, and transferable skills, due to the limited number of more senior academic positions. Some also cited a perception that there are currently too many PhD students competing for too few roles, and that the number of PhD students trained should take account of the volume of academic opportunities.

5.5.6. The academic publishing system may need to adapt to changes in how research is conducted and made available

Less than 5% of respondents (52 out of 1,930) identified changes to the academic publishing system that would support changes in the research landscape. One of the most frequent changes discussed was the need for more open access publishing (n=20) and less reliance on traditional selective journals within the research landscape (n=9). Respondents felt that this would help make science more reproducible and rigorous through the open publication of pre-registrations, datasets, replication studies and studies with null results. They also identified that more open access publishing would help save resources by preventing datasets from being duplicated or unused, and would facilitate the publication of non-traditional outputs that are more accessible to a wider audience.

Some respondents to the survey also commented on changes that they would like to see in the peer review system used in publishing,[53] such as the need for a faster, more efficient process, and the need to avoid publishing decisions perceived as arbitrary and biased. Some commented on the need to ensure that peer reviewers have equal or greater expertise in the research topic than the author of the paper to ensure that a high standard in peer review is met. An option identified in the responses that may increase the quality and efficiency of peer review is to recognise peer reviewers for their contributions by open acknowledgement or reward.

5.5.7. IT and infrastructural improvements may support changes within the research landscape

Respondents identified infrastructure (47 out of 1,930) and IT improvements (17 out of 1,930) as being able to support changes in the research landscape, such as the growing number and size of collaborations, interdisciplinary research and open science. Respondents identified the need for open data repositories and open collaboration platforms, along with more interdisciplinary infrastructure at an institutional level, rather than investing in departments that can silo funding, activities and collaboration. To facilitate impact and engagement activities, respondents cited the need for more networks between HEIs, policymakers, media contacts and other non-academic stakeholders.

To support high-quality research in response to new technologies and methodologies, respondents suggested computational support and support with statistical modelling and infrastructure to support AI, large datasets and integrated data.

53 Previous research on peer review in the grant application process identified potential improvements to peer review. These include asking reviewers both for their rating of the proposal and a measure of their confidence in this rating, introducing an element of randomness into the allocation system in order to acknowledge the difficulty of predicting the future (e.g. a lottery system or a two-stage system), making the application process more valuable for unsuccessful applicants, and publishing results from evaluations of alternative approaches (Guthrie et al. 2018).

6 How could national research assessment exercises learn from developments in peer review?

Peer review is defined as 'the process of subjecting an author's scholarly work, research or ideas to the scrutiny of others who are experts in the same field' (International Journal of Computer Applications n.d.). Peer review plays an important role in the research system. It is commonly used to assess research in a number of settings, such as funding allocation, through grant applications and ex-post assessments; journal publications; and selecting oral and poster presentations for conferences (Deveugele & Silverman 2017; Shergill et al. 2017). It can be (and is being) used to consider all elements of research, from the proposed methodology, manuscripts and finalised outputs themselves, to the environment that research takes place in, and the impact that it has beyond the academy. Peer review activities for researchers have also been developed, such as workshops on group peer review (Dumenco et al. 2017) and collaborative manuscript writing activities (Corcelles et al. 2017).

Within national research assessment in the United Kingdom, peer review is the central method used to evaluate and grade the quality of research outputs, impact and environment. Developments in automated or semi-automated data processing and analysis are likely to change the way research is assessed, and may become more integrated into the research assessment process.

This chapter describes the role and purpose of peer review, and how technology could be used to complement peer review and contribute to the process. It is primarily based on the results of desk research synthesised by the project team, and includes reflections from discussions at the three workshops that aimed to explore how the purpose and process of research assessment may change in the future, the role of peer review in the process of research assessment, and how technology may impact the process of research assessment.

The key findings are:

- Peer review is the predominant method for research assessment in the United Kingdom, and there is no expectation that this will change.
- Technological approaches are expected to further support peer review in the future.
- Cultural shifts, as well as technological shifts, are both needed and happening.

6.1. Peer review is the predominant method for research assessment in the United Kingdom, and there is no expectation that this will change

As described above, peer review is used for research assessment across many contexts, such as grant applications, journal

Figure 6.1: Settings in which peer review occurs

publications, *ex-post* assessments and conference contributions. Peer review can also be supplemented by metrics, which is the dominant approach in some international contexts (e.g. Norway) (Kolarz et al. 2019). Peer review is currently the predominant method for research assessment in the United Kingdom, and there was no expectation from workshop participants, across all three workshops, that this will change in the next 5 to 10 years.

The process of research assessment through peer review involves a number of stages, which may or may not be present in the different settings of research assessment (Figure 6.2).

Typically, the peer review process consists of three stages: a triage stage where items that clearly do not meet the eligibility requirements are rejected, a review stage in which items are reviewed and assessed for quality, and a decision phase where the final outcome

Figure 6.2: The stages of peer review

of the review process is determined and communicated (Guthrie et al. 2018). The main role of peer review is in the review stage, which generally involves selecting reviewers, allocating research outputs to reviewers, and assessing and scoring the quality of research.[54] These different steps are not always present in the different settings for research assessment, and the order in which they are conducted can vary. Further details on each step, and the specific process of peer review in UK national research assessment, are described in Section 6.2.

6.1.1. Strengths and weaknesses of peer review

The process of peer review has been widely studied, and a number of strengths and weaknesses have been identified. This section provides a brief overview of some of these strengths and weaknesses in order to set the context within which technological developments may operate, and how they may support or enhance the process currently undertaken.

Strengths

Peer review 'sets academia apart from all other professions by construing value through peer judgement, not market dynamics' (Biagioli 2002). Participants from the workshops agreed that the peer review process is a highly valued mechanism for research assessment. In the context of academic publishing, peer review is intended to serve two primary purposes (Ware 2008). First, it ensures that only high-quality research is published by determining the validity, significance and originality of research (Kelly et al. 2014). Participants from the peer review workshop, which considered peer review in all contexts, agreed that peer review serves as a quality assurance mechanism. Second, peer review is intended to improve the quality of research and its outputs through suggestions on how to improve the quality of a manuscript or a research proposal.[55] Participants from the workshops on both peer review and technology also commented that many academics participate in peer review as it provides them with the opportunity to learn and helps them become better scholars.

Peer review also supports and ensures integrity and authenticity in the progress of science. This view was shared by participants from the peer review workshop, who agreed that it serves as a way of providing accountability and enhancing international development. Some believe that 'a scientific statement is generally not accepted by the academic community unless it has been published in a peer reviewed journal' (Mulligan 2005).

Participants from the workshop on peer review commented on the role of peer review in bringing experts into research. Peer review generally relies on the views of more than one expert, which, in the context of publishing, ensures that editors are supported in their decisions by the views of experts (Ware 2008). The evaluation of the impact element of REF 2014 found that there was value in diversifying those classified as experts for the purpose of assessment. For example, it was felt to be successful and valuable to bring together the different perspectives of academics and research users to assess impact case studies and strategies (Manville et al. 2015c). It was widely agreed that the two perspectives moderated each other and added to panellists' confidence in the process.

54 These stages have been identified based on the project team's understanding of assessment systems, such as the Research Excellence Framework (REF) (Manville et al. 2015a).

55 There are a number of studies that support this (Ware 2008; Ballantyne et al. 2017; Mulligan et al. 2013).

Some studies of peer review have found a high level of agreement between reviewers on between 80% and 90% of manuscripts (Bornmann et al. 2008; Clarke et al. 2016). However, there is also a body of literature that claims inter-reviewer reliability is low (Jirschitzka et al. 2017; Pier et al. 2018), and that peer review is not able to accurately stratify research proposals to identify the most meritorious (Fang & Casadevall 2016).

There is mixed evidence on the role of collaborative discussion such as panel meetings to improve reviewer agreement, with an argument that they can be subject to collective anchoring effects (the cognitive bias that describes the common human tendency to rely too heavily on the first piece of information offered) (Roumbanis 2017; Derrick & Samuel 2017). Pina et al. (2015) found that consensus meetings improved agreement where there were high levels of disagreement. However, across all proposals this improvement was not detected. Conversely, when evaluating the process of National Institutes of Health (NIH) research grant applications, Martin et al. (2010) found that meeting discussions had an important effect in more than 13% of applications (Guthrie et al. 2018).

Weaknesses

Peer review is often cited as the 'gold standard' for the evaluation of scholarly activities; however, as with any system it has challenges (Biagioli 2002; Enslin & Hedge 2018; Mayden 2012; Sayer 2014; Wilsdon et al. 2015), such as managing bias effectively, ensuring transparency, minimising burden, and providing incentives through reward and recognition.

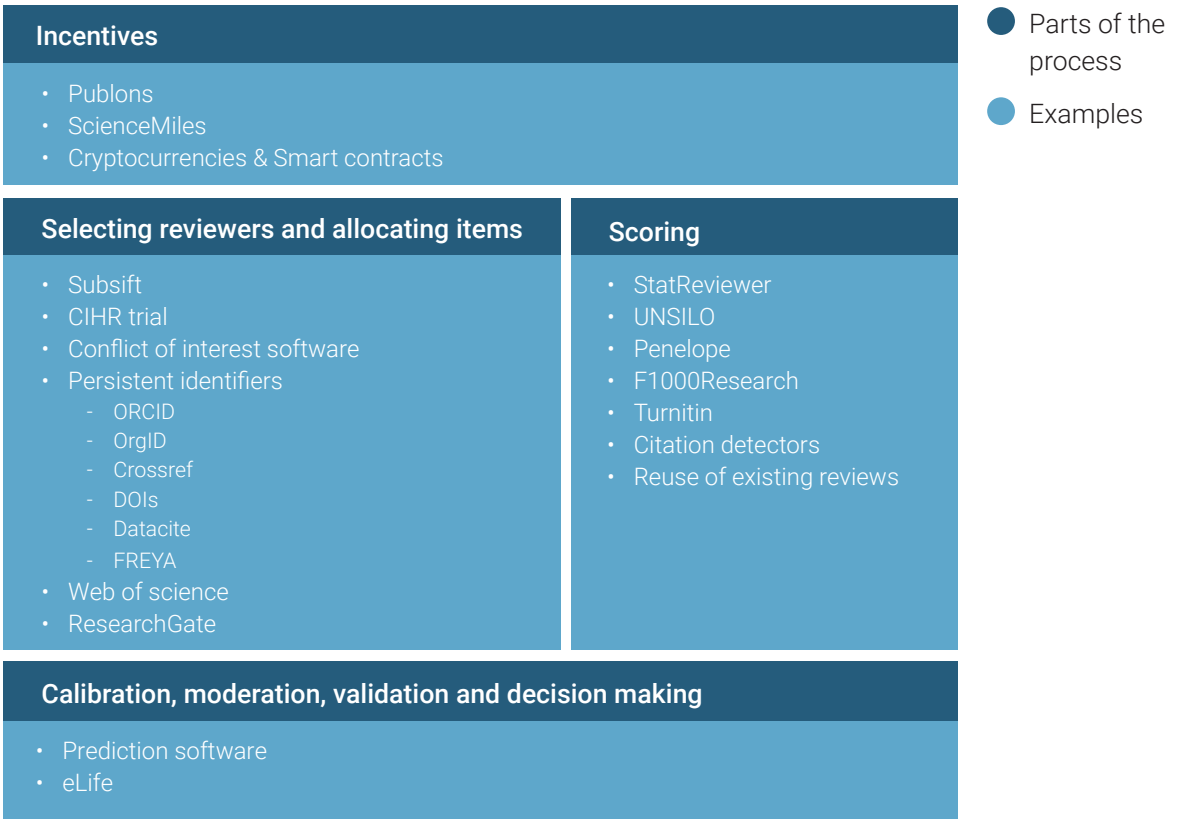
Peer review is a human process, and therefore subjective. For example, there are reports in the literature of an advantage or disadvantage to a subset of applicants (e.g. early-career researchers with a limited publication record, or women) (Malikireddy et al. 2017; Risnes 2018; Tamblyn et al. 2018; Wennerås & Wold 1997) or types of research (e.g. null findings) (Nosek et al. 2015). Peer review seeks to manage subjectivity through the specification of clear criteria and review procedures, including, in some cases, relevant training such as unconscious bias training that seeks to minimise and provide space to challenge conscious or unconscious bias.

Transparency regarding the rules and processes of research assessment is considered by researchers to be an important characteristic of the assessment of research. In many settings, peer review is anonymous.[56] Anonymity promotes the creation of full and frank review that is not limited by concerns of unreasonable challenge, and reduces the risk of 'status' playing a strong role (Samorodnitsky n.d.; Enago Academy 2018; DeCoursey 2006). Although the principles of the process may be clear, the anonymity of reviewers has contributed to concerns around potential bias in decision making and misuse of reviewer power (Lipworth et al. 2011). There are also concerns that it can contribute to slow peer review and extended publishing times (Jan 2018).

Peer review is time consuming (Huisman & Smits 2017; Riley & Jones 2016), and it has been noted that the pool of known peer reviewers does not appear to be expanding at a rate sufficient to accommodate the growth in outputs (Björk 2015; Spearpoint 2017; Van Noorden 2014). The demands of peer review are not necessarily evenly distributed across the sector or aligned with wider incentives, as although there are benefits of participating in peer review, reviewers are not typically

56 It is important to note that this is not the case in UK national research assessment.

Figure 6.3: The peer review process and examples of technologies that can support the different stages



recognised or rewarded directly for their efforts (Ballantyne et al. 2017).

Participants from workshops on both peer review and technology felt that although the concept of peer review was part of scholarly endeavour, and that it was important and valuable to contribute to peer review, there was concern regarding a lack of recognition and reward, which made it difficult to prioritise. Participants commented that this was less observed in the REF, where panel membership is often associated with some relief of other duties by an employer in recognition of the value of the reviewer's experience of the process more generally. There is also scope for researchers to contribute to the development of the REF process nationally and locally.

6.2. Technological approaches are expected to further support peer review in the future

Keeping these strengths and weaknesses in mind, workshop participants across the two workshops focusing on peer review and technology identified a number of areas where technological developments could support or complement the peer review process (Figure 6.3). Workshop participants felt that this was a timely discussion as advances in technology meant that it was possible to do things now which were previously undeliverable due to the scale of data. It was felt that this could enhance the process going forwards.

6.2.1. Selecting reviewers and allocating items

The first step in research assessment by peer review is the selection and recruitment of reviewers. Editorial peer review is generally conducted by two independent reviewers, who are mostly unpaid volunteers viewed as knowledgeable and capable in the subject matter (Ballantyne et al. 2017). Grant application and *ex-post* assessment peer reviews are generally conducted using a panel of reviewers comprised of two or more reviewers (Manville, Guthrie, Henham, et al. 2015; Parks et al. 2017). Often in these circumstances, two reviewers will review the submission, which is calibrated or moderated with the views of others through discussion.

Peer review holds a central place in national *ex-post* research assessment as it is the sole method for assessing the quality of research at a national level across all disciplines within the United Kingdom. In other countries, such as Belgium, Italy and Portugal, it is used together with metrics (Kolarz et al. 2019). In the case of the UK REF, main panel and sub-panel members are nominated by members of the academic community and wider stakeholders, and appointed by the four UK funding bodies.[57] Reviewers are selected to be on panels because of their expertise in the subject area covered by that unit of assessment (Manville, Guthrie, Henham, et al. 2015). The funding councils use the intention to submit process to verify that different research fields within a unit are sufficiently represented by experts. This process, conducted one year before submission, allows HEIs to provide an indication of what their submission will look like (REF 2012a). Individual items are then manually allocated by the panel chair to individual reviewers on the panel to review, in line with their knowledge of the subject area.

There can be challenges in identifying reviewers and assigning outputs within the limits of known networks; an increase in demand for review is seen as placing increased burden on a limited pool of reviewers. Participants at the peer review workshop reported that in their experience, it is increasingly necessary to reach out to a larger number of people in order to get positive responses to review requests.

The use of persistent identifiers and text mining can facilitate reviewer selection

A persistent identifier (PID) is an enduring reference to a resource that is often associated with a set of metadata describing the object. In the context of research, PIDS can be used for items such as publications or researchers (THOR 2019). PIDS could be used to expand the pool of relevant reviewers by serving as a database of active researchers in the different fields and topic areas. A number of persistent identifiers have been developed for research, mainly in a digital format, which has led to the name of digital object identifier (DOI). Such identifiers include ORCiD, Crossref, and Datacite (Box 6.1).

The European Commission has funded a three-year project, FREYA, that aims to 'build the infrastructure for persistent identifiers as a core component of open science'. Goals of the project include (1) improving data discovery by extending and cross-linking PID services, building on existing infrastructure; (2) designing and delivering services for data discovery, resource identification and provenance tracking; (3) integrating the PID Graph (which connects and integrates PID systems) in

57 Any association or organisation with an interest in the conduct, quality, funding or use of research may make nominations to the REF panels (REF, n.d.).

Box 6.1: Description of some current persistent identifiers

ORCiD: web-based service that provides a non-proprietary alphanumeric code to uniquely identify academic authors. This allows researchers to track contributions and affiliations (ORCiD 2019).

Crossref: membership-based organisation that aims to make research outputs easy to find, cite, link and assess. It offers and enables access to a registry of metadata and DOIs for millions of sources, including books, articles, conference proceedings and datasets (Crossref 2016).

Datacite: organisation that provides and manages persistent identifiers to research data and outputs of its member organisations (DataCite n.d.).

the European Open Science Cloud (EOSC); (4) building and promoting a community of practice; and (5) sustaining an open PID e-infrastructure for the broader research community (FREYA 2019).

Online research platforms, such as Web of Science and ResearchGate that catalogue publications, may also facilitate identifying appropriate reviewers. Web of Science enables the simultaneous cross-searching of a range of citation indexes and databases, and offers access to research tools such as citation reports and cited reference searching. The platform also provides personalised features such as saved searches and alerts (University of Sheffield 2019). ResearchGate is a global professional network for scientists and researchers that provides an online platform for members to share and discuss research. It provides members with access to statistics on who is reading and citing their work, as well as the opportunity to connect with peers and specialists, and search for jobs (ResearchGate 2019).

Artificial intelligence and machine learning have been used to profile researchers and match submitted papers to appropriate reviewers based on a full text analysis of the reviewer's previous work in specific contexts. For example, new technologies allow expert reviewers to be taken from an 'open world setting' or from the whole pool of researchers within a certain field, language or geographical area, which reduces reliance on the possibly incomplete knowledge of the known network of a particular journal or funder (Price & Flach 2017). This process has already been implemented through a web service called SubSift, which was used to profile and match papers and reviewers for a data mining conference where 537 papers were matched to reviewers with high rates of success (Flach et al. 2010). It has also been used in several other major conferences, where a full text analysis of publications available on bibliographic databases has been conducted (Price et al. 2013).

Technologies that make use of text mining can help assign appropriate reviewers. Frameworks have been specified for the use of ontological text mining to cluster papers for review based on full-text analysis. The papers can then be assigned to appropriate reviewers based on their full body of work (Arunachalam et al. 2013; Patil & Uddin 2015; Srivastava & Bagwan 2015). Text mining can also be incorporated into conflict of interest software that manages and automates conflict of interest disclosure, attestations, certifications, policies and compliance surveys to help organisations remain compliant.

The use of new technologies is not always well received. In an attempt to reform the former Open Operating Grants Program, the Canadian Institutes of Health Research

(CIHR) made the decision to replace face-to-face peer review meetings with an online system (Gluckman et al. 2017), which was not well received by the research community. Researchers found the reforms to be poorly designed and rolled out hastily, and stated that this decision had led to unpredictability and a lack of confidence in the review process (Payne 2016a). Following the controversy, CIHR reverted back to face-to-face peer review (Payne 2016b). A participant from the workshop on the purposes of research assessment used the CIHR case as an example of why the use of technology should be implemented carefully and in a progressive manner.

Crowdsourcing and public involvement can contribute to increasing the pool of reviewers

Crowdsourced peer review shifts the concept of 'peer' in peer review from academic experts to a broader involvement of the public. With this approach, any reviewer or qualified reviewer would be able to openly comment on the paper and suggest revisions, which, with careful moderation, would have the potential to improve the quality of research outputs (Cohen 2017). The result of crowdsourced peer review would be paper-level metrics that may more accurately reflect the heterogeneous quality of research outputs, compared to journal-level scores, such as impact factors, that do not fully illustrate the quality of each article published within a given publication (Sabater-Mir et al. n.d.). Metrics in which credible researchers are able to award reputational points based on their assessment of the research may increase the speed at which the quality of research is assessed and captured in metrics, and could capture a wider range of views than is currently captured (Sabater-Mir et al. n.d.; van Rossum 2017). However, these metrics would be susceptible to gaming, for example if those awarding reputational points were closely associated with the author, or if they awarded points transactionally. Crowdsourced peer review has already been implemented in open access publishers such as F1000Prime, where a crowd of relative experts are invited to rate, recommend and comment on published articles, which leads to an evaluation that leverages the wisdom of the crowds (Fresco-Santalla & Hernández-Pérez 2014; Kovanis et al. 2017).

As mentioned previously, the changing definition of 'peer' in peer review is broadening from disciplinary experts to include those beyond the sector, such as the wider public, which could contribute to increasing the pool of reviewers and diversify the views considered when assessing research quality. This has the potential to decrease bias in panel discussions. For example, panels could be chaired by non-academics to encourage debate and actively challenge the consensus (Derrick 2018). In 2014, the UK REF included a greater proportion of non-academics in the review panel than in the previous assessment (Derrick 2018; Manville, Guthrie, Henham, et al. 2015). As the public is brought more into research through initiatives to encourage patient and public involvement and engagement (INVOLVE n.d.), the role of non-academics in research assessment is likely to grow.

6.2.2. Scoring

The scoring phase of peer review generally includes two slightly different tasks: an objective measure that the research meets basic requirements of scientific rigour, and a more subjective measure of how much the research contributes to the wider field, and its significance. First, research needs to be scrutinised to ensure that it meets basic eligibility requirements for submission, for example validating the author's identity and institutional associations, and assessing the scientific accuracy of the output. Second, reviewers assess the value of the contribution

against the scoring criteria. For example, with journal articles this often includes the contribution and significance of the research. Although many factors may come into play when making decisions about contribution and significance, there are some limitations in accurately assessing this aspect of research.

There are two main challenges to the scoring stage of the peer review process: the relevance and ability of the reviewer to review the output; and the context they bring into the process, consciously or unconsciously, that informs their decision. Workshop participants were concerned that as outputs and applications become increasingly interdisciplinary in nature, it is very difficult for a single reviewer to confidently review all aspects of an output.

Specific to national research assessment, participants from the workshops noted that the review and scoring stage of the assessment process could be considered a repetition of work that may already have been carried out (e.g. publications are peer reviewed prior to their publication), although it is important to note that the criteria may vary. More broadly this could also be seen to be the case when journal articles are reviewed following the success of a funding application. However, this may reinforce biases and unfairly prejudice against research that pushes the boundaries or contradicts accepted dogma, where research which is unimaginable is continually assessed in light of these initial views around which subsequent reviews anchor.

Limiting peer review criteria

New and emerging technologies can automate or partially automate some parts of the peer review process, which may reduce burden by focusing the peer reviewer's efforts on other elements of review, or reduce the risk of bias by removing individual subjectivity from some elements of the process. Tools that can support ensuring an output is eligible include plagiarism software, which validates the author's identity and institutional associations and confirms the scientific accuracy of specific elements, such as statistics. Examples of software to deliver this are listed in Box 6.2.

These kinds of automated or semi-automated artificial intelligence checks can be used to support the traditional peer review system or to assist in the publication of pre-prints in the absence of comprehensive peer review (Tennant et al. 2017). There have also been instances of supervised machine learning completing an automated risk of bias assessments on a set of 1,467 full-text articles, with reasonable success compared to human researchers (Millard et al. 2015). This was used in a systematic review context, but may be possible to use it to support research assessment processes in a wider context.

Box 6.2: Examples of software to support eligibility checks

Plagiarism detection: e.g. Turnitin highlights similarities between the content of submitted papers and the content of academic papers, webpages and student papers available online (Turnitin 2019).

Review of statistical reporting integrity: e.g. StatReviewer scans manuscripts and assessed standard format statistics from multiple scientific fields, verifying that information such as sample sizes are correctly included (Stat Reviewer 2019). The software generates a report based on the guidelines specified by a given journal, which could be adapted for national research assessment.

Publish-then-filter model

In addition to technological developments, the 'peer review light' idea has been gaining popularity as a way of addressing limitations with the current peer review system (Tennant et al. 2017), or of reviewing outputs to ensure that the research was conducted through a scientific process and that conclusions are based on results rather than reviewing to evaluate contribution or significance. With this approach, humans or machines would assess outputs for scientific accuracy, and filter out research that was not conducted according to the scientific process. Crowdsourced peer review would then assess the research for contribution and significance over time. In this scenario, the role of peer review would move from selective gatekeeper to more of an objective filter (Tennant et al. 2017), which may lead to more favourable assessments for studies with null results, studies whose results contradict the current status quo and replication studies (Nosek et al. 2015; Risnes 2018).

Distributed ledger technologies may maximise the knowledge gained through peer review

Workshop participants agreed that there was a considerable amount of knowledge and information that could be reused across the research process. Participants suggested that reusing information from existing reviews at other stages in the research process, such as grant applications and journal article submissions, could reduce the burden of assessment, facilitate the review process and allow the transfer of knowledge.

Distributed ledger technologies such as blockchain could support this through an immutable file management system accessible to all actors in the research system (Janowicz et al. 2018). This would mean that tamper-proof and permanently linked data, pre-analysis plans and pre-prints could be assessed alongside the final output to ensure that data and protocols are consistent throughout the research process. Others have echoed this use for distributed ledger technologies in making data and research protocols permanent and linking all outputs throughout the research process as a way of helping mitigate reproducibility concerns in science (Kochalko et al. 2018), which may come to play a larger role in the research assessment process as they are integrated into the larger research system. Smart contracts in particular may radically change how research is conducted and assessed as they make it possible for protocols that were previously set in 'blockchain stone' before data was collected to be automatically carried out (van Rossum 2017).

6.2.3. Calibration, moderation, validation and decision making

Once an individual reviewer has reviewed an output and provided comments and/or a score, there is usually a level of moderation. This can be conducted through discussion or through independent arbitration, such as by an editor for a journal. In many cases of grant applications and *ex-post* assessments, such as for the REF, at least two panellists review and score the output prior to the panel discussion. The number of outputs discussed and the depth of discussion on each one will depend on the size and breadth of the panel, the number of submissions, the degree of variation in view, and the length of the meeting. Options include discussing all those that meet the minimum score by both reviewers, those where there is disagreement between the reviewers or those that are borderline. Within the impact element of REF 2014, the review process was decided at a sub-panel level. For example, in some cases the submission was discussed by the reviewers, and if consensus not achieved it

was escalated to the sub-panel level (Manville, Guthrie, Henham, et al. 2015).

Moderating discussion generally follows the scoring stage. However, in REF 2014 there was a calibration stage for both output and impact assessments at a main panel and sub-panel level, which took place prior to the scoring of all assigned case studies (Manville, Guthrie, Henham, et al. 2015; REF 2012b). Each main panel calibrated a sample of items from their respective sub-panels and shared their views on what constituted impact in each of the sub-panels, as well as across the main panels. This calibration stage ensured consistency of understanding and approach to assessing and evaluating impact (Manville, Guthrie, Henham, et al. 2015).

The peer review process leads to a decision on the quality of the research. The outcome is often linked to a rating or judgement, which has implications for publication or funding. Participants from the workshops commented that the decision-making process was different for editorial publishing and grant applications, and national research assessment.

Using technology to moderate reviews

In cases where a research output has been assigned to more than one reviewer for assessment, new and emerging technologies can help to reconcile score differences. For example, machine learning can be used to automatically calibrate the scores of individual reviewers based on their previous history of reviews. This technology is enabled by open access for peer review (Price & Flach 2017).

One digital example of collaborative review is eLife, which is an open access, peer reviewed biomedical journal that uses open internal consultation between reviewers when deciding whether to accept a journal article. Once a decision has been made, eLife makes reviewer decisions and author responses publicly available. Although workshop participants agreed that collaborative review facilitates discussion and increases transparency, they also felt that the process was likely to further increase the burden and expense of peer review.

6.3. Cultural shifts, as well as technological shifts, are both needed and happening

When thinking about the future, it is important to consider how peer review and emerging technology fits in with the other trends influencing change. For example, the rise of open science has led to significant changes in how research is conducted (Neylon 2013), and may lead to more significant changes in the future, possibly disrupting the traditional publishing model (Van Noorden 2013; Risnes 2018).

During the workshops on peer review and technology, participants were asked their perspectives on the ongoing developments they envisage in the field of peer review, and to prioritise the topics they thought were most likely to change and that were most beneficial to change (Table 6.1 and Table 6.2).[58] Participants from the peer review workshop provided insight into the cultural developments around peer review, which have been aligned with the new technologies described in the workshop on technology for this report.

Within both workshops there was misalignment between what participants viewed as developments likely to change within the next 5 to 10 years and the developments participants viewed to be most beneficial to peer review.

58 Each participant was given three dots to place in each column (likely to change and most beneficial) to distribute as they wished.

For example, in the peer review workshop, nearly 60% of votes were allocated to rewarding reviewers and initiatives on equality, diversity and inclusion as changes that would be the most beneficial to peer review. These were also the areas that participants felt were not likely to change in the next 5 to 10 years, which were instead identified as increasing the pool of reviewers, allocating articles, and checking requirements through platforms and automation (nearly 50% of votes).

Within the technology workshop, participants felt that the most beneficial advances to peer review would be the use of ORCiD, digital preservation and distributed ledger technology, although ORCiD was seen as likely to change in the next 5 to 10 years. Other realistic developments were in areas of reward, such as publons, AI and machine learning techniques.

The responses from organisations identified that caution was needed regarding the potential of technology to be abused, such as the use of machine learning to produce deep fakes or to compromise datasets and codebases, which could lead to a reduction in trust of academic research. It was also noted that although technology could support increased diversity in the types of output and impact possible, it could further disadvantage those taking a career break, for example to look after dependants, due to the speed at which the digital environment and the associated culture changes.

Table 6.1: Views from the workshop on peer review on the areas most likely to change, and those that would be most beneficial to change, in the next 5 to 10 years

Developments	Description and role of the development in peer review	Likely to change in the next 5-10 years (%)	Most beneficial to peer review (%)
Increasing pool of reviewers	The development of platforms such as Web of Science or ResearchGate enable research activities to be more visible, and therefore contribute to broadening the pool of reviewers for a given discipline or topic area.	23.5	5.8
Output visibility	One of the issues raised by participants was regarding whether the research community was assessing the most appropriate research outputs or the most visible research outputs. Increasing the visibility of non-traditional research outputs (e.g. genome sequences or databases) could impact how research is assessed.	5.8	8.8
Rewarding reviewers	Peer reviewing is a time-consuming process. Compensating researchers for the time spent reviewing a research output may contribute to more researchers agreeing to participate in the peer review process, as well as encourage researchers to provide reviews in a timely manner.	11.7	29.4

Developments	Description and role of the development in peer review	Likely to change in the next 5-10 years (%)	Most beneficial to peer review (%)
Automation	Automation refers to the use of technology such as text mining, artificial intelligence or machine learning to streamline certain aspects of peer review (e.g. identifying reviewers and allocating research outputs).	23.5	2.9
New metrics	Participants felt that with an increase in the variety of research outputs (e.g. databases), new metrics should be developed to more accurately assess the quality and impact of research.	14.7	0
Review of reviews	One of the main issues highlighted by participants was that knowledge gained through peer review was usually lost. Participants felt that peer review would be less burdensome if reviewers could rely on reviews already carried out.	0	2.9
Training	Providing training to researchers undertaking peer review could contribute to improving the quality of reviews. Training could be provided in the form of a buddy system or through learned societies.	14.7	8.8
Collaborative review	Collaborative review refers to reviews being conducted collaboratively between reviewers, rather than having independent reviews.	0	8.8
Self-assessment of confidence	This refers to providing reviewers with a self-assessment opportunity on whether they have the desired knowledge to review the entire journal article, sections of the article, or neither. Experts can be both topical and methodological, and participants felt that reviewers should be assessed on both counts.	2.9	2.9
Understanding of metrics	In addition to the development of new metrics, participants felt that a better understanding of the different metrics in place could be beneficial to research assessment.	0	11.7
Quality threshold	The scoring stage has a subjective component to it. It has been suggested that peer review cannot properly distinguish between two excellent research proposals, and that it would be better to instate a lottery to randomly allocate funding among the top applications. Participants felt that in order to do this a standardised quality threshold should be developed, and reviewers should be thoroughly trained on these standards.	2.9	0
Equality, diversity and inclusion	Equality, diversity and inclusion initiatives are working towards removing the biases of traditional publishing.	0	29.4

Table 6.2: Views from the workshop on technology on the areas most likely to change, and those that would be most beneficial to change, in the next 5 to 10 years

Technology	Likely to change in the next 5 to 10 years (%)	Most beneficial to peer review (%)
ORCID	18.2	18
Technology to increase discoverability of research outputs	9.1	6.5
Publons	20.5	9.8
Distributed ledger technology	2.3	13.1
Artificial intelligence	18.2	3.3
Machine learning	13.6	4.9
Sentiment analysis	2.3	1.6
Automation of the assignment of outputs to peer review	2.3	3.3
Conflict of interest software	2.3	0
Plagiarism software	0	0
Citation detector	4.5	4.9
REF predictors	2.3	0
Preservation (digital)	2.3	14.7
Distributed ledger technology	2.3	13.1
Continuous project reporting	0	6.5

7 Reflections on how national research assessment may need to adapt to changes in the research landscape

This chapter provides a summary of the key findings of the report, and reflections across the questions asked in this study. It considers in particular how UK national research assessment may need to adapt to the changing research landscape in terms of adaptations that may be needed to ensure that it continues to assess the key elements of the research landscape, and those that may allow it to incentivise, and potentially drive, desired research cultures.

7.1. Why assess research, and how might that change in the next 5 to 10 years?

There are many reasons for assessing research. This study summarises the six 'A's, which expand on the existing four 'A's previously described in the literature (Morgan Jones & Grant 2013). The six 'A's, accountability, acclaim, advocacy, analysis, allocation and adaptability, are dynamic and interrelated. The purposes for research assessment are both implicit and explicit, which results in a varied understanding and interpretation of purpose by different stakeholders. Over time there has been a shift in the focus of the rationale behind assessment, possibly due to the legitimacy of the aims developing and the different aims gaining popularity or importance within the research system and wider society. Given that the six 'A's are dynamic and interrelated elements for research assessment, they are likely to continue to evolve, and the weight and importance of each 'A' as a reason for assessment may continue to shift over time. This is particularly visible through the additional emphasis now placed on analysis in terms of the use of research assessment to inform higher education and funding strategies, and acclaim in terms of the ranking of universities and departments according to the research conducted within them at an institutional and national level.

7.2. How do researchers expect the forms of output they are producing to change in the next 5 to 10 years?

Researchers expect that the different forms of output they will each produce in the next 5 to 10 years will increase from a mean of 4.7 to a mean of 6.5. Researchers will continue to produce common output forms such as journal articles and conference contributions (currently produced by 85% and 70% of respondents, respectively), while also starting to produce less common outputs and outputs aimed at a wider audience. The forms of output with the greatest percentage increase in the number of researchers producing them between now and 5 to 10 years' time are books (authored book, chapter in a book, and edited book),

non-confidential research reports for external bodies and openly published peer review.

The changes are particularly driven by an expectation of career progression, which brings with it the opportunity or requirement to produce different output forms (e.g. books). Other factors influencing the changes in output forms cited within the survey include the desire to reach new audiences and create impact, as well as wider changes controlled by external bodies (e.g. funding, open access requirements, the REF) or other changes influencing the research landscape (e.g. societal changes and new technology).

There are significant differences in the forms of output being produced by researchers from different disciplines, and some outputs are highly specific to certain disciplines. There are also some significant differences between career stages, although there are fewer differences between career stages than between disciplines.

7.3. How do researchers expect the types of societal impact their research produces to change in the next 5 to 10 years?

Researchers expect their research to lead to more types of impact in the future, with the mean number of types of impact increasing from 2.2 to 3.2. The number of respondents who expect that their research will have an impact on society also increases between now and the future, with the percentage of those expecting their research to lead to impact increasing from 77% to 86% of respondents. Impact type differs by disciplines, and this is expected to continue.

When asked about the distribution of balance of effort between producing research outputs and impacts, researchers expect the majority of effort to remain on outputs in the future, but with a slight increase of effort spent producing impacts, mainly due to the continued emphasis on the impact agenda and its implications for funding at an individual and institutional level.

The focus on impact may change throughout a researcher's career. Some argue that as research takes time to have an impact it is more common in more established researchers. Others argue that early-career researchers are less likely to be able to invest time and resource on creating impact, as short-term contracts mean that they must prioritise publications. More research could be conducted to understand what can be done to support researchers across career stages deliver impact from their research.

7.4. How do researchers expect the research environment they are in to change in the next 5 to 10 years?

Researchers identified a large number of drivers as being important in influencing the changes happening in the research system. Across disciplines the three most important drivers were consistently collaborating with other academic researchers, collaborating globally with other academic researchers, and the focus on multidisciplinary research. However, there were significant differences by discipline in the importance of most of the drivers further down the list.

There were also changes across career stages. Overall, most drivers, particularly open science, were seen as more important by PhD students and early-career researchers than mid-career and established researchers.

Researchers were asked about how the research environment needs to adapt to the changes they foresee in the outputs and impacts they produce. These are important considerations to ensure that new forms of

output are acceptable in research assessment and other aspects of the sector. Many researchers discussed how they would like the environment to change, and their preferred direction of travel.

The range of topics discussed is presented in Box 7.1. Changes to support and drive developments need to happen at an institutional and a sector level. The specific forms of support suggested by respondents are provided in Box 7.2.

7.5. How could UK national research assessment learn from advances in other applications of peer review?

Peer review is currently the predominant method for research assessment in the United Kingdom. It is used across many contexts such as grant applications, journal publications, *ex-post* assessments and conference contributions. Although it has both strengths

Box 7.1: Factors identified by participants that will shape the research landscape over the next 5 to 10 years

- Societal impact: both to increase and decrease the emphasis on this factor.
- Reducing pressure and incentives to produce a large number of research outputs in selective journals.
- Incentivising researchers to produce higher quality and new forms of output to engage a more diverse audience.
- Focusing on dissemination and engagement as routes to societal impact.
- Increasing collaborative research.
- Balancing basic and applied research.
- Making research accessible through open science and open access.
- Increasing support for interdisciplinary research.

Box 7.2: Types of support suggested by survey respondents

- Funding to develop research that has societal impact.
- Valuing societal impact and engagement within HEI reward and recognition systems.
- Adjusting workload models and the creation of new roles to take into account work to develop societal impact.
- Changes to policy to address concerns about a culture of audit and the impact of the United Kingdom's changing relationship with the EU.
- Training to develop expertise in engagement, societal impact and new digital methodologies.
- Changes to the academic publishing system to increase openness and improve peer review.
- IT and infrastructure to support openness and collaboration on a global scale.

and weaknesses, there was no expectation from workshop participants, across all three workshops, that its predominance in research assessment will change in the future.

There is, however, an expectation that technological approaches, which already underpin many aspects of peer review, may further support peer review in the future. There are a number of technologies and approaches being developed which span the entire pathway of peer review, from selecting reviewers and allocating items, to scoring, to calibration moderation, validation and decision making, and incentives

However, current technologies are not able to address all the limitations of peer review alone. For example, some areas that participants in the workshop on peer review felt most needed to be addressed, such as equality and diversity issues, may in fact be exacerbated by automation and technological developments if not carefully thought through and adapted when implemented. Additionally, improvements to peer review are likely to require cultural changes, as well as technological changes, and may require additional approaches such as training and incentives

7.6. Considerations for the future

As described above, this study has considered three main questions: why is national research assessment carried out and how might that change in the next 5 to 10 years; how might the research landscape, and in particular the forms of output and the types of impact being produced, change in the next 5 to 10 years; and how might the practicalities of national research assessment change, including what can be learnt from developments in technology being applied to other research assessment processes. Across these questions no disruptive changes that would indicate a large or immediate shift in the research landscape have been identified. Instead there are likely to continue to be gradual changes as current drivers within the system develop alongside developments in the external environments (e.g. technological developments). UK national research assessment is therefore likely to need to continue to remain engaged with the sector and respond to changes as they arise or can be anticipated.

7.6.1. Research assessment needs to continue to consider the diversity of outputs produced by academic research

It is important that national research assessment can shift with the research landscape. The survey indicated an expected increase in diversity of output forms, with the possibility that research projects may produce a 'basket' of outputs that complement each other, rather than one key output (such as a journal article). The vast majority of outputs that have been submitted to research assessment exercises in the United Kingdom (and considered as important and hence used within promotion and hiring decisions) represent a small number of output forms; they are largely journal articles and books, depending on discipline (Table 7.1). Overall, over 80% of output submissions to REF 2014 were journal articles, 8% were chapters in books, 5% were authored books, and all other output forms made up just 6% of the submissions. If the increased diversity of output forms is considered valuable to the system and need assessment, then it may be necessary to consider suitable ways to encourage the submission of these forms of output and ensure appropriate capacity to both assess and ensure confidence in the assessment of these outputs. This is because, as shown in this study, national research assessment and funder requirements and policies are drivers of the forms of output researchers produce.

Table 7.1: The percentage of different output forms submitted to REF 2014 overall and by discipline

	Percentage of different output forms submitted (%)				
Output type	**Medicine, health and life sciences**	**Physical sciences, engineering and mathematics**	**Social sciences**	**Arts and humanities**	**All disciplines**
Authored book	0.08	0.21	7.19	16.52	5.43
Edited book	0.01	0.02	0.82	4.30	1.12
Chapter in book	0.11	0.43	7.91	25.51	7.54
Journal article	99.51	94.41	81.52	40.16	81.09
Conference contribution	0.08	4.26	0.45	0.97	1.44
Patent/published patent application	0.06	0.11	0.00	0.06	0.06
Software	0.00	0.03	0.02	0.03	0.02
Website content	0.01	0.02	0.05	0.31	0.08
Performance	0.00	0.00	0.00	1.24	0.26
Composition	0.00	0.00	0.00	1.70	0.35
Design	0.00	0.00	0.22	0.18	0.10
Artefact	0.00	0.01	0.03	1.80	0.38
Exhibition	0.00	0.02	0.04	3.09	0.65
Research report for external body	0.11	0.06	0.96	0.24	0.36
Devices and products	0.00	0.00	0.00	0.06	0.01
Digital or visual media	0.00	0.00	0.01	1.21	0.25
Scholarly edition	0.00	0.00	0.02	0.89	0.19
Research datasets and databases	0.00	0.00	0.03	0.14	0.04
Other	0.02	0.04	0.09	1.21	0.29
Working paper	0.01	0.36	0.65	0.39	0.35

Source: REF 2019b

Books are the second most common outputs submitted to REF 2014 (Table 7.1). The survey results indicate that books (or book chapters) are still seen by researchers as aspirational outputs that they wish to produce in the future. This sits alongside a smaller number of comments indicating that books are becoming less important and less relevant. The strong desire to produce books (or book chapters) is seen across disciplines and career stages, and assessment will need to continue to consider

how wider assessment policy relates to books/monographs.

7.6.2. It is important to consider the needs of different disciplines when undertaking a nationwide assessment

Across outputs, impacts and drivers, there were more significant differences in the survey between disciplines than between career stages. This was particularly strong for impacts, but also very noticeable for outputs and slightly less noticeable for the drivers of change. This reinforces the importance of considering the needs of different disciplines when making decisions about national research assessment, particularly if that assessment will be applied across all disciplines. It is worth noting that disciplinary differences are not expected to increase, rather that disciplinary differences currently exist, and it is not expected that disciplines will become more similar over time.

7.6.3. Drivers that researchers perceive to be important are generally within the academic system

While the majority of drivers participants were asked about were considered to be important in driving changes in the system, those that were seen as the most important were more inwardly facing academic drivers rather than drivers related to societal impact. For example, emphasis was placed on the need to collaborate, in general and internationally, the need to focus on multidisciplinary research, the need to focus on research integrity, and a drive towards open science. The questions on impact revealed that a high percentage of researchers expect their research to have greater impact in the future, and that they expect to spend some more of their time on impact in the future, although the majority of time will still be spent on outputs. These results show the increased value being placed on societal impact, although this increased value did not emerge as a primary driver of the system as a whole.

While this research shows how researchers think the outputs and impacts of research will change going forwards, and the trends that are driving them, it did not explicitly address whether the direction of change of the research sector is the 'right' direction, and if the changes are desirable. Further research should try to understand the specific impacts of the drivers identified as being of particular importance, which of these impacts and changes are seen as beneficial, and which are seen as less beneficial. This research could also consider the contributions of different stakeholders (e.g. academics, HEIs, funders and charities) to the drivers. This would allow stakeholders within the system to consider how they can encourage beneficial changes, while considering interventions to guard against the effect of changes seen as less beneficial.

7.6.4. National research assessment is an important driver of behaviour for the sector

UK national research assessment needs to continue to consider its own role in the system and how it may drive changes. As the reasons for research assessment shift over time, and more focus is placed on analysis (even if in part due to increased technological capacity to carry out analysis) and adaptation, it is important to acknowledge that research assessment is itself a driver of the research system. While this is exemplified by the behavioural changes that have taken place throughout the research system in the United Kingdom as a result of the introduction of the impact element of the REF, smaller changes to the rules and process of research assessment also influence the system. The existence of the national research assessment also drives the system at an institution and individual

academic level, as can be seen by how universities deploy scores as a measure of acclaim and the inclusion by some institutions of societal impact as a criterion for reward and recognition. Continued research is needed to understand the incentives and effects and ensure that they encourage a positive research environment.

Initially national research assessment will need to choose whether to reduce burden or provide additional data when considering the role of technology in supporting the peer review process. The research has highlighted a number of technologies which could be implemented to support peer review in the context of national research assessment. When considering which of these should be explored it is important to consider the aim of changing systems. A common discussion in the context of national research assessment is burden, and technological developments bring the opportunity to reduce burden on those organising peer review systems, as well as potentially on those undertaking peer review by improving the supporting systems and architecture. However, across the workshops there were concerns regarding whether national research assessment data were fully utilised. In light of the growing emphasis on data use and analysis to help inform future strategies and learn from experiences, it is worth considering whether technological developments could bring opportunities to improve the utility of the system itself and provide more outputs that could be used for analysis and learning. However, there is a risk that this additional information may, in the short term at least, increase the burden of the process. From a practical point of view, it may be necessary to initially prioritise these aims and select only some types of technology to explore. Regardless of the purpose of technology, it should be noted that potential developments highlighted in this work have not been tested for utility within a national research assessment system – pilots and more research would be needed to test the effectiveness of these tools, how much of a difference they would make to the process, and at what cost.

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Annex A. Methodology

A.1. Methodology overview

This study considers the following questions in relation to the current research system and possible changes to the research environment in the next 5 to 10 years:

- Why do we assess research and how might that change in the next 5 to 10 years?
- How do researchers expect the forms of output they are producing to change in the next 5 to 10 years?
- How do researchers expect the types of societal impact their research produces to change in the next 5 to 10 years?
- How do researchers expect the research environment they are in to change in the next 5 to 10 years?
- How could national research assessment exercises learn from developments in peer review?

The methodological approach to this study is broadly summarised in Figure A.1 and Table A.1 below.

Figure A.1: Methodology used in this study

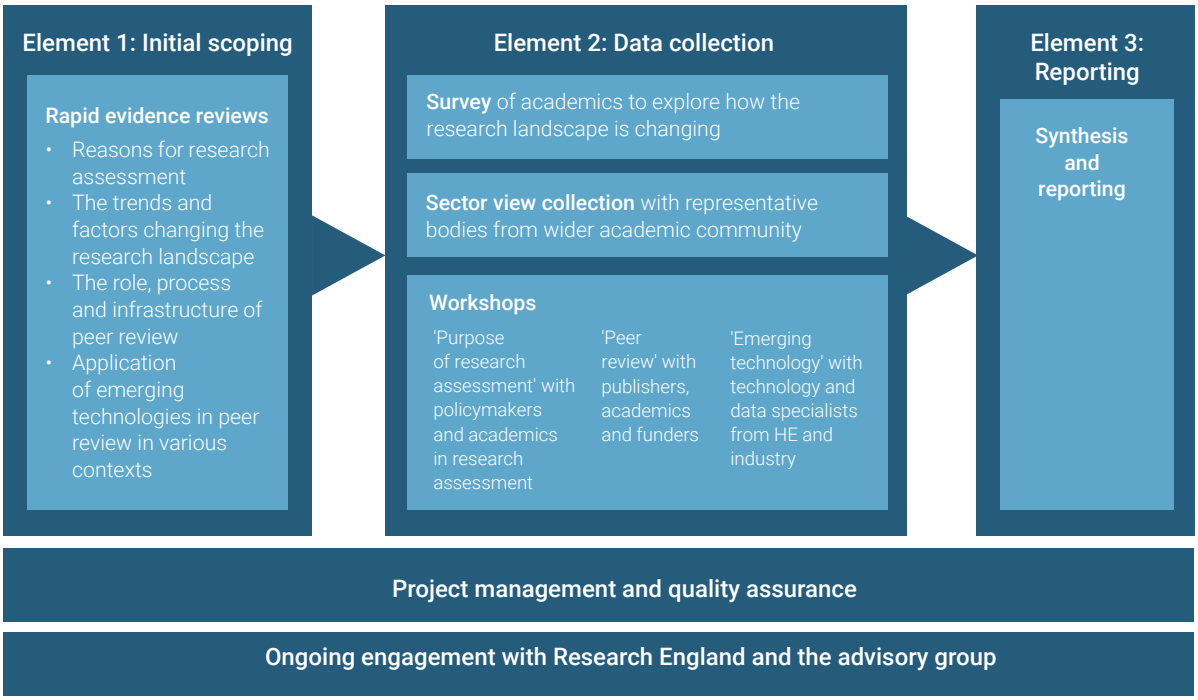


Table A.1: Methods used to address the key questions

		Questions				
		Why do we assess research and how might that change in the next 5 to 10 years?	How do researchers expect the forms of output they are producing to change in the next 5 to 10 years?	How do researchers expect the types of societal impact their research produces to change in the next 5 to 10 years?	How do researchers expect the research environment they are in to change in the next 5 to 10 years?	How could national research assessment exercises learn from developments in peer review?
Rapid evidence assessments	Reasons for research assessment	✓				
	The trends and factors changing the research landscape		✓	✓	✓	
	The role, process and infrastructure of peer review					✓
	Application of emerging technologies in peer review in various contexts					✓
Survey			✓	✓	✓	
Sector view collection		✓	✓	✓	✓	✓
Workshops	'Purpose of research assessment' with policymakers and academics in research assessment	✓				
	'Peer review' with publishers, academics and funders					✓
	'Emerging technology' with technology and data specialists from higher education and industry					✓

A.2. Rapid evidence assessments

This study was informed by four rapid evidence assessments (REAs) that looked at the published and grey literature. These REAs were conducted concurrently at the beginning of the study, and later supplemented with additional publications suggested by workshop participants and key stakeholders. Rapid evidence assessments aim to be rigorous and explicit in method, and thus systematic, however they limit particular aspects of the full systematic review process which provide value for money.

A search strategy for each of the four REAs was developed using key words through an iterative process to ensure that searches would produce informative results to answer the key research question of the REA. Details about the research question and key word search strings for each REA are provided in Box A.1. Each search string was run in Google Scholar and Web of Science, with results limited to the past five years to ensure that they were up-to-date with current trends. For each search string detailed below, the first 100 results in Google Scholar were screened, and those that were relevant were read completely. This initial search was supplemented with targeted searches based on prior knowledge and expertise within the project team, as well as a snowball methodology in which appropriate references were pulled from relevant articles identified in the original searches conducted in Google Scholar and Web of Science. Along with the results of the initial searches, targeted searches and articles retrieved through the snowball technique, the literature review was supplemented with articles suggested by workshop participants (described in Section A.3 below) and other key stakeholders.

Relevant information from each article read completely was extracted into a matrix, which was organised into sub-themes to aid in analysis (sub-themes provided in Box A.1). After information from all articles was extracted in this way, the matrix was read in its entirety and analysed to provide information on the research question for each REA.

A.3. Workshops

The results of the literature review were used to inform three separate workshops, which addressed the topics of the study. During the workshops, stakeholders provided perspectives on developments in research assessment and the research environment. This helped ensure that a wide range of views from across the research system in England were included in the study, and that the findings captured emerging trends not yet published in the literature, which tends to be less future focused. The names of those who attended the workshops is listed in Annex G.

A.3.1. Workshop 1 – Why is research assessed?

The first workshop focused on why research is currently assessed at a national level, and how this may change in the future. It took place in London on 1 February 2019 and was delivered primarily by Research England, with RAND Europe developing the material, the agenda for the workshop and providing secretariat. The workshop included representatives from the government and national funding bodies, organisations that fund research and the higher education sector. There were eight participants (including two who attended via teleconference), along with two representatives from RAND Europe and two representatives from Research England. During the workshop, participants considered findings from the rapid evidence assessment (REA 1, described above) and had the chance to discuss, as a group, why research is assessed.

Box A.1: Search sequence for the rapid evidence assessments

REA 1: Why do we assess research and how is this changing?

Initial search strings:

'Research assessment' OR 'research evaluation' AND '2013-2018'

'Research assessment' AND 'national' AND 'consequence' OR 'purpose'

Total articles read: 36

REA 2: How is the research landscape changing?

Initial search strings:

'international collaboration' AND 'academic research'

'research nation' AND ('future' OR 'change' OR 'trend' OR 'shift' OR 'growth' OR 'rise')

'researcher mobility' AND 'future'

"impact of ('global challenges' OR 'grand challenges') research"

'impact' AND ('open science' OR 'open data' OR 'open access' OR 'citizen science' OR 'altmetrics' OR 'open research' OR 'open research data' OR 'open scientific code' OR 'open scholarly communication')

('research products' OR 'publication format' OR 'altmetrics') AND ('change' OR 'future')

('big data' OR 'artificial intelligence') AND ('research assessment' OR 'measuring research' OR 'quality of research')

('technology' OR 'technological') AND 'change' AND 'research method'

('future' OR 'change') AND ('public funding' OR 'public spending' OR 'public expenditure') AND 'research' AND ('UK' OR 'United Kingdom' OR 'England')

future impact 'trust in science' assessment

('future' OR 'change' OR 'trend' OR 'shift') AND 'academic research' AND ('UK' or 'United Kingdom')

('change' OR 'growth' OR 'trend' OR 'shift' OR 'rise' OR 'future') AND ('open science' OR 'open data' OR 'open access' OR 'citizen science' OR 'open research' OR 'open research data' OR 'open scientific code' OR 'open scholarly communication')

'replication crisis' OR 'reproducibility crisis'

('change' OR 'growth' OR 'trend' OR 'shift' OR 'rise' OR 'future') AND ('open science' OR 'open data' OR 'open access' OR 'citizen science' OR 'open research' OR 'open research data' OR 'open scientific code' OR 'open scholarly communication')

Sub-themes: Global balance, international collaboration, Brexit, open science, role of science, public funding, emerging technology, altmetrics, interdisciplinary research, impact, outputs, commercialisation

Total articles read: 52

REA 3: What is the role, process and infrastructure of peer review in research assessment?

'academic peer review' AND '2015-2018'

'peer review' AND 'academia' AND '2015-2018'

'peer review' AND 'proposal' AND '2015-2018'

'peer review' AND 'conference' AND 'abstract' AND '2015-2018'

'peer review' AND 'grant' AND '2015-2018'

Total articles read: 82

REA 4: What is the role and impact of emerging technologies on research assessment?

Key words used:

'Bibliometric'*, 'text mining', 'machine learning', 'artificial intelligence', 'emerging technology', 'open peer review', 'crowdsource'*, 'blockchain', 'bitcoin', 'distributed ledger'

AND

('Research assessment' OR 'research evaluation' OR 'peer review')

Sub-themes: Bibliometrics, text mining, machine learning and artificial intelligence, peer review, blockchain, crowdsourcing

Total articles read: 39

A.3.2. Workshop 2 – Peer review

The second workshop focused on how peer review is used in research assessment, developments and trends in peer review, and how these may shift in the future. It took place in London on 13 March 2019, and was jointly delivered by Research England and RAND Europe. There were 12 participants along with two representatives from RAND Europe and three representatives from Research England. Attendees included representatives from academia, academic publishing houses and research funders.

Discussions in the workshop focused around the following topics:

- What are the strengths and weaknesses of peer review as a method for research assessment?
- How can developments in the system, including technological developments, seek to address the limitations of traditional peer review?
- What are the opportunities and challenges associated with changes to the peer review process?
- What level of technology do you think would be appropriate for use in peer review as part of national research assessment?
- How might trends, both internal and external to the research system, influence the development of peer review, particularly within national research assessment?

Following the plenary discussion, participants were divided into three groups, each of which was assigned a stage of the peer review process (selecting reviewers and allocating items; scoring; and calibration, moderation,

validation and decision making). Participants were asked to fill in a table to provide information on new developments they were aware of in peer review, as well as their benefits and drawbacks. The tables from the three groups were combined into one table and participants were asked to distribute six voting dots across the different developments they considered most likely to change in the next 5 to 10 years, and those most beneficial to peer review.

A.3.3. Workshop 3 – Emerging technology

The third workshop focused on how emerging technologies may be incorporated into research assessment in the future. It took place in London on 14 March 2019 and was jointly delivered by Research England and RAND Europe. There were 16 participants, including two participants that overlapped with workshop 2 from the previous day.[59] Attendees included participants from the higher education sector, publishing services and experts in emerging technologies.

Discussions in the workshop focused around the following topics:

- What are the strengths and weaknesses of current research assessment processes?
- What are the up-and-coming technologies that will change how research is assessed?
- What are the opportunities and challenges regarding the use of technology in the research assessment processes?
- What level of integration of technology do you think would be appropriate for use in peer review as part of national research assessment?
- How might trends, both internal and external to the research system, influence the development and use of technology in research assessment processes?

As with workshop 2, participants were divided into three groups following the plenary discussion, each of which was assigned a stage of the peer review process (selecting reviewers and allocating items; scoring; and calibration, moderation, validation and decision making). Participants were asked to fill in a table to provide information on any new technologies they were aware of being developed for research assessment, as well as their benefits and drawbacks. The tables from the three groups were combined into one table and participants were asked to distribute six voting dots across the different developments they considered most likely to change in the next 5 to 10 years, and those most beneficial to peer review.

A.4. Survey

A.4.1. Designing and sending the survey

In order to get a broad range of perspectives of how the research environment may shift over the next 5 to 10 years, an online survey of academic researchers in England was conducted. This survey was designed to capture expected changes in research outputs, research impacts and the research environment more broadly, as well as information such as the participant's field of study, career stage, institutional affiliation and gender. The survey protocol is attached in Annex C. It was uploaded to SmartSurvey and consisted mainly of multiple choice questions, with several opportunities for participants to provide open text responses.

The strategy for sending out the survey was to invite HEIs to participate in the study, and

59 In addition, there were three representatives from RAND Europe and three representatives from Research England in attendance.

then send the survey to all researchers at those institutions, including PhD students and postdoctoral researchers. Academic researchers in England were also invited to participate via RAND Europe's Facebook and Twitter pages.

The sample of HEIs invited to participate was obtained by splitting all universities that had made submissions as part of the REF 2014 exercise into groups based on number of staff; eight universities per group were then randomly selected. The sample was checked and redrawn if necessary to ensure that it met the following criteria: one HEI from each of the nine regions in England; no more than one HEI within each group from the same region outside London; no more than two HEIs within the same group from the region of London; at least one mono-technic HEI (submitting to only one unit of assessment (UOA) in REF 2014); at least one HEI that submitted to all UOAs in REF 2014; and a proportionate spread across disciplines (determined using REF2021 UOAs and main panels as a proxy for discipline). Using this strategy, 24 institutions were invited to participate.[60]

Research England sent each institution an email inviting them to participate and requesting a point of contact at the HEI who would liaise with the project team for the study. Of the 24 HEIs invited to participate, 19 accepted the invitation and participated in the study. The point of contact at the HEI was given the option of either sending out the survey link to all researchers at the HEI themselves using an institution-specific link, or providing the project team with a list of contact information for all researchers to send the link directly. All but one institution that participated in the study chose to send out the survey link to their researchers themselves rather than have the project team reach out to researchers, although one institution included the link in their routine newsletter rather than sending the link via email.

The project team provided the point of contact at each HEI with a document that suggested text for the initial invitation to send to researchers at their institution, as well as two reminder messages to be sent out at set intervals while the survey was open. The survey was open for a period of four weeks. So as not to be restrictive, it was also publicised on social media so that researchers from the wider community could participate. Through this route responses from researchers at an additional 44 HEIs across England were received.[61]

60 The HEIs selected within the sample were: The University of Oxford, Queen Mary University of London, University College London, The University of Bristol, The University of Liverpool, The University of Cambridge, University of Nottingham, Newcastle University, The University of Brighton, The University of Derby, Liverpool John Moores University, University of Durham, Leeds Beckett University, Birmingham City University, Kingston University, The University of East Anglia, Goldsmiths College, The Royal College of Music, The University of Bolton, Keele University, Norwich University of the Arts, The University of Chichester, The University of Hull and The University of Northampton.

61 These were Aston University, Bath Spa University, Birkbeck College, Birmingham City University, Bournemouth University, Coventry University, Cranfield University, Edge Hill University, King's College London, Leeds Arts University, Liverpool John Moores University, London School of Hygiene and Tropical Medicine, Loughborough University, Middlesex University, Oxford Brookes University, Royal Holloway and Bedford New College, St George's, University of London, The Institute of Cancer Research, The Open University, The University of Bath, The University of Birmingham, The University of Bradford, The University of Central Lancashire, The University of Exeter, The University of Greenwich, The University of Kent, The University of Lancaster, The University of Leicester, The University of Manchester, The University of Portsmouth, The University of Reading, The University of Sheffield, The University of Southampton, The University of Westminster, The University of Winchester, The University of Wolverhampton, The University of Chester, The University of Cumbria, The University of Durham, The University of Hertfordshire, The University of London (Institutes and activities), The University of Northumbria at Newcastle, The University of Worcester, The University of York

Table A.2: Open response question coding

Question text	Number of responses	Number of references coded	Number of categories	Method for coding
Do you expect a change in the type of outputs you are producing in the next 5 to 10 years? If yes, please explain below.	1,072	2,068	87	Excel
In an ideal world, would you choose to produce different types of outputs from those you have selected above? If you answered yes to Question 8, what would they be and why would you choose to produce them instead?	640	1,574	87	Excel
Do you anticipate that the type of impacts that your work might contribute to will change in the next 5 to 10 years and why?	1,863	3,146	40	Excel
Given the changes you foresee in the outputs and impacts you produce (if any), how do you think the research environment needs to adapt to support these changes?	1,930	5,491	244	NVivo

A.4.2. Survey analysis

In total, 3,768 responses[62] were received and included in the survey analysis. Quantitative analysis of the survey results was conducted in R. Results were analysed to test if there were significant differences in current and expected future research outputs and impacts, and to look at drivers of change that researchers identified as important within the research landscape. Sub-group analyses were conducted to look at how responses differed between disciplines (determined by REF 2021 main panels) and career stage using chi-squared tests.

Four open response questions were analysed qualitatively using NVivo and Excel. The codebooks for the qualitative analysis are provided in Annex E. There were 1,930 free text responses to the question 'Given the changes you foresee in the outputs and impacts you produce (if any), how do you think the research environment needs to adapt to support these changes?' This resulted in 5,491 references being coded into 244 codes in NVivo. However, many of these codes were at a high level, and did not have any references coded to them. NVivo was chosen to analyse this question based on the broad range of ideas that respondents expressed through their open text responses, although Excel was used for the other questions to make analysis more efficient. An overview of coding processes is provided in Table A.2 above, which provides information on the number of responses, number of references and number of categories used for coding, as well as the coding method used.

62 Responses have been defined as those researchers who answered at least one question related to outputs, impacts or the research environment.

Once the open text responses were coded, all references within codes with a large number of coded references were reread to understand the body of responses as a whole. Codes identified as often being coded into the same category were read together.

A.5. Collection of sector views

Representative bodies from the wider academic community were invited to respond to a collection of views, which asked representatives to provide their views on how they thought research outputs, impacts and the research environment would change over the next 5 to 10 years, and to comment on factors that may be driving these changes.[63] They were also asked how research assessment might adapt and how specific groups would be affected by changes in the research landscape. These questions were uploaded to SmartSurvey, although responses were also accepted via email.

The collection of views was originally going to be left open for eight working days, however, to allow further participation following a low response, the deadline was extended a further ten days. In this time, three responses to the collection of views were received. One late response was received via email and is included in the analysis.

A.6. Analysis and reporting

An internal team workshop was held to identify cross-cutting themes across the three phases. Analysis focused on the changes to the research produced as a result of changes emerging in the research environment across the United Kingdom, and how research assessment can be supported by technological and cultural developments. Key findings for each phase, as well as for the overall project, were identified, and a narrative was developed and presented to the advisory group and Research England on 1 May 2019 for input and feedback.

63 These were Higher Education Race Action Group, Association of Research Managers and Administrators (ARMA), Universities UK, GuildHE, Advance HE, Scottish Library and Information Council, Research Libraries UK, UK Research Integrity Office (UKRIO), Royal Society, British Academy, Society of College, National and University Libraries (SCONUL) and Jisc.

Annex B. Survey respondent demographics

This annex presents a description of the types of respondent who responded to the survey based on demographic data collected at the beginning and end of the survey (See Annex C for survey protocol). The survey was not specifically designed to collect a fully representative sample of researchers from across the United Kingdom, but rather to collect a diverse range of views.

In total there were 3,768 respondents to the survey. Respondents have been defined as those researchers who answered at least one question related to outputs, impacts or the research environment. Demographic questions specifically required for the analysis were asked at the beginning of the survey, while additional demographic questions were asked at the end of the survey. Due to a drop off in respondents across the survey, which is to be expected, there are fewer respondents who answered demographic questions at the end of the survey than at the beginning.

B.1. Career stage

At the beginning of the survey, respondents were asked how they would define their career stage. The options were: PhD student, early-career research, mid-career researcher, established researcher and retired or emeritus researcher. Figure B.1 shows the distribution of respondents across career stages. In general, there were similar numbers of respondents from each career stage, with the exception of retired or emeritus researchers, for which a lower number of respondents was expected.

B.2. Universities

Respondents were asked to select the institution that represented their primary affiliation from a drop-down list of institutions that submitted to REF 2014, or by selecting 'other' and writing their primary affiliation in an open text response. Some 89% of responses came from HEIs within the sample of 19 HEIs, and 11% from outside the sample. Table B.1 shows the number of respondents from each HEI within the sample, and Table B.2 shows the number of respondents from HEIs outside the sample. In addition, 43 respondents did not provide an affiliation, and 26 classified themselves as 'other'.

There was representation from all regions of England, with a skew towards some areas (particularly in the East of England). This is likely due to a high response rate from the University of Cambridge and a very low response from University College London. The smallest number of responses from any particular region was 94 from Yorkshire and the Humber. There were at least 100 respondents from each region, with many regions greatly exceeding this number.

Figure B.1: Career stage of respondents

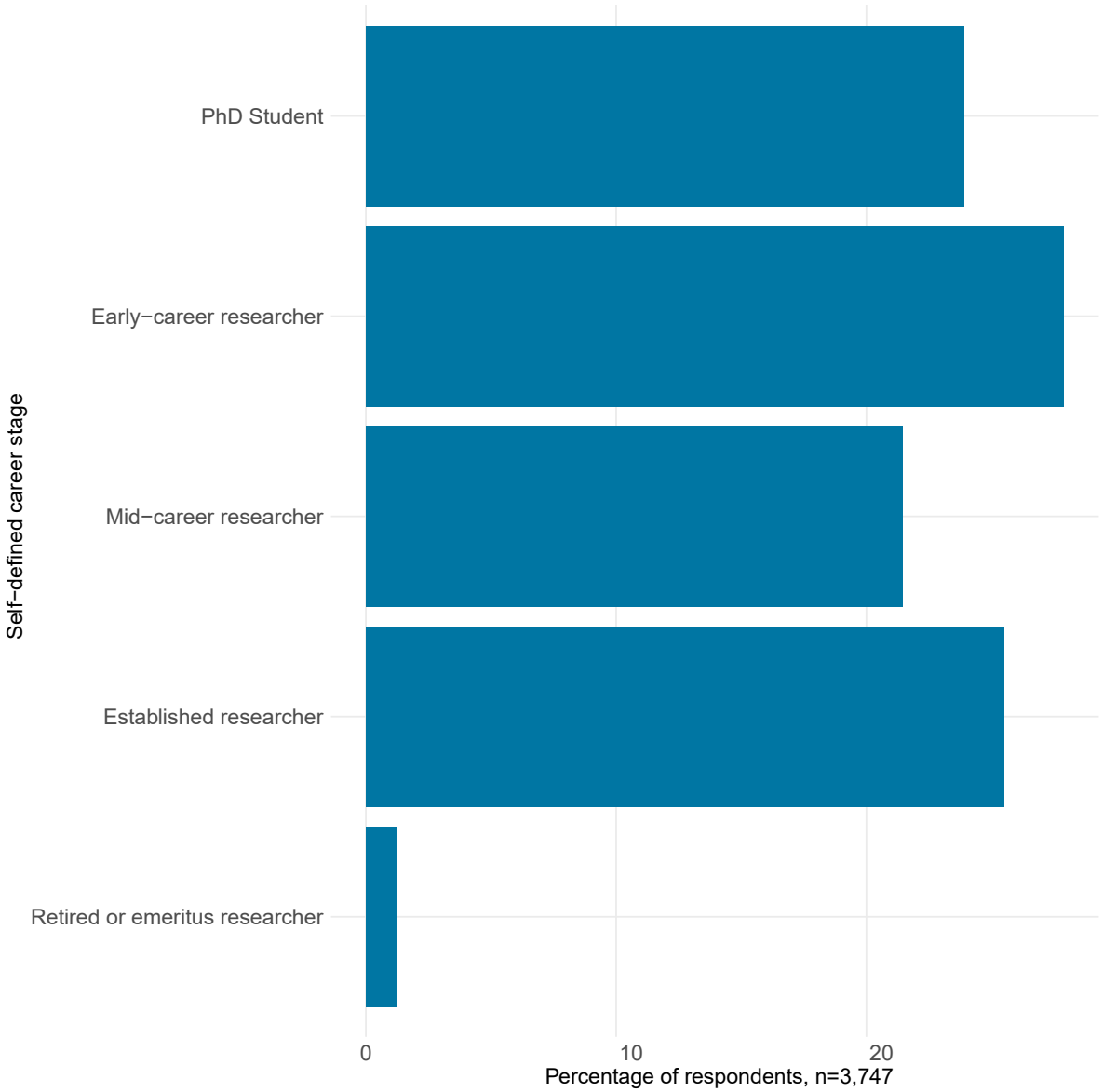


Table B.1: Number of respondents from each HEI within the sample

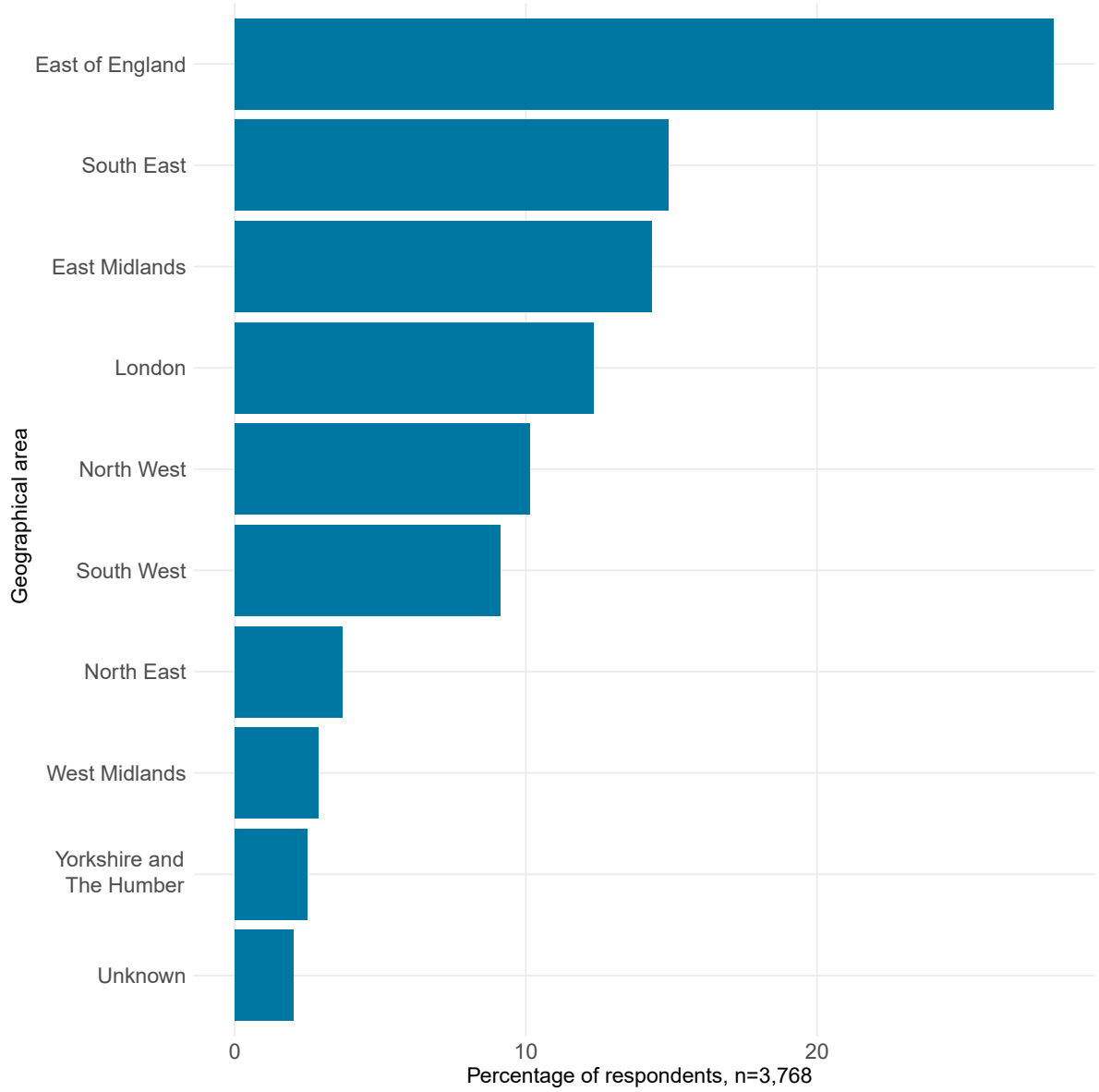
Higher education institution	Number of respondents
Goldsmiths College	56
Keele University	96
Kingston University	130
Newcastle University	67
Queen Mary University of London	202
Royal College of Music	9
The University of Bolton	34
The University of Brighton	133
The University of Bristol	270
The University of Cambridge	925
The University of Chichester	24
The University of East Anglia	113
The University of Hull	74
The University of Liverpool	294
The University of Northampton	2
The University of Oxford	385
University College London	10
University of Derby	21
University of Nottingham	513

Table B.2: Number of respondents from HEIs outside of the sample

Higher education institution	Number of respondents
Aston University	1
Bath Spa University	41
Birkbeck College	2
Birmingham City University	1
Bournemouth University	7
Coventry University	2
Cranfield University	8
Edge Hill University	1
King's College London	3
Leeds Arts University	1
Liverpool John Moores University	1

Higher education institution	Number of respondents
London School of Hygiene and Tropical Medicine	1
Loughborough University	3
Middlesex University	1
Oxford Brookes University	6
Royal Holloway and Bedford New College	1
St George's, University of London	5
The Institute of Cancer Research	20
The Open University	1
The University of Bath	24
The University of Birmingham	5
The University of Bradford	18
The University of Central Lancashire	27
The University of Exeter	2
The University of Greenwich	18
The University of Kent	1
The University of Lancaster	10
The University of Leicester	1
The University of Manchester	11
The University of Portsmouth	2
The University of Reading	5
The University of Sheffield	2
The University of Southampton	1
The University of Westminster	7
The University of Winchester	2
The University of Wolverhampton	1
The University of York	1
University of Chester	3
University of Cumbria	1
University of Durham	66
University of Hertfordshire	14
University of London (Institutes and activities)	5
University of Northumbria at Newcastle	6
University of Worcester	2

Figure B.2: Geography of respondents



B.3. Disciplines

Respondents were asked to select the main research area that best describes their work, along with a selection of all research areas in which they work. Respondents were able to select research areas that represented the 34 REF 2021 units of assessment (described in Annex F, Table F.1), which were then grouped into Main Panels A, B, C and D according to REF 2021 main panels.[64] Respondents were classified to a UOA and main panel based on

64 Main panel A: medicine, health and life sciences; Main Panel B: physical sciences, engineering and mathematics; Main Panel C: social sciences; and Main Panel D: arts and humanities.

the main research area they provided. They were classified as interdisciplinary if they provided multiple main research areas.

Table B.3 shows the percentage of respondents from each UOA. There were respondents from all REF2021 UOAs, although the proportion varied. A particularly strong response was received from researchers from UOA 5 (579 respondents, 15% of all responses) and UOA 4 (291 respondents, 8% of all responses), which correspond with biological sciences and psychology, and psychiatry and neuroscience, respectively. At the main panel level, 37% of respondents came from Main Panel A, 25% from Main Panel B, 18% from Main Panel C and 15% from Main Panel D.

In terms of subject area, more responses were received from main panels A and B compared to C and D, although all main panels had more than 500 respondents.

Main Panel A and Main Panel B have a higher percentage of responses from PhD students and early-career researchers (53% and 58%, respectively), and Main Panel C and Main Panel D have a higher percentage of respondents from mid-career and established researchers (52% and 53%, respectively) (Table B.4). Main Panel B also has a much higher percentage of respondents who are male than other main panels (Table B.5).

Table B.3: Respondents from each UOA

Main Panel	UOA	Percentage of responses
Main Panel A	1	3.8%
	2	4.8%
	3	2.4%
	4	7.7%
	5	15.4%
	6	1.8%
Main Panel C	13	1.2%
	14	1.5%
	15	1.3%
	16	1.5%
	17	2.7%
	18	1.3%
	19	1.6%
	20	0.5%
	21	1.4%
	22	0.8%
	23	2.5%
	24	0.5%
Main Panel B	7	2.8%
	8	3.4%
	9	5.8%
	10	3.2%
	11	3.3%
	12	5.6%
Main Panel D	25	0.4%
	26	1.8%
	27	2.9%
	28	3.3%
	29	0.7%
	30	0.9%
	31	0.6%
	32	1.6%
	33	1.6%
	34	0.8%
Other		2.8%
Interdisciplinary		5.5%

Units of Assessment (UOA) are listed in Annex F, Table F.1.

Table B.4: Percentage of respondents across career stages for each main panel

Discipline	PhD Student	Early-career researcher	Mid-career researcher	Established researcher	Retired or emeritus researcher
Main Panel A	23%	30%	22%	23%	1%
Main Panel B	29%	29%	17%	24%	1%
Main Panel C	21%	25%	24%	28%	2%
Main Panel D	21%	24%	24%	29%	1%
Interdisciplinary	22%	27%	20%	30%	1%
Total	**24%**	**28%**	**21%**	**25%**	**1%**

Due to rounding the total does not add to 100%

Table B.5: Gender distribution of respondents for each main panel

Discipline	Female	Male	Other or unknown
Main Panel A	42%	36%	22%
Main Panel B	19%	55%	26%
Main Panel C	42%	40%	18%
Main Panel D	44%	34%	22%
Interdisciplinary	42%	29%	29%
Total	**36%**	**41%**	**23%**

Annex C. Survey protocol

See overleaf.

National Research Landscape Survey

Introduction

Research England is interested in understanding how researchers think the research landscape (i.e. research outputs, impacts and the research environment) might change over the next 5 to 10 years, in order to inform their planning for future research assessment (post 2021). This survey is intended to collect information on these issues and is part of a wider study being conducted by RAND Europe (https://www.rand.org/randeurope.html) on behalf of Research England.

This survey is for researchers within English Higher Education Institutions (HEIs).

It should take 8-12 minutes to complete. We are very grateful for your participation.

If you have any questions about the survey please contact the RAND Europe project team at research_landscape_survey@rand.org (mailto:research_landscape_survey@rand.org).

Privacy Notice

About the project
RAND Europe has been commissioned by Research England to conduct a study of how the research landscape in the UK will change in the next 5-10 years in order to inform how research assessment may need to adapt. This document describes a survey of academic researchers being carried out as part of the study.

Who is conducting this research?
RAND Europe is a not-for profit research Institute based in Cambridge. They have been commissioned by Research England (UK Research and Innovation) to carry out this study, who are the data controller for any data you submit. The research team is led by Dr Catriona Manville.

What data are we collecting?
RAND Europe is collecting information on the research landscape now, as well as how you think

it will develop over the next 5-10 years. It will also collect demographic information including: the number of years you have been conducting research, your research area, your institution, your career stage, your age, your gender, your ethnicity and whether you have a disability. We are not collecting email addresses or names. RAND Europe and Research England will not use the information you submit to identify you.

How are we collecting the data?
The data will be collected through a survey hosted on SmartSurvey. The data will be stored on SmartSurvey and then downloaded to RAND Europe servers where it will be stored in password protected folders. Only SmartSurvey and the research team at RAND Europe carrying out the study will have access to your data.

Why are we collecting it?
The purpose of the study is to better understand how research, the research environment and its outputs are developing and may change over time. This study is part of a programme of work that Research England have commissioned to explore the research assessment landscape. The study involves a survey of the academic population focusing on how they feel the research landscape may change, and what is driving these changes.

What is the legal basis for processing your data?
Your data will be processed in accordance with the General Data Protection Regulation 2016 (GDPR). All information collected will be treated as sensitive. Personal data and sensitive data including demographic information such as gender, ethnicity, disability and age inform the research. We are required by law to ensure that we protect this information, the use of the data is considered a task in the public interest. In doing so RAND Europe and Research England (UKRI) recognise the need to ensure your privacy and in doing so will not include any personal identifiers. No attempt will be made to combine the information you have provided in order to identify you and in doing so your data is pseudoanonymised. In doing so RAND Europe and Research England recognise the need to ensure your privacy and in doing so will not include any personal identifiers. No attempt will be made to combine the information you have provided in order to identify you and in doing so your data is pseudoanonymised.

What are we using the data for?
Responses will be analysed and aggregated to inform a report to be presented to Research England and published.

How will we be sharing the data?
Data will be aggregated and reported to Research England in a report which will also be published. Within the report, some quotes may be used from free text responses. These will be presented anonymously. Research England has instructed that access to the survey data be limited to the research team based at RAND Europe and destroyed on completion of the research.

How do we keep your data secure?
RAND Europe has implemented a company wide Information Security Management System (ISMS). RAND Europe is accredited for ISO 27001 certification and Cyber Essentials Plus. We have a senior management team that supports the continuous review and improvement of the company ISMS.

Key controls RAND Europe has implemented include:

An Information Security Risk Assessment Process that assesses the business harm likely to result from a security failure and the realistic likelihood of such a failure occurring in the light of prevailing threats and vulnerabilities, and controls currently implemented.
An Information Classification and Handling Policy including compliance with regulations under the Data Protection Act to protect client, partner, supplier, our own and personal employee information which is not in the public domain.
A Business Continuity Plan to counteract interruptions to business activities and to protect critical business processes from the effects of major failures or disasters.
Defined security-controlled perimeters and access to controlled offices and facilities to prevent unauthorised access, damage and interference to business premises and information and data that might be held there.
Mandatory Information security awareness guidance for all company employees.
Background screening of all company employees

Data will be held on a server located in RAND Europe's Cambridge, UK office. Only the research team will have access to the data. Backups taken for disaster recovery purposes will be encrypted and stored in a secure offline site.

How long do we keep your data?
Your data will be destroyed after the research is completed and the project published.

What choices do you have in our use of your data?
You are able to request deletion of any data supplied although identification is only possible through re-provision of all your data.

What are your rights?
RAND Europe operates in accordance with the Data Protection Act 2018 and GDPR. You are provided with certain rights that you may have the right to exercise through us. Your data is pseudoanonymised at the point of receipt and thereafter shall not be made identifiable as instructed by Research England. You are entitled to request your data's deletion through contacting Research England at researchpolicy@re.ukri.org (mailto:researchpolicy@re.ukri.org) whilst the study is underway. We note that to exercise this right you will need to provide all data originally provided to facilitate identification of your records as no personal identifiers are retained in this project.

How do you contact us?
If you have any questions about the survey or the study please contact RAND Europe (research_landscape_survey@rand.org (mailto:research_landscape_survey@rand.org)) or Research England (Charlotte.Lester@re.ukri.org (mailto:Charlotte.Lester@re.ukri.org)).

If you wish to raise concerns independently of the study team please contact RAND Europe (REdpo@rand.org (mailto:REdpo@rand.org)) or Research England (researchpolicy@re.ukri.org (mailto:researchpolicy@re.ukri.org)).

Demographics

1. Do you conduct academic research as part of your current job? *

Thank you

Thank you for your interest in this survey. However, the questions are intended for those undertaking research as part of their current role as we are trying to gather data and information to inform understanding of potential changes in UK research.

Demographics (cont.)

2. How many years have you been conducting research, including postgraduate/PhD study?

- [ ] 0-5 years
- [ ] 6-10 years
- [ ] 11-15 years
- [ ] 16-20 years
- [ ] 21-25 years
- [ ] 26-30 years
- [ ] 31-35 years
- [ ] 36-40 years
- [ ] 41-45 years
- [ ] 45-50 years
- [ ] 51+ years

3. Which of the following best describes your research area? Please select all those that apply and then the research area that you mainly associate yourself with.

	All research areas you work in	Main research area (Please select only 1 area)
Clinical Medicine	☐	☐
Public Health, Health Services and Primary Care	☐	☐

	All research areas you work in	Main research area (Please select only 1 area)
Allied Health Professions, Dentistry, Nursing and Pharmacy	☐	☐
Psychology, Psychiatry and Neuroscience	☐	☐
Biological Sciences	☐	☐
Agriculture, Veterinary and Food Science	☐	☐
Earth Systems and Environmental Sciences	☐	☐
Chemistry	☐	☐
Physics	☐	☐
Mathematical Sciences	☐	☐
Computer Science and Informatics	☐	☐
Engineering	☐	☐
Architecture, Built Environment and Planning	☐	☐
Geography and Environmental Studies	☐	☐
Archaeology	☐	☐
Economics and Econometrics	☐	☐
Business and Management Studies	☐	☐
Law	☐	☐
Politics and International Studies	☐	☐
Social Work and Social Policy	☐	☐
Sociology	☐	☐
Anthropology and Development Studies	☐	☐
Education	☐	☐
Sport and Exercise Sciences, Leisure and Tourism	☐	☐
Area Studies	☐	☐
Modern Languages and Linguistics	☐	☐
English Language and Literature	☐	☐
History	☐	☐
Classics	☐	☐

	All research areas you work in	Main research area (Please select only 1 area)
Philosophy	☐	☐
Theology and Religious Studies	☐	☐
Art and Design: History, Practice and Theory	☐	☐
Music, Drama, Dance, Performing Arts, Film and Screen Studies	☐	☐
Communication, Cultural and Media Studies, Library and Information Management	☐	☐
Other (Please explain below)	☐	☐

If you selected other, please provide an explanation

4. Which of these institutions is your primary affiliation?

If you selected none, please provide information below

5. How would you define your career stage?

- ☐ PhD Student
- ☐ Early-career researcher
- ☐ Mid-career researcher
- ☐ Established researcher
- ☐ Retired or emeritus researcher

Research Outputs

6. What type of outputs are you currently producing and what type of outputs are you planning to produce in the next 5 to 10 years?

	Please select all those you are producing **now**	Please select all the types you may produce **in the next 5 to 10 years**
Authored book	☐	☐
Edited book	☐	☐
Chapter in book	☐	☐
Scholarly edition	☐	☐
Journal article	☐	☐
Conference contribution	☐	☐
Working paper	☐	☐
Artefact	☐	☐
Devices and products	☐	☐
Exhibition	☐	☐
Performance	☐	☐
Patent/ published patent application	☐	☐
Composition	☐	☐
Design	☐	☐
Research report for external body (non-confidential)	☐	☐
Confidential report for external body	☐	☐
Software	☐	☐
Website content	☐	☐
Social media content and blogs	☐	☐
Digital or visual media	☐	☐
Research datasets and databases	☐	☐
Preprint	☐	☐
Analysis plan/ research protocol/ pre-registration	☐	☐
Code	☐	☐
Slide deck	☐	☐
Openly published peer review	☐	☐
Crowdsourced paper	☐	☐
Podcast	☐	☐
Video	☐	☐
Editorial	☐	☐
Book review	☐	☐
Data visualisation	☐	☐

	Please select all those you are producing **now**	Please select all the types you may produce **in the next 5 to 10 years**
Other (provide details below)	☐	☐

If you selected other, please provide details below:

7. Do you expect a change in the type of outputs you are producing in the next 5-10 years?

- ☐ Yes
- ☐ No

If yes, please explain below:

8. In an ideal world, would you choose to produce different types of outputs from those you have selected above?

- ☐ Yes
- ☐ No

9. If you answered yes to Question 8, what would they be and why would you choose to produce them instead?

Research outcomes/impacts

10. What types of impacts might you reasonably expect your research to lead to now and what type of impacts do you think your research might lead to in the next 5 to 10 years?

	Please select all those you might reasonably expect your research to lead to **now**	**Please select all those** you might reasonably expect your research to lead to **in the next 5 to 10 years**
Impact on the economy *Examples (including, but not limited to): Generating revenue; improving processes; opening up new markets; creating employment in industry; generating revenue through books, materials or events; attracting capital investment to the region; contributing to the digital economy; enabling companies to access new markets; creating new products which are now sold.*	☐	☐
Impact on social cohesion *Examples (including, but not limited to): Conflict reduction, improving equity, alleviating inequalities, strengthening civic participation*	☐	☐
Impact on education and training *Examples (including, but not limited to): Changing curricula; improving training materials, text books or other teaching resources; creating materials for specialised teaching contexts; changing the structure of a course; increasing access to education; improving educational outcomes*	☐	☐

	Please select all those you might reasonably expect your research to lead to **now**	**Please select all those** you might reasonably expect your research to lead to **in the next 5 to 10 years**
Impact on the environment *Examples (including, but not limited to): Reducing pollution levels; improving measures of environmental conditions; contributing to conservation; improving waste management, environmental efficiency or environmental management; reducing the depletion of a natural resource; developing adaptations to environmental conditions/changes*	☐	☐
Impact on legal systems *Examples (including, but not limited to): Improving the efficiency of the legal process, setting a legal precedent, improved access to legal counsel, improving the quality of evidence underpinning a legal decision*	☐	☐
Impact on safety and security *Examples (including, but not limited to): Improving infrastructure security/resilience; improving policing/security practices; creating new tools for police, safety and security services; improving safety in workplace, at home or in other settings*	☐	☐

	Please select all those you might reasonably expect your research to lead to **now**	**Please select all those** you might reasonably expect your research to lead to **in the next 5 to 10 years**
Impact on health and wellbeing *Examples (including, but not limited to): Improving health outcomes; changing healthcare practice; improving health equity; increasing patient/user choice; increasing access to health services; improving the management of healthcare performance; improving patient/user satisfaction*	☐	☐
Impact on policy and public services *Examples (including, but not limited to): Informing policy debate with the general public, in a government body, or at a non-governmental organisation; increasing public engagement with the policy process; improving efficiency of or access to public services; improving the equity of public service provision*	☐	☐
Impact on public engagement, awareness and perceptions *Examples (including, but not limited to): Shaping the nature of public debate; increasing public engagement with research findings; increasing public awareness; creating publicly available tools or resources*	☐	☐

	Please select all those you might reasonably expect your research to lead to **now**	**Please select all those** you might reasonably expect your research to lead to **in the next 5 to 10 years**
Impact on culture *Examples (including, but not limited to): Improving the quality of cultural events/activities or the evidence underpinning it; contributing to or improving public debate; improving attendance at cultural events; preserving cultural heritage; increasing engagement of cultural activities; improving understanding of cultural heritage; enriching cultural experiences.*	☐	☐
Other (provide details below)	☐	☐

If you selected other, please provide details below:

11. Do you anticipate that the type of impacts that your work might contribute to will change in the next 5-10 years and why?

Balance of outputs and impact

12. What is the balance of effort you currently spend on outputs versus impacts?

0% is all effort is on **impacts** and 100% is all effort is on **outputs**

13. In the next 5 to 10 years, what is the balance of effort you plan to spend on outputs versus impacts?

0% is all effort is on **impacts** and100% is all effort is on **outputs**

Research and the environment

14. Given the changes you foresee in the outputs and impacts you produce (if any), how do you think the research environment needs to adapt to support these changes?

Drivers of change

15. How important are the following factors in driving the changes you foresee in the next 5 to 10 years?

	This factor is not important in driving the changes	*This factor is somewhat important in driving the changes*	*This factor is very important in driving the changes*	*Unsure*
Importance of collaborating with other academic researchers *(e.g. collaborating rather than working alone)*	☐	☐	☐	☐
Importance of collaborating globally with other academic researchers *(e.g. collaborating with researchers in other countries)*	☐	☐	☐	☐

	This factor is not important in driving the changes	*This factor is somewhat important in driving the changes*	*This factor is very important in driving the changes*	*Unsure*
Importance of collaborating with industry	☐	☐	☐	☐
Importance of collaborating with non-academic partners (excluding industry) *(e.g. charities, non-governmental organisations, museums, etc.)*	☐	☐	☐	☐
Importance of being mobile as a researcher *(e.g. travelling to other countries for short or long term visits)*	☐	☐	☐	☐
Shift in global research balance *(e.g. change in which countries produce the most or best research)*	☐	☐	☐	☐
Emergence of new professional roles in academia	☐	☐	☐	☐
Open science *(e.g. open access, open data, open code, etc.)*	☐	☐	☐	☐
Citizen science *(e.g. the involvement of the public in research)*	☐	☐	☐	☐
Focus on inclusion and diversity	☐	☐	☐	☐
Focus on research integrity	☐	☐	☐	☐
Focus on research into global challenges *(e.g. ageing society, food security, etc.)*	☐	☐	☐	☐
Focus on multidisciplinary research	☐	☐	☐	☐

	This factor is not important in driving the changes	*This factor is somewhat important in driving the changes*	*This factor is very important in driving the changes*	*Unsure*
Changes in how research is assessed *(e.g. assessment of research excellence)*	☐	☐	☐	☐
Focus on accountability*(e.g. demonstrating that publicly funded research is valuable)*	☐	☐	☐	☐
Focus on the non-academic impact of research	☐	☐	☐	☐
Increasing investment in some areas of research	☐	☐	☐	☐
Decreasing investment in some areas of research	☐	☐	☐	☐
The value placed on research by society	☐	☐	☐	☐
The use of metrics (e.g. citation measures) in understanding research	☐	☐	☐	☐
Other (Please describe below)	☐	☐	☐	☐

If you provided another driver of change, please describe below

Additional demographic questions

16. How old are you?

- ☐ Under 21
- ☐ 21- 30
- ☐ 31-40
- ☐ 41-50

- [ ] 51-60
- [ ] 61-70
- [ ] Over 70

17. How would you describe your gender?

- [ ] Male
- [ ] Female
- [ ] Other
- [ ] Prefer not to say

18. What is your ethnicity?

If you selected other, please specify:

19. The Equality Act 2010 considers a person disabled if: You have a physical or mental impairment or disability that has lasted or is likely to last at least 12 months, and this condition or disability has a substantial long-term effect on your ability to carry out day to day activities. Do you consider yourself disabled?

- [ ] Yes
- [ ] No
- [ ] Prefer not to say

Final comments

If there are any other comments you think should be considered within this study please provide them below.

Annex D. Sectoral views questions

See overleaf.

National Research Landscape - Organisational Views

Introduction

Research England is interested in understanding how the research landscape (i.e. research outputs, impacts and the research environment) might change over the next 5 to 10 years, in order to inform their planning for future research assessment (post 2021). This evidence gathering is intended to collect information on these issues and is part of a wider study being conducted by RAND Europe (https://www.rand.org/randeurope.html) on behalf of Research England.

We are very grateful for your participation.

If you have any questions please contact the RAND Europe project team at research_landscape_survey@rand.org (mailto:research_landscape_survey@rand.org) or Research England at Charlotte.Lester@re.ukri.org (mailto:Charlotte.Lester@re.ukri.org).

Privacy Notice

About the project
RAND Europe has been commissioned by Research England (one of the councils within UK Research and Innovation) to conduct a study of how the research landscape in the UK will change in the next 5-10 years in order to inform how research assessment may need to adapt. This document describes a request for views on the developing research landscape being carried out as part of the study.

Who is conducting this research?
RAND Europe is a not-for profit research Institute based in Cambridge. They have been commissioned by Research England (UK Research and Innovation) to carry out this study, who are the data controller for any data you submit. The research team is led by Dr Catriona Manville.

Research England is responsible for funding, engaging with and understanding English higher education institutions (HEIs). Research England is formed of the Research and Knowledge Exchange functions of the former HEFCE. This includes oversight of the Research Excellence Framework (REF) and the UK Research Partnership Investment Fund (UKRPIF).

What data are we collecting?
RAND Europe is collecting information on how organisations supporting the academic community think the research landscape will develop over the next 5-10 years. It will collect your organisational affiliation, IP addresses and email address for the purpose of this study.

How are we collecting the data?
The data will be collected through a survey hosted on SmartSurvey. The data will be stored on SmartSurvey and then downloaded to RAND Europe servers where it will be stored in password protected folders. Only SmartSurvey and the research team at RAND Europe carrying out the study will have access to your personal data.

Why are we collecting it?
This survey involves an opportunity for input from organisations, such as yourselves to provide views on how you feel the research landscape may change, and what is driving these changes. We will collect two pieces of personal data: your email address in order to be able to contact you for any clarifications and to send you a copy of the final report, and your IP address (which is collected automatically in the process of accessing the online survey and may be used to verify the response is unique).

What is the legal basis for processing your data?
Your data will be processed in accordance with the Data Protection Act 2018 and the General Data Protection Regulation. We are required by law to ensure that we protect this information, the use of the data is considered a task in the public interest. RAND Europe and Research England recognise the need to ensure your privacy and will minimise the use of personal identifiers.

What are we using the data for?
The organisational affiliation will allow us to compare and contrast responses with similar organisations. Your email address will be collected in order to allow the research team be able to contact you for any clarifications and to send you a copy of the final report, and your IP address (which is collected automatically in the process of accessing the online survey) may be used to verify the response is unique. Responses will be analysed and aggregated to inform a report to be presented to Research England and published.

How will we be sharing the data?
Research England (UKRI) has instructed that access to personal data be limited to SmartSurvey and RAND Europe.

How do we keep your data secure?
RAND Europe has implemented a company wide Information Security Management System (ISMS). RAND Europe is accredited for ISO 27001 certification and Cyber Essentials Plus. We have a senior management team that supports the continuous review and improvement of the company ISMS.

Key controls RAND Europe has implemented include:

An Information Security Risk Assessment Process that assesses the business harm likely to result from a security failure and the realistic likelihood of such a failure occurring in the light of prevailing threats and vulnerabilities, and controls currently implemented.
An Information Classification and Handling Policy including compliance with regulations under the Data Protection Act to protect client, partner, supplier, our own and personal employee information which is not in the public domain.
A Business Continuity Plan to counteract interruptions to business activities and to protect critical business processes from the effects of major failures or disasters.
Defined security-controlled perimeters and access to controlled offices and facilities to prevent unauthorised access, damage and interference to business premises and information and data that might be held there.
Mandatory Information security awareness guidance for all company employees.
Background screening of all company employees

Data will be held on a server located in RAND Europe's Cambridge, UK office. Only the research team will have access to the data. Backups taken for disaster recovery purposes will be encrypted and stored in a secure offline site.

How long do we keep your data?
Your data will be destroyed after the research is completed and the project published.

What choices do you have in our use of your data?
You are able to request deletion of any data supplied whilst the study is underway.

What are your rights?
RAND Europe operates in accordance with the Data Protection Act 2018 and GDPR. You are provided with certain rights that you may have the right to exercise through us. You are entitled to request your data's deletion through contacting Research England at researchpolicy@re.ukri.org (mailto:researchpolicy@re.ukri.org) whilst the study is underway.

How do you contact us?
If you have any questions about the use of your personal data in this study please contact Research England (researchpolicy@re.ukri.org (mailto:researchpolicy@re.ukri.org)) or RAND Europe (REdpo@rand.org (mailto:REdpo@rand.org)).

Demographics

1. What organisation are you responding on behalf of? *

2. What is your email address?

3. How do you expect the types of outputs and impacts of research to change over the next 5-10 years? (i.e. what different types of outputs or impacts might be produced and how might the balance of outputs and impacts change from what we have now)

4. How do you think the research environment might evolve in response to these changes?

5. What are the key drivers you foresee causing these changes?

6. Do you foresee that these changes would have a particular effect on specific groups of researchers?

Annex E. Codebooks for open-ended questions in the survey

This annex provides the codebooks used to qualitatively analyse responses to four free text questions in the survey of academic researchers in England. The thematic categories were produced based on the responses, which is why the categories between similar questions may vary, and why some categories are very specific. When a response did not fit into an existing category, a new one was made.

E.1. Codebook for expected outputs question

Table E.1 provides the codebook used in Excel to analyse the 1,072 responses to the open text question asking respondents to explain their responses to the question 'Do you expect a change in the type of outputs you are producing in the next 5 to 10 years?'

Table E.1: Codebook used in Excel for expected outputs question

Respondent expects to produce more	Book chapters
	Textbooks
	Patents and products
	Pre-prints
	Books and scholarly books
	Books for the public or practitioners
	Textbooks
	Book reviews
	Review articles
	Edited volumes
	Online-only or digital outputs
	eBooks
	Journal articles
	Conference contributions
	Public-facing outputs
	Interactive and multimedia outputs

	Creative outputs
	Social media
	Blogs
	Website content
	Open access books and monographs
	Open access publications
	Junyper workbooks
	Action-research activities
	Crowdsourced papers
	Collaborative and interdisciplinary outputs
	Policy briefs
	Editorials
	Reports
	Projects with multiple outputs
	Monographs
	Videos
	Open code and software
	Podcasts/radio
	Protocol outputs
	Open science outputs
	Open peer review
	Open methodologies and pre-registrations
	Open data and datasets
	Data visualisations
	Visual media
	More quantity of outputs
	Higher quality outputs
	Shorter format outputs
	Longer format outputs
	More impactful and new forms of output
	Peer reviewed multimedia outputs
	Industry outputs
	Grants
	Other
Respondent expects to produce fewer	Articles as PDFs
	Books
	Textbooks

	Journal articles
	Reviews
	Conference contributions
	Monographs
	Randomised Control Trials
	Reports
	Edited volumes
	Lower quantity of outputs
	Lower quality outputs
	Blogs
	Social media
	Collaborative outputs
	Practitioner-focused research
Reason respondent provided for expecting different outputs in the future	Career development
	Promotion, recognition and reward system
	Funding
	Time
	The REF
	Impact agenda
	Machine readable science
	Reaching new audiences
	Creating impact
	Improving research
	Improving communication
	Changes in open access
	Changes in academic publishing system
	Reproducibility project
	Saving resources
	New technology
	Brexit
	Marketisation of research
	Better teaching tools
Non-response	
Unsure	

E.2. Codebook for ideal outputs question

Table E.2 provides the codebook used in Excel to analyse the 640 responses to the question 'If you answered yes to Question 8, what would they be and why would you choose to produce them instead?' This question immediately followed the closed-ended question 'In an ideal world, would you choose to produce different outputs from those you have selected above?'

Table E.2: Codebook used in Excel for ideal outputs question

Respondents would ideally like to produce more	Alternative outputs and public-facing outputs	
	Books and monographs	Scholarly books and monographs
		Books for the public or practitioners
	Conference contributions	
	Creative outputs	
	Critical editions	
	Crowdsourced papers	
	Open data and datasets	
	Data visualisations	
	Design	
	Digital articles and digital dissemination	
	Editorials	
	Engagement with industry	
	Evaluations	
	Foreign language outputs	
	Grey literature	
	Guidelines and recommendations	
	Implementation and interventions	
	Interactive outputs	
	Interdisciplinary and collaborative outputs	
	Journal articles	
	Lab books	
	Longer format publications	
	Open access articles	
	Open science outputs	
	Open access books and monographs	
	Pamphlets	
	Papers	
	Patents and products	
	Peer reviews	

	Popular media (blogs, podcasts, magazines, newspapers)
	Policy briefs
	Practice- or practitioner-based outputs
	Pre-registrations
	Pre-prints
	Protocols and workflows
	Shorter format publications
	Social media
	Open code and software
	Teaching tools
	Technical reports
	Talks and lectures
	Textbooks
	Translations
	Reports
	Resources
	Videos
	Virtual reality outputs
	Visual artefacts and exhibitions
	Website and online content
	Workshops and events
	New ways of communicating with different audiences
	Other
Respondents would ideally like to produce fewer	Journal articles
	Workshops
	Conference contributions
	Books and monographs
	Book chapters
	Book reviews
	Quantity of outputs
	Alternative outputs
	Proprietary or confidential research outputs
	Open access outputs
Reasons why respondents would like to produce different outputs or why they cannot produce the outputs they would ideally like to	No time in role
	Lack of know-how or tools
	Lack of remuneration or resources
	The REF prevents respondent from producing ideal outputs

	Creating impact
	Reaching new audiences
	Producing certain outputs in research system or in career progression
	Funding for research
	Funding model of academic journals
	Publishing and peer review model
	Improving communication
	Improving research
	Salesmanship
	Avoiding information overload
	Getting immediate feedback
	Better teaching tools
Non-response	
Unsure	

E.3. Codebook for expected impacts question

Table E.3 provides the codebook used in Excel to analyse the 893 responses to the question 'Do you anticipate that the type of impacts that your work might contribute to will change in the next 5 to 10 years and why?'

Table E.3: Codebook used in Excel for expected impacts question

Expected changes in impact	Unsure of future impact
	No change or decrease in impact
	More impact
Reason provided for expected changes in impact	Changes or developments in research
	More collaborations with other researchers
	More collaborations with non-academics
	Career progression
	Networking/meeting new people
	Technology
	More data
	The REF
	Impact agenda
	Funding
	Changes to academic publishing system
	Institutional pressure (incentives, promotion)

	Moving towards commercialisation or private sector
	Topic becoming more relevant or impactful
	Societal change
	Information overload
	More actively focusing on impact and engagement
	Impact is difficult or impossible because public is not interested
	Science or career is rigid
	Brexit
	Policy changes
	Decreased 'risky' or basic research
	Research is fundamental or basic
	Arts and humanities research
	My research already has an impact
	My research does not have impact
	Open science and open access
	More training
	Teaching

E.4. Codebook for the research environment question

Table E.4 provides the codebook used in NVivo to analyse the 1,930 responses to the question 'Given the changes you foresee in the outputs and impacts you produce (if any), how do you think the research environment needs to adapt to support these changes?' The table also shows the respondent attributes that were coded automatically using respondents' answers to the demographic questions at the beginning and end of the survey.

Table E.4: Codebook used in NVivo for the research environment question

01 Value/focus		
01.01 Dissemination and engagement	01.01.01 Suggested direction	01.01.01.01 Should increase
		01.01.01.02 Should decrease
	01.01.02 Other	
01.02 Societal impact	01.02.01 Suggested direction	01.02.01.01 Should increase
		01.02.01.02 Should decrease
	01.02.02 Other	01.02.02.01 Clarifying definition of impact
		01.02.02.02 Creating impact takes resources and time
		01.02.02.03 Geographic range of impact

		01.02.02.04 Impact needs to be considered at beginning of project	
		01.02.02.05 Measuring impact leads to more shallow impacts	
		01.02.02.06 Some disciplines and researchers will have impact and some won't	
		01.02.02.07 Impact activities should be done by non-academics	
		01.02.02.08 Focusing on impact jeopardises career	
		01.02.02.09 Other	
01.03 Outputs	01.03.01 Quantity of outputs	01.03.01.01 Suggested direction	01.03.01.01.01 Should increase
			01.03.01.01.02 Should decrease
		01.03.01.02 Other	
	01.03.02 Quality of outputs	01.03.02.01 Suggested direction	01.03.02.01.01 Should increase
			01.03.02.01.02 Should decrease
		01.03.02.02 Other	
01.04 Collaboration	01.04.01 Academics	01.04.01.01 Suggested direction	01.04.01.01.01 Should increase
			01.04.01.01.02 Should decrease
		01.04.01.02 Other	
	01.04.02 International	01.04.02.01 Suggested direction	01.04.02.01.01 Should increase
			01.04.02.01.02 Should decrease
		01.04.02.02 Other	
	01.04.03 Non-Academics	01.04.03.01 Suggested direction	01.04.03.01.01 Should increase
			01.04.03.01.02 Should decrease
		01.04.03.02 Other	
	01.04.04 Other		
01.05 Type of research	01.05.01 Interdisciplinary research	01.05.01.01 Suggested direction	01.05.01.01.01 Should increase
			01.05.01.01.02 Should decrease
		01.05.01.02 Other	
	01.05.02 Basic research	01.05.02.01 Suggested direction	01.05.02.01.01 Should increase
			01.05.02.01.02 Should decrease
		01.05.02.02 Other	
	01.05.03 Applied research	01.05.03.01 Suggested direction	01.05.03.01.01 Should increase
			01.05.03.01.02 Should decrease
		01.05.03.02 Other	
	01.05.04 Global challenges research	01.05.04.01 Suggested direction	01.05.04.01.01 Should increase
			01.05.04.01.02 Should decrease
		01.05.04.02 Other	

	01.05.05 Other	01.05.05.01 Size of project	01.05.05.01.01 Bigger projects
			01.05.05.01.02 Smaller projects
		01.05.05.02 Specific topics	01.05.05.02.01 Addressing societal issues
			01.05.05.02.02 Climate change and the environment
			01.05.05.02.03 New technological developments
			01.05.05.02.04 Education
			01.05.05.02.05 Arts and humanities
			01.05.05.02.06 Medical and clinical research
			01.05.05.02.07 Social Sciences
		01.05.05.03 Riskier research	
		01.05.05.04 More varied projects	
		01.05.05.05 Translational research	
		01.05.05.06 Other	
01.06 Open science	01.06.01 Suggested direction	01.06.01.01 Should increase	
		01.06.01.02 Should decrease	
	01.06.02 Other		
01.07 Academic independence	01.07.01 Suggested direction	01.07.01.01 Should increase	
		01.07.01.02 Should decrease	
	01.07.02 Other		
01.08 Reproducibility, reliability and integrity	01.08.01 Suggested direction	01.08.01.01 Should increase	
		01.08.01.02 Should decrease	
	01.08.02 Other		
01.09 Other	01.09.01 Distinction between outputs and impacts		
	01.09.02 Other		
02 Institutional support			
02.01 Goal	02.01.01 Engagement	02.01.01.01 Public	
		02.01.01.02 Business/industry	
		02.01.01.03 Third sector	
		02.01.01.04 Other academics	
	02.01.02 Impact	02.01.02.01 Creating impact	
		02.01.02.02 Gathering evidence	
		02.01.02.03 Other	
	02.01.03 Outputs	02.01.03.01 Producing outputs	
		02.01.03.02 Other	

	02.01.04 Workload	02.01.04.01 Administrative
		02.01.04.02 Teaching
		02.01.04.03 Impact and engagement
		02.01.04.04 Research time
		02.01.04.05 Other
	02.01.05 Career development	
	02.01.06 Other	
02.02 Mechanism	02.02.01 Training	
	02.02.02 Funding	
	02.02.03 Personnel	
	02.02.04 IT	
	02.02.05 Infrastructure	
	02.02.06 Reward and recognition	02.02.06.01 Promotion
		02.02.06.02 Tenure
		02.02.06.03 Recruitment
		02.02.06.04 Other
	02.02.07 Dedicated time	
	02.02.08 Other	
02.03 Other		
03 Sectoral support		
03.01 Goal	03.01.01 Engagement	03.01.01.01 Public
		03.01.01.02 Business and industry
		03.01.01.03 Third sector
		03.01.01.04 Other academics
	03.01.02 Impact	03.01.02.01 Creating impact
		03.01.02.02 Gathering evidence
		03.01.02.03 Other
	03.01.03 Outputs	03.01.03.01 Producing outputs
		03.01.03.02 Other
	03.01.04 Workload	
	03.01.05 Career development	
	03.01.06 Other	03.01.06.01 Protecting Intellectual Property
		03.01.06.02 Transparency, clarity, flexibility
		03.01.06.03 Anonymity and transparency in funding
03.02 Mechanism	03.02.01 Funding	
	03.02.02 Training	

	03.02.03 Infrastructure	
	03.02.04 Policy	
	03.02.05 Academic publishing overhaul	
	03.02.06 Other	
03.03 Other		
04 Research assessment		
04.01 Goal	04.01.01 Transparency	
	04.01.02 More meaningful impact	
	04.01.03 Measuring research quality	
	04.01.04 Other	
04.02 Mechanism	04.02.01 Metrics	
	04.02.02 Output type	
	04.02.03 Weighting impact	04.02.03.01 Should increase
		04.02.03.02 Should decrease
		04.02.03.03 Other
	04.02.04 Tailoring impact to disciplines	04.02.04.01 Impact in arts and humanities
		04.02.04.02 Impact in social science
		04.02.04.03 Impact in pure science
		04.02.04.04 Other
	04.02.05 Other	
04.03 Other		
05 Other topics		
05.01 Brexit		
05.02 World standing in research		
05.03 Trust in research	05.03.01 Policymaking	
	05.03.02 Public trust	
05.04 Accountability		
05.05 Marketisation or quantification of research		
05.06 Other		
06 Simple answers		
06.01 Yes		
06.02 No		
06.03 Unsure		
07 General comments		
07.01 Research system	07.01.01 Positive	
	07.01.02 Negative	

	07.01.03 Other
07.02 Research assessment	07.02.01 Positive
	07.02.02 Negative
	07.02.03 Other
07.03 Survey	07.03.01 Positive
	07.03.02 Negative
	07.03.03 Other
07.04 Other	07.04.01 Positive
	07.04.02 Negative
	07.04.03 Other
08 Disciplinary context	
08.01 Basic research	
08.02 Applied research	
08.03 Science	08.03.01 Main Panel A
	08.03.02 Main Panel B
08.04 Arts/ humanities/ social science	08.04.01 Main Panel C
	08.04.02 Main Panel D
08.05 Interdisciplinary research	
08.06 Other	
09 Institution	
09.01 Specific types of universities	
09.02 Specific universities	
09.03 Other	
10 Equality and Diversity and Inclusion	
10.01 Gender	
10.02 Ethnicity	
10.03 Disability	
10.04 Other	
11 Career stage	
11.01 PhD student	
11.02 Early-career researcher	
11.03 Mid-career researcher	
11.04 Established researcher	
11.05 Retired or emeritus professor	
12 Other context	

13 Unsure
Attributes (Coded automatically)
Main panel
UOA
Interdisciplinary by UOA
Interdisciplinary by main panel
HEI Group
Location
Career Stage
Gender

Annex F. REF 2021 Units of Assessment

Main Panel	Unit of assessment (UOA)	
A	1	Clinical medicine
	2	Public health, health services and primary care
	3	Allied health professions, dentistry, nursing and pharmacy
	4	Psychology, psychiatry and neuroscience
	5	Biological sciences
	6	Agriculture, food and veterinary sciences
B	7	Earth systems and environmental sciences
	8	Chemistry
	9	Physics
	10	Mathematical sciences
	11	Computer science and informatics
	12	Engineering
C	13	Architecture, built environment and planning
	14	Geography and environmental studies
	15	Archaeology
	16	Economics and econometrics
	17	Business and management studies
	18	Law
	19	Politics and international studies
	20	Social work and social policy
	21	Sociology
	22	Anthropology and development studies
	23	Education
	24	Sport and exercise sciences, leisure and tourism

Main Panel	Unit of assessment (UOA)	
D	25	Area studies
	26	Modern languages and linguistics
	27	English language and literature
	28	History
	29	Classics
	30	Philosophy
	31	Theology and religious studies
	32	Art and design: history, practice and theory
	33	Music, drama, dance, performing arts, film and screen studies
	34	Communication, cultural and media studies, library and information management

These are taken from https://www.ref.ac.uk/panels/units-of-assessment

Annex G. Workshop participants

Participant	Affiliation	Workshop
Morag Campbell	Scottish Funding Council	Purpose of research assessment
Dr Jenn Chubb	University of Sheffield	Purpose of research assessment
Professor Jonathan Grant	Kings College London	Purpose of research assessment
Dr Chonnettia Jones	Wellcome	Purpose of research assessment
Paola Quattroni	Cancer Research UK	Purpose of research assessment
Sue Smart	Engineering and Physical Sciences Research Council	Purpose of research assessment
Fiona Goff	Natural Environment Research Council	Purpose of research assessment
Dr Carolyn Reeve	Department for Business, Energy and Industrial Strategy	Purpose of research assessment
Prof Alison Park	Economic and Social Research Council	Peer review
Prof Maria Delgado	The Royal Central School of Speech and Drama	Peer review
Prof Jane Millar	University of Bath	Peer review
Prof Claire Squires	University of Stirling	Peer review
Dr Andrew Clark	Royal Academy of Engineering	Peer review
Prof Aileen Fyfe	St Andrews	Peer review
Dr Ed Gerstner	Springer	Peer review
Dr Ken Emond	British Academy	Peer review
Dr Damian Pattinson	Research Square	Peer review
Prof Margot Finn	Royal Historical Society	Peer review
Dr Joris van Rossum	Digital Science	Peer review Emerging technologies
Dr Liz Allen	F1000	Peer review Emerging technologies

Participant	Affiliation	Workshop
Dr Elizabeth Gadd	Loughborough University	Emerging technologies
Professor John Domingue	The Open University	Emerging technologies
Simon Thomson	Clarivate	Emerging technologies
Lucy Davies	Vertigo Ventures	Emerging technologies
Dr Lotte Boon	University of Oxford	Emerging technologies
Tamsin Burland	JISC	Emerging technologies
Dr Steven Wooding	Centre for Science and Policy, University of Cambridge	Emerging technologies
Dimity Flanagan	The British Library	Emerging technologies
Dr Beverly Sherbon	Research Fish	Emerging technologies
Simon Porter	Digital Science	Emerging technologies
Tom Letcher	Symplectic	Emerging technologies