technopolis group

June 2023

Strategic Priorities Fund (SPF) evaluation

Interim Impact Evaluation – Technical Annex

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Technopolis, in collaboration with Science Metrix, Ipsos MORI and CECAN

Notes to the report:

The Department for Business, Energy and Industrial Strategy (BEIS) was dissolved on 7 February 2023, with its functions split into three new departments. Responsibility for R&I passed to the newly created Department for Science, Innovation and Technology (DSIT). The report refers to BEIS, as the department responsible at the time that the interim evaluation was undertaken.

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Appendix A Methodological aspects

A.1. Consultations

A.1.1. Programme lead consultation

We are consulting with programme leads at each phase of the evaluation (baseline, interim and final). In each case, this will comprise the completion of template (survey) to provide factual information and headline views, plus further consultation (through interviews or workshops). During the current phase of evaluation, we have employed a four step process:

1. Initial request for basic information. All programme leads were asked to provide details of stakeholders involved in programme governance (leads and co-leads, government department partners, Directors, Champions and Advisory Board members). A return was provided by 25 programmes, with the study team and UKRI targeting non-respondents.

2. A programme information template. A second request went out to all programme leads to provide factual information on their programme and its implementation, as well as high-level views and perceptions on several key areas relating to Fund objectives. This asked, for instance, about the extent of involvement of different types of organisation in the implementation processes, as well as overall views on the added value of SPF. Again, all programme leads were contacted multiple times, with additional support from the SPF team and SPF coordinators. A completed template was provided for 25 of the 34 programmes. Subsequent interviews (see below) sought to build on this initial input and pursue areas in more depth through discussion.

3. Interviews. Finally, a selection of programme leads and co-leads were invited to participate in a semi-structured interview about their programme and experiences (as an input to case study development – see Appendix B for more details and lists of interviewees).

4. Workshops. Two workshops were held with programme leads during the interim evaluation. The first event took place in April 2022 and was used to present and discuss key findings from the last phase of the evaluation, as well as introduce plans for this phase. We also facilitated a discussion on the relevant dimensions to cover when exploring the outputs and impacts of the Fund relating to MIDRI. There were 45 attendees at this event. A second workshop was then held in October 2022, with all SPF programme leads and coordinators invited. The purposes of the workshop were to provide an update on the progress of the evaluation, to present a preliminary analysis of evidence in relation to the MIDRI objective of SPF, and to discuss further (in two break out groups) the extent to which and how SPF has driven an increase in high quality MIDRI. There were 18 attendees (plus representatives from UKRI and the study team).

Table 1 Response rate to programme lead consultation activities

Approach	Response
Initial request for basic information	25 returns
Programme information template	25 returns
Interviews with programme leads / co-leads (for case studies)	9 interviews, covering 8 programmes
Workshops with programme leads / SPF coordinators	45 attendees 18 attendees

A.1.2. Advisory Board Survey

The evaluation has run a short survey consultation exercises addressed to members of individual SPF Programme Advisory Groups (where these exist). All programmes were asked to provide details of their advisory group members (where these bodies existed). From the 25 that responded, 20 provided details of Advisory Board members, which together contained 250 members. Where individuals were being consulted through other means (e.g. case study interviews), they were removed from this list. Those with a missing email address were also removed. The remainder were approached with a request to complete an online survey about their role and activities within the advisory group, their experiences of the SPF programme and views on added value in relation to SPF objectives. The survey remained live for 1 month, with a reminder sent before the deadline. In total 90 responses were received from the 183 individuals targeted, representing a very good response rate of 49%.

A.1.3. Stakeholder interviews

An additional 42 interviews have been undertaken with other stakeholders, tied to the development of case studies, where (in addition to programme leads) we have consulted with other programme partners, government representatives, programme Directors and Champions and key participants involved in each of the programmes in focus. The case studies and lists of interviewees are presented in Appendix B.

A.2. Measuring spend in government priority areas

Analysing UKRI spend in priority areas required mining the entire GtR database to compare investments made historically in the areas of interest (using a classification algorithm applied to grant abstracts). Given the scope of the exercise (and diversity of areas covered by SPF), we have focused the analysis on the eight areas that correspond to the eight longitudinal case studies selected for this evaluation, which provide a good spread in terms of themes covered, partners involved and Waves.

In order to draw comparisons with a benchmark (UKRI), the analysis focuses on the value of grants in competitive calls. Not all SPF programmes have launched competitive calls (up to 2022) or planned to do so. Further iterations of the analysis could draw comparisons with the total value of the SPF programmes and UKRI data up to 2023, when most SPF programmes are expected to conclude.

A total of eight priority areas have been identified by the Government Office of Science together with departmental Chief Scientific Advisers:

1. Cybersecurity
2. Productivity
3. Space weather
4. Time infrastructure / measuring time
5. Bacterial plant diseases
6. Modern slavery
7. Mental health and adolescence
8. Air quality

Firstly, the analysis of SPF's coverage of these areas required the classification of individual SPF-funded grants. This was achieved by using TextRazor, a Natural Language Processing (NLP) service. TextRazor offers out of the box classification models based on publicly available

taxonomies such as Wikipedia[1], DBPedia[2] and Wikidata[3]. Its classification service is based on a proprietary knowledge graph[4] in combination with machine learning algorithms that assigns topics from the taxonomies of interest to any form of textual data.

In this analysis, the text data consisted of the abstracts of SPF grants that were available in GtR. A total of 730 SPF grants were covered by GtR as of late August 2022. All of these were classified based on Wikidata topics after which these initial results were filtered down to relevant topics only. The allocation of relevant topics per priority areas is summarised in Table 2. Most priority areas were sufficiently captured by a single Wikidata topic, with the exception of "Adolescence and mental health" which was captured by cross referencing the separate topics of "mental health" and "adolescence".

Table 2 Allocation of topics per priority area

Priority area	**Topic (with Wikidata code)**
Cybersecurity	Computer security (Q3510521)
(Research on) Productivity	Productivity (Q2111958)
Space weather	Space weather (Q584093)
Time Infrastructure / Measuring time	Horology (Q41767)
Bacterial plant diseases	Bacterial plant disease (Q9164481)
Modern slavery	Contemporary slavery (Q3369955)
Mental health and adolescence	Adolescence (Q131774) and mental health (Q317309)
Air quality	Air quality (Q56245086)

The initial classification of SPF grants allowed for a subsequent analysis of the key words and phrases by priority area, to be used for the classification of all remaining grants in GtR not covered by SPF (referred to as UKRI grants hereafter). To carry out this step, key words were identified using a Rapid Automatic Keyword Extraction (RAKE) algorithm.[5] RAKE follows a three-step process:

- Keywords are extracted from contiguous sequences of words that do not contain irrelevant words (such as stop words)

[1] Wikipedia is a free online encyclopaedia, created and edited by volunteers around the world and hosted by the Wikimedia Foundation., see: https://www.wikipedia.org

[2] DBPedia is a project aiming to extract structured content from the information created in Wikipedia, see: https://www.dbpedia.org

[3] Wikidata is a collaboratively edited multilingual knowledge graph hosted by the Wikimedia Foundation, see: https://www.wikidata.org

[4] "Knowledge graphs (KGs) organise data from multiple sources, capture information about entities of interest in a given domain or task (like people, places or events), and forge connections between them", for more information see: https://www.turing.ac.uk/research/interest-groups/knowledge-graphs and https://www.textrazor.com/named_entity_recognition

[5] Rose, Stuart & Engel, Dave & Cramer, Nick & Cowley, Wendy. (2010). Automatic Keyword Extraction from Individual Documents. Text Mining: Applications and Theory. 1 - 20. 10.1002/9780470689646.ch1.

- A score is calculated for each word based on its frequency as well as its co-occurrence with other words. Specifically, the score is calculated as the ratio of co-occurrence to frequency
- The RAKE score for each keyword is calculated by summing the scores of its component parts
- Based on a combination of RAKE scores and manual inspection, a set of key words was identified per priority area, summarised in Table 3.

Table 3 Summary of key words identified per priority area

Priority area	Keywords used
Cybersecurity	Cyber security, cybersecurity, computer security
(Research on) Productivity	Productivity (restricted to ESRC grants)
Space weather	Space weather, weather in space
Time Infrastructure / Measuring time	Atomic clock, molecular clock, clock
Bacterial plant diseases	Bacteria AND plant pathogens OR plant diseases
Modern slavery	Modern slavery, slavery in the 21st century
Mental health and adolescence	Adolescent mental health, adolescence AND mental health (overall co-occurrence within abstracts)
Air quality	Air quality

The identified key words were used to formulate dictionaries per priority area. For all UKRI grants (i.e. non-SPF grants available in GtR), a document-term matrix was constructed using these dictionaries. In short, a document-feature matrix tabulates the coverage of certain features, in this case priory area-specific dictionaries, across all documents, in this case non-SPF project abstracts. This process automatically performs basic text mining tasks such as converting characters to lower case, removing stop words, and stemming words (reducing terms to their word stem, base, or root) to enable more accurate text analysis.

The result of this process is an overview of the occurrence of previously identified key words across project abstracts, based on which corresponding grants were assigned to one of the priority areas. A set of random spot checks were carried out in order to ensure no grants were mislabelled. The total number of grants per priority area, for SPF and UKRI is summarised in Table 4 below.

Table 4 Number of grants per priority area - SPF compared to UKRI

Priority area	Number of SPF grants (N = 730)	Number of UKRI grants (N = 130,246)
Cybersecurity	11	805
(Research on) Productivity*	19	255*
Space weather	25	225
Time Infrastructure / Measuring time	8	253
Bacterial plant diseases	13	109
Modern slavery	9	32
Mental health and adolescence	15	195
Air quality	40	749

* Restricted to ESRC grants only

A.3. Bibliometric analysis

Bibliometrics consists of a suite of methods that help track some of the immediate research outputs of funding programmes and their projects, such as the number of peer-reviewed publications and their impact within academic circles (as measured by citations within the scientific literature).

A.3.1. Measuring MIDRI in publications

One expected output of the Fund is an increase in high quality MIDRI projects and publications[6].

There are different approaches to measuring MIDRI using bibliometric data. The current state of development of these approaches is such that they each have their respective strengths and weaknesses, with none of them standing out as the perfect means to capture MIDRI. Science-Metrix, who lead this work package, has however been working in this space for the past 5 years, developing state-of-the-art approaches to measuring both multi- and interdisciplinary research, which have been deployed here.

In line with our conceptual framework, the analysis of research crossing disciplinary boundaries using bibliometric data can be undertaken on at least two dimensions:

- A human dimension, capturing collaborations of researchers with different disciplinary backgrounds (an input to cross-disciplinary work, and a proxy of multidisciplinarity)
- An epistemic dimension, capturing publications that draw on knowledge from different disciplines (an output from cross-disciplinary work, and a proxy of interdisciplinarity).

Various diversity metrics can be implemented to capture the number of, intellectual distance between, or balance among the represented disciplines.[7] Within the current evaluation, disciplinary diversity amongst a publication's author list (multidisciplinarity) is captured by adapting the Rao-Stirling diversity index to the disciplinary profiles of co-authors, while disciplinary diversity in a publication's integrated knowledge (interdisciplinarity) is inferred by applying the Rao-Stirling index to the disciplines represented in the papers' reference list.

This means that we have computed the disciplinary diversity (DD) of SPF publications based on their author list (multidisciplinarity) and based on their reference list (interdisciplinarity). That allows us to approach MIDRI from two angles using bibliometrics. Furthermore, the above two indicators (of diversity) have been computed for different groups of papers, SPF and UKRI overall, to provide a comparison point.

A detailed description of the methods implemented for this analysis are presented in Appendix B.3 of the Baseline and Early Findings report (Technopolis, 2021)[8].

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[6] This is one the indicators included in the Business Case. We understand however that the ultimate intent of the Fund (and assumption) is that the knowledge produced by multidisciplinary teams will lead to a higher uptake of knowledge outputs and to higher societal impacts. With that in mind, we will not restrict the analysis of uptake or societal impacts to those publications with a high degree of MIDRI, but will instead test the extent to which higher degrees of MIDRI in publications led to higher results (as explained in the section on econometric analysis).

[7] Leydesdorff, L., Wagner, C. S., & Bornmann, L. (2019). Interdisciplinarity as diversity in citation patterns among journals: Rao-Stirling diversity, relative variety, and the Gini coefficient. *Journal of Informetrics*, 13(1), 255–269.

[8] https://www.ukri.org/wp-content/uploads/2022/07/UKRI-190722-StrategicPrioritiesFundBaselineInterimProcessEvaluation-TechnicalReport.pdf

A.3.1.1 Measuring MIDRI for SPF papers

The bibliometric indicators reported are based on 899 peer reviewed publications from 2018 to 2021 that have already been reported in GtR (or acknowledged by authors as supported by SPF). These publications represent 25 % (194) of the 767 SPF projects awarded to date that are already reported in GtR. This output represents a marked increase over the Year 1 output, which, at 242 publications, was most likely a reflection of the relatively recent start date (in 2018) of most SPF projects rather than underreporting in GtR or papers' acknowledgements (though this latter factor may still be at play). Given that only 25 % of SPF projects are represented in the figures provided in this report, and knowing that the majority of SPF supported publications have yet to be published, the SPF results presented should be interpreted with caution as they may change during the following years as new publications are added to the SPF portfolio.

Comparator groups were selected from four publication sets as adequate benchmarking references against which to measure the performance of SPF papers:

- UK papers (all publications with at least one UK-based author).
- UKRI papers (all UK publications with funding from a UKRI council, identified in GtR and Scopus acknowledgements).
- Prior publications from SPF researchers (papers authored by SPF researchers and published prior to the first year of any of the SPF projects in which the researcher has participated. This group includes papers published between 2006 and 2019).
- Parallel publications from SPF researchers (papers authored by SPF researchers after their first year in any SPF project and excluding papers that have been identified as an SPF paper in GtR or Scopus). These are presumed to be publications associated with concurrent projects by SPF-funded researchers. They include papers published between 2018 and 2021. Note that the parallel papers group may include SPF papers not correctly identified as such in GtR or in Scopus acknowledgments.

The indicators were computed for 2 periods (2006-17, 2018-21).

Limitations and caveats

We identified two potential concerns related to the data used to compute the indicators reported here.

1. Approximately 75% of SPF projects have not yet been linked to publications. This should be expected, given that most of them are still too recent to accumulate a considerable number of publications; it is also possible that some of their publications are just not yet reported in GtR. The extent of this potential issue may become clear in the next iteration of this project.
2. It is possible that GtR does not provide a comprehensive list of all researchers involved in each SPF project. For instance, 267 of the SPF projects listed one or zero researchers in GtR (35% of the 767 SPF projects in GtR). 167 of them are the SPF projects funded by the Innovate UK (i.e. none of the Innovate UK projects have more than 1 researcher in GtR), meaning that the analyses on multidisciplinarity of research teams did not include any project from this funder). There were also 107 projects with only 2 researchers listed in GtR which may not be representative of the entire research team involved in the project. Therefore, the analyses of multidisciplinarity of research teams is focused on the remaining research grants that listed at least 3 researchers in GtR (further discussed below).

A.3.1.2 Measuring MIDRI for SPF projects

To complement the analyses of cross-disciplinarity patterns observed for SPF projects the multidisciplinarity index was also computed at the level of SPF research projects (rather than for the aggregated scores of publications presented so far). The multidisciplinarity indexes computed for the research projects broadly followed the concept used to compute multidisciplinarity at paper level. The difference is that, instead of relying on the prior publication profile of a paper's co-authors, the indicator is built on the prior publication profile (in Scopus) of the researchers listed as participants on a given SPF project in GtR (i.e., using information on SPF co-applicants). Therefore, one underlying assumption to this analysis is that a project's list of co-applicants in GtR is comprehensive, or at least representative, of the corresponding SPF research team.

The scores for multidisciplinarity for SPF research teams were computed in relation to the average scores of similar research projects found in GtR. For this purpose, the researchers found in GtR were matched to Scopus (not only for SPF projects), allowing the computation of the same MI indicator for most GtR projects (i.e., not only for the SPF projects). The MI scores computed for SPF grants are the raw score obtained for a grant divided by the scores of all grants (starting on 2018 and after), in the same Research Topics (as obtained from GtR) and having at least 3 researchers matched to Scopus.

As a result, from the steps above, only 218 SPF projects had MI scores computed. Most of the projects for which the MI score could not be computed (390) refer to projects with less than 3 researchers matched to Scopus (including 21 projects with more than 3 researchers in GtR but that could not have at least 3 of them matched to Scopus). Another 117 projects refer to cases not associated to any research topic or that were associated to research topics that have less than 20 projects with a MI score (so they could not be normalised according to the process described above).

An important remark concerning the evidence about the multidisciplinary indexes of SPF research teams is that, at this point, the results are based on only 218 of 725 SPF projects found in GtR. In many cases, MI scores could not be computed for SPF projects because there were not enough researchers in GtR to compute the score. If more researchers are included in GtR in the following years, it may change the figures reported for the MI levels of SPF research teams.

We have also measured the extent to which researchers in the UK (and through SPF) collaborate in publications with authors affiliated to Universities, Government Departments, PSREs and Industry. The data set used is similar to the one described above (and based on the 899 peer-reviewed publications from 2018 to 2020 that have already been reported as SPF-supported on GtR or in the paper's funding acknowledgments. As above the indicators are calculated for four comparator groups and computed for two periods (2006-17, 2018-21). The first limitation listed above should be considered when analysing this data.

A.3.2. Further analysis of researchers' prior experience on MIDRI

The analysis of multidisciplinarity and interdisciplinarity reveals that SPF papers also have similar MI and II scores to the two groups of SPF researchers' other publications (prior and parallel to SPF). This may reflect a higher inclination of multidisciplinary researchers to apply for SPF grants and/or the success of SPF's review process in selecting researchers with prior cross-disciplinary achievements, and SPF may have helped to sustain their multidisciplinary activity.

We further explored the extent to which SPF is attracting researchers that are new to MIDRI, by examining the degree of MIDRIness of the papers published by SPF researcher prior to their SPF involvement.

We limited this exercise to papers published 5 years prior to the first year of each researcher appearing in an SPF-supported grant. For example, if one researcher's first year in SPF is 2022, we used the papers from 2017-2021. If another researcher has a first year in SPF as 2019, we used the papers from 2014-2018. All scores are normalized by year (and document type and subfield).

This analysis shows that SPF has attracted researchers with varying degrees of experience of producing multidisciplinary papers, with 33% of them having produced one paper or more with a low degree of multidisciplinarity 5 years prior to SPF involvement, 24% with a medium degree of multidisciplinarity and 44% with a high degree of multidisciplinarity. This further confirms that SPF is attracting researchers that are active in multidisciplinary work (see Table 5)

Low multidisciplinarity corresponds to researchers that have any paper scoring 2.5% or less than the top 10% most multidisciplinary papers at the world level, Medium multidisciplinarity to those that have papers scoring 13% or less than the top 10% most interdisciplinary papers at the world level, and High multidisciplinarity to those that have any paper scoring more than 13% than the top 10% most multidisciplinary papers at the world level. A similar distribution of researchers in each category (low, medium and high multidisciplinarity) is observed for 11 or more papers (i.e. percentage of researchers with 11 or more papers that have low multidisciplinary scores in comparison with the world average) (see Table 5).

Similarly, this analysis shows that SPF has attracted researchers with varying degrees of experience of producing interdisciplinarity papers, with 23% of them having produced one paper or more with a low degree of interdisciplinarity in the 5 years prior to SPF involvement, 20% with a medium degree of interdisciplinarity and 57% with a high degree of interdisciplinarity (see Table 6).

Table 5 Degree of multidisciplinarity of SPF researchers' papers prior to SPF

Category	Bin of $II_{10\%}$	Number of papers in the 5 years prior to the SPF							
		Any	3 or less	4 to 10	11 and more	Any	3 or less	4 to 10	11 and more
Low	<= .25	716	180	209	327	33%	68%	42%	23%
Medium	> .25 and <= .7	208	0	0	208	10%	0%	0%	15%
Medium	>.7 and < 1.3	292	0	54	238	14%	0%	11%	17%
High	>=1.3	942	86	229	627	44%	32%	47%	45%
	Total	**2,158**	**266**	**492**	**1,400**	**100%**	**100%**	**100%**	**100%**

Source: Computed by Science-Metrix using Scopus and GtR data (2022).

Table 6 Degree of interdisciplinarity of SPF researchers' papers prior to SPF

Category	Bin of $MI_{10\%}$	Number of papers in the 5 years prior to the SPF							
		Any	3 or less	4 to 10	11 and more	Any	3 or less	4 to 10	11 and more
Low	<= .25	493	168	133	192	23%	64%	28%	13%
Medium	> .25 and <= .7	171	0	1	170	8%	0%	0%	12%
Medium	>.7 and < 1.3	262	0	46	216	12%	0%	10%	15%
High	>=1.3	1,228	96	287	845	57%	36%	61%	59%
	Total	**2,154**	**264**	**467**	**1,423**	**100%**	**100%**	**100%**	**100%**

Source: Computed by Science-Metrix using Scopus and GtR data (2022).

A.3.3. Additional indicators

We have also collected data on the share of publications cited in patents and policy-related literature. The same warnings regarding the SPF papers already mentioned above should be considered here. An additional warning should be considered for the share of papers cited in patents and in the policy-related literature. In the case of patents, at least 5 years are required to gain a sense of the uptake of publications into patents due to the time needed to accrue citations and the time to file patents. In the case of policy-related literature, only around 30% of citations are accrued in the 2 years following the publication of a paper. Therefore, the indicators based on patent and policy citations presented in these tables should not be regarded as robust for the period 2018-21 (even when the stability intervals presented do not overlap each other).

Appendix B Longitudinal case studies

B.1. Introduction to the case studies

As part of the SPF Fund evaluation, a series of eight longitudinal case studies are being developed, each focusing on a specific SPF programme.

The first iteration of each of these case studies was developed for the baseline and interim process evaluation (published January 2022). At this point the focus was primarily on describing the programmes and their origins, as well as any early learnings and preliminary outputs.

A second iteration of each case has now been developed as part of the interim evaluation. In each, we revisit the programme in question and update and revise the case with additional evidence about outputs, outcomes and direction of travel in terms of impact achievement.

Each of the cases for this interim stage have been developed on the basis of desk research, combined with 5+ interviews with key stakeholders (programme leads and partners from Councils, PSREs and government, plus others) undertaken July – September 2022.

The case studies should not be viewed as evaluations of the programmes, but rather a summary of key features and achievements. Individual programme evaluations are under way and key findings from these (where available) will be incorporated in the final Fund evaluation.

Each case follows a standard structure and looks to address a series of questions that are relevant to the SPF interim evaluation. Each starts by exploring how the programme has been designed and its operational and day-to-day management. Each then discusses outputs, outcomes and impact, based on the 3 objectives of the fund, and finishes by exploring what is expected to be seen in the final report and by the final evaluation.

B.2. Bacterial Plant Diseases

SPF Wave 1	**SPF funding amount**: £17.7 m	**Programme Start and end date** 01/10/2018 - 31/12/2024
Lead Council / PSRE: BBSRC	**Other Council / PSRE**: NERC	**Government departments**: DEFRA and Scottish Government
Key objectives • To deliver research that addresses threats to UK plant health and biosecurity from bacterial diseases.		
Main phases • Phase 1: a £5M integrated body of research on *Xylella fastidiosa* by a consortium of institutions led by the John Innes Centre. • Phase 2: an open managed-mode call for multidisciplinary studies of a range of bacterial pathogens and their interactions with host plants, invertebrate vectors and wider ecosystems.		

B.2.1. Summary

At the time of writing (November 2022) Phase 1 of the *Bacterial Plant Diseases* programme has finished, while phase 2 is still in progress. The projects suffered considerable delays due to the COVID-19 pandemic and lockdowns, which impacted on the ability of the researchers to conduct fieldwork, but they are now making good progress.

SPF has enabled the further development of collaborations between disciplines that have long-standing experience of working together, such as biological and environmental sciences. Furthermore, since bacterial plant diseases pose a significant threat to food production, economic supply chains and the UK environment, the programme is directly addressing government priorities. The programme has already developed knowledge on how to respond to the threat of *Xylella* in case it reaches the UK and this foundational knowledge is helping policy makers become better prepared for necessary policy responses. The outcomes of the phase 2 have not yet been collated because research is still ongoing.

B.2.2. Introduction

The wider distribution and more frequent occurrence of bacterial diseases as a result of climate change and increased mobility of potentially contaminated items in international trade are major sources of concern for UK plant health. These pathogens (and their invertebrate vectors) pose a potentially devastating threat to crop production, forestry, commercial and ornamental horticulture, woodlands, and wider biodiversity. They also have severe and pervasive negative effects on rural and urban landscapes and ecosystems in terms of the economy, the environment, and society which are key government priorities.

Numerous different bacterial diseases are caused by bacterial phytopathogens. They can spread through the air, the soil, or invertebrate vectors, but there was little understanding of the particular ways they spread, although they were known to be very invasive. In contrast to many other plant diseases, they usually have a large variety of potential hosts, making them difficult to manage using chemicals. In addition, the symptoms of bacterial diseases are often slow to appear, so early treatment is difficult.

The Bacterial Plant Diseases programme aims to develop knowledge and applied research in plant health and biosecurity to better understand and address the challenges posed by bacterial diseases in crops, forestry, and other plants.

The programme involves two research councils (BBSRC and NERC), plus DEFRA and the Scottish Government, and was divided into two phases:

- Phase 1 (2018/19-2021/22) focused on formulating an urgent response to the threat of *Xylella fastidiosa*, a highly contagious, possibly disastrous plant pathogenic bacterium, which has a wide range of host plants and has devastated olive production in continental Europe. Due to the timescales imposed by SPF funding, this research was commissioned directly from the John Innes Centre. The phase is now completed, and a final report has been submitted. Principal Investigators are also currently writing papers which will be published in due course.
- Phase 2 (2019/20-2022/23) involved an open call for multi and interdisciplinary studies of the biology and epidemiology of a variety of bacterial pathogens, as well as their interactions with host plants, invertebrate vectors, and the wider environment. Eight research grants were funded, which are in progress. These projects suffered significant delays because of the COVID-19 pandemic and the lockdowns. They were scheduled to start around April 2020 but could only kick off around September-October 2020 and suffered further delays in the January 2021 lockdown. Plants and their pathogens grow on a seasonal basis and much fieldwork involves planting and sampling in spring and summer, so these projects missed the opportunity of doing fieldwork both in Spring 2020 and 2021 due to the lockdowns. The projects were granted no cost extensions and are now proceeding with the research.

B.2.3. Programme Design and Delivery

Intersectoral working and collaboration

The programme has a Programme Management Group which BBSRC, NERC, DEFRA, and the Scottish Government are part of. They met regularly in the early stages of the programme but now meet less frequently because the programme is largely running itself.

BBSRC manages the delivery of the programme on behalf of other funders. NERC, DEFRA, and the Scottish Government were more involved in the bidding stage and representatives of these organisations sit on the Programme Management Group, but their involvement in the operation of the programme is light touch. BBSRC stays in touch with the other funders mostly through newsletters and email communications, where they share updates and ask for input when necessary. If BBSRC receives information that is of strategic relevance, it forwards that information to other funders as well. This approach is felt to have worked well so far by those involved.

In addition, the programme had planned to organise several meetings for knowledge exchange but due to the COVID-19 pandemic and the lockdowns, some of these were cancelled while others were moved online. This meant that for stakeholder meetings, a larger range of stakeholders could be involved, including some that could not afford to send personnel to face-to-face meetings. However, the networking aspect was hindered by the nature of the digital interactions. In this sense, it is believed that some aspects of the work the programme was expecting to deliver in terms of stakeholder engagement could not be carried out.

BBSRC, NERC, DEFRA and the Scottish Government had an extensive record of working together before SPF so it was expected that the funders would build on their previous experience to deliver this programme. However, it was noted that DEFRA found it particularly valuable to bring in university partners to work with them through the research grants. They are pleased to develop further collaborations with academia, and from their perspective SPF was

successful in arranging this partnership. Although the organisations already have experience of working together, they were pleased that SPF enabled the continuity of intersectoral working and a MIDRI approach that has been part of strategic actions for 20 years.

The coordination team organised a mid-term grant holders' workshop in March 2022. Although this was a hybrid meeting, it was the first opportunity for many of the participants to meet in person. Indeed, for many participants this was their first physical interaction with colleagues outside of their institution since lockdown commenced in March 2020 – and had broader networking value as a result. In this workshop, research project leaders met funders to present updates on their work. The meeting included a specific session dedicated to knowledge exchange and transfer, where the different projects were able to share ideas and good practices with each other. The workshop was very successful, as demonstrated by the feedback that the coordination team received.

In October 2022 the programme also ran an early career researcher meeting, while other in-person events are planned. Individual projects are also starting to hold in-person events after two years of online activity.

Multi- and inter-disciplinary approach

Bacterial Plant Diseases involves a strong collaboration between biological sciences and environmental sciences, which is demonstrated by the presence of BBSRC and NERC in the programme governance. These two fields of knowledge already have an established past of working together due to the nature of the problems they explore. This programme also involves social scientists as well as researchers from engineering, mathematics, and computational sciences in diagnostics and modelling. Some of the projects also involve chemistry and geography. These are the disciplines that are required to be involved to address the challenges proposed by the programme.

Phase 1 of Bacterial Plant Diseases was commissioned research. This is different from the more open competition architecture BBSRC typically commissions, but justifiable here on the basis of the need for a rapid response (to inform UK policy in relation to *Xylella*) and being able to draw on obvious centres of expertise to convene a broad consortium. BBSRC is now increasingly using such commissioned approaches to deliver rapid response investments (e.g. to avian influenza and MPox) where this approach can be justified on the basis of timeliness and where a more open approach would be unlikely to deliver the necessary research consortia architectures. The BPD Phase I award was a useful example of this sort of approach.

Phase 2 of the programme supported a multi- and interdisciplinary approach from the start by requiring that the submitted proposals involved researchers from different disciplines coming together and addressing the issues outlined in the call for proposals. This was explicit in every aspect of the call. In addition, the composition of the panel that evaluated the proposals was multidisciplinary and members were briefed about the importance of this approach.

Changing needs and opportunities

The challenges that the programme addresses are associated with prevention against long-term threats. In this sense, the priorities have remained constant. Nevertheless, the funders were ready to provide emergency funding to address biosecurity crises if necessary.

B.2.4. Programme Outputs

Phase 1, a three-year research project involving 12 institutions, included the development of the BRIGIT (Surveillance and response capacity for *Xylella fastidiosa*) website, which collates a wide range of information and resources on *Xylella* available to a diverse public, from a music video to information about how people can spot insect vectors on plants and recordings of

webinars where the key findings from the project were shared with funders. The final report has been submitted to funders and potential policy and decision makers who are now better equipped to deal with *Xylella* in case it reaches the UK.

The 'citizen science' aspect of the *Xylella* project is an interesting example of outputs that are relevant to different end-users, in this case families and communities. It is understood that individual behaviour can on the one hand increase the spread of insects and diseases in the UK through, for example, the acquisition of diseased ornamental plants. On the other hand, people can be educated to identify vectors of the disease or symptoms in plants and avoid its circulation. The project 'citizen science' addresses this educational problem. It has collated a range of videos, information sheets, and infographs to inform the public, including children, about insects that may pose a threat to plant health and a protocol for reporting symptoms of this disease in plants to the TreeAlert service. This demonstrates that the outputs are relevant and have been synthesised beyond the immediate plant health academic community.

For phase 2, the programme was able to attract high quality proposals but in smaller number than expected. This was probably not helped by the short timeframe provided by SPF, which offered little flexibility in terms of deadlines for incurring spend. The funders also identified that there is a higher level of governance and reporting in this programme compared to other UKRI calls.

It is early to present concrete outputs, but it is believed that the programme has enabled funders to build a shared knowledge base and a shared language which will be carried forward. They are looking forward to maintaining this relationship that they continued to develop with the help of SPF.

B.2.5. Programme outcomes and impact - R&I to address priorities

The outcomes of the phase 2 have not yet been collated because research is still ongoing.

For phase 1, which looked at the *Xylella* disease, there are several outputs that are relevant and address the challenges identified during the design of the programme. The project has developed a protocol for analysing *Xylella* samples in the event of it reaching the UK. There are now a number of specified labs that will be analysing the samples, and all will use the BRIGIT protocol, so information will be comparable. Additionally, the project has compiled information about trade routes and how plants move around the UK. It has a better understanding of what influences the decisions of people who are involved in those trade routes, including plant importers, plant buyers, nurseries, schools etc. By understanding how people make those choices, and what might influence those choices, policymakers can possibly make interventions that will have the greatest impact in stopping movement of diseases.

The programme has also developed a better understanding of the biology of the disease. It has compiled knowledge about how the vector moves in different parts of the country at different temperatures, when it is most likely to move around, when it is most likely to be dangerous, how it affects the plant, and how signs of it can be found. These findings have been compiled in a final report which has been sent to funders. The foundational knowledge is helping policy makers become better prepared for necessary policy responses in the likely event of an eventual Xylella incursion into the UK.

Stakeholders are also looking forward to the outputs from the eight funded projects within phase 2. There are two projects on oak health, for example, that explore the syndrome of acute oak decline, which is a major disease and is causing significant losses of mature oak trees. The projects try to understand the relationship between the tree and the environment and the different ways the disease progresses. Since oaks are used in a variety of industries and sectors in the country, it is crucial to develop that understanding to create policies to prevent and

manage it. At the moment, every time a diseased plant is found it is burnt. The projects are exploring whether is possible to disrupt biological processes or develop resistant plants, while protecting the natural environment. Since research is still being carried out, it is too early to capture outputs and research impact.

B.2.6. Programme outcomes and impact – ecosystem change

It is still too early to identify many structural changes brought by the programme. As these funders have worked together previously, they have already developed strategies of collaboration and good practices before SPF. Interdisciplinary programmes and intersectoral working have been at the core of the work they do for more than 20 years. They have also put in place what they consider to be the best practice, from what they have learnt previously. There is no evidence of radical structural change brought about by this funding. Nevertheless, with SPF funding, they were able to establish a coordination team, which had a transformative effect in terms of connecting people, bringing them together and ensuring that outputs have been captured.

The funders were able to refine a strategy that was already adopted in intersectoral programmes before this one. It involved having DEFRA and the Scottish Government rating the applications separately from the reviewers according to their fit to their strategic priorities. Considering the short timeframe, the funders were pleased to see that the ones rated best in terms of scientific excellence were also strategically relevant to the partners. In addition, the NERC representative in the Programme Management Group identified that spending more time and effort targeting the Learned Societies would have been beneficial to the programme, in order to have a wider range of disciplines involved and more collaboration between different partners.

In terms of intersectoral working, interviewees reported that this programme enabled a good balance between the long time needed to complete research and the short time of government that usually demands quick answers to tackle specific problems. SPF enabled these different partners that usually come with different agendas to co-design their priorities and meet in the middle ground. This was beneficial both for Research Councils and government organisations and they plan to continue developing partnerships in the future.

In terms of the MIDRI approach, funders are aware of the importance of involving different disciplines to develop a wider understanding of real problems. One interesting example to illustrate this comes from the diseases associated with insect vectors, such as the *Xylella* disease investigated through the BRIGIT project. Due to climate change, the UK is starting to deal with some vectors that were previously not found here and there is a need for additional capacity to build facilities to house and grow these insects and to understand their genetics. There is a narrow set of expertise that needs to be broadened out. With the help of SPF, a multidisciplinary team was put in place to address this issue from different perspectives. The stakeholders were already informed about priorities and were sharing strategic information among them. The fund allowed them to put this knowledge in place.

B.2.7. The Future

By the time of the final evaluation, all the projects will have been finished. There will be a cohort of people from different disciplines trained in the area of bacterial plant diseases. They will have brought their own skills and expertise from their fields of knowledge but will leave their projects with a deeper knowledge and interest in plant diseases. The programme will have developed an understanding of new diagnostics, new ways of treating plant diseases, how new technologies can support the development of more resilient plants, mitigations in the

environment, among other issues. In addition, it is expected that a better understanding of how these diseases spread and what change in behaviours we can engage with to avoid it.

It is too early to foresee further activities related to the programme. The funders will try to address other gaps in knowledge from other fields beyond bacterial plant diseases. The plant health community will continue to apply to funding calls to address these gaps.

B.2.8. Stakeholders interviewed

- Debbie Harding, Programme Lead, BBSRC
- Weihao Zhong, Research Council Partner, NERC
- Clare Trivedi, Government Department Partner, DEFRA
- Jef Grainger, Senior Responsible Officer, BBSRC
- Sarah Green, Director of the Programme Coordination Team, Forest Research

B.3. Ensuring the Security of Digital Technologies at the Periphery

SPF Wave 1	**SPF funding amount**: £30.6 m	**Programme Start and end date** 01/09/2018 – 31/03/2025
Lead Council / PSRE: EPSRC	**Other Council / PSRE**: AHRC, ESRC and IUK	**Government departments**: DCMS, GCHQ/NCSC and the Home Offfice
Key objectives • Ensure that Internet of Things (IoT) systems are safe and secure. The programme will investigate combined cyber and physical safety and security alongside human behaviour and provide evidence for required regulation		
Main phases • Research / funding calls • Synthesis, outreach and enagement		

B.3.1. Summary

The Ensuring the Security of Digital Technologies at the Periphery (SDTaP) programme addresses a core government priority, which is to continue to be leading edge in the fields of cybersecurity, artificial intelligence, and Internet of Things (IoT). SDTaP ensures the involvement of a multi and interdisciplinary team which delivers tangible outcomes to industry and government departments. The programme has now distributed all funding and the team is now busy synthesising final outputs. The programme is built on the expertise developed by the Privacy, Ethics, Trust, Reliability, Acceptability and Security National Centre of Excellence for IoT Systems Cybersecurity (PETRAS). The SPF funded 63 research projects, which increased the size of PETRAS from 16 to 23 universities (plus one other research institution).

The stakeholders consulted believe that the programme has enabled an increase in high quality multi and interdisciplinary research and innovation (MIDRI) in the field, which has borne fruit in terms of the outputs produced. More than 600 peer-reviewed articles have been published as a result of projects run through SDTaP funding and many of these outputs have been taken as policy recommendations by government departments and/or innovation initiatives by industry. SPF has given gravity and focus to demonstrators, whilst things were more dispersed before it. Furthermore, both academic and industry partners have enhanced their knowledge about how each other operates, which increases the potential for future collaboration.

B.3.2. Introduction

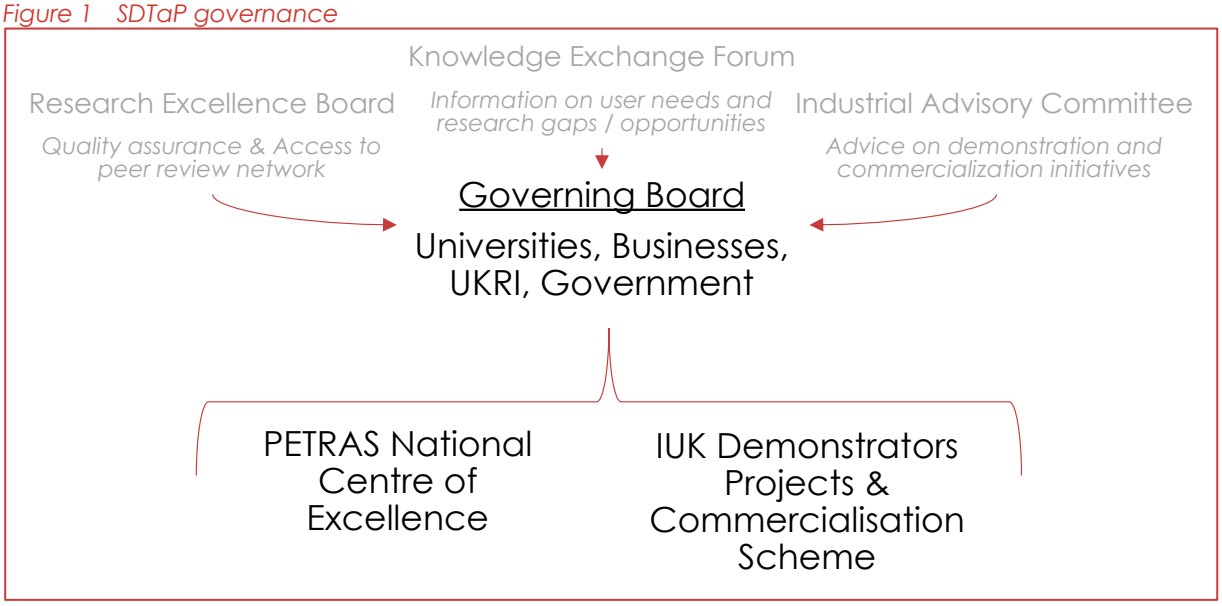
The increase in linkages and dependencies between systems, which is referred to as the 'Internet of Things' (IoT), makes people and gadgets more susceptible to cybersecurity threats. Cybersecurity is a UK Tier One National Priority. The country is among the top three in the world in cybersecurity and in Machine Learning and Artificial Intelligence (AI). Additionally, AI is one of five priority technologies identified by the UK Government, which suggests that the Security of AI systems and consequential issues of trust is a key area for further research.

While complex systems such as computers, tablets, and mobile phones have enhanced protection, peripheral gadgets connected to the Internet such as vacuum cleaners, lights, and alarm clocks have less sophisticated protection and are thus less resistant to threats. The

assurance that such systems will behave appropriately, even in unforeseen circumstances, must be addressed through improvements in system verification and validation as well as through methods that watch over, adapt, and limit their behaviour in response to shifting conditions. In particular, interdisciplinary research and innovation in the fields of technological, behavioural, legal, and ethical sciences is required to design effective solutions to this challenge. The SDTaP programme aims to develop knowledge and applied research in cybersecurity and IoT with peripheral technology to better understand and address the challenges posed by these growing threats.

The SDTAP programme involves four UKRI Councils (EPSRC, AHRC, ESRC and IUK), two government departments (DCMS and the Home Office) and a consortium of universities and other institutions that are part of the Privacy, Ethics, Trust, Reliability, Acceptability and Security National Centre of Excellence for IoT Systems Cybersecurity (PETRAS). PETRAS has a group of five universities that are part of the senior management team, called the quintet.

Figure 1 SDTaP governance



The SPF-funded programme built on the pre-existing PETRAS centre. Therefore, PETRAS got ~£14m of the ~£30m that SDTaP received and is heavily involved with the programme operation. IUK is another organisation that gives considerable input, through its demonstration and commercialisation programme, and received £11m. The rest of the SPF funding supported three research grants and fellowship projects which were related to IoT and consequently of interest for SDTaP, and numerous small grants for start-up businesses.

The programme has now distributed all funding. PETRAS ran two national open research calls since the programme started and an internal funding call. A total of 63 research projects were funded through these calls and they were able to bring seven more universities into PETRAS, taking the total from 16 to 23. They were also able to integrate government and industry partners in an enhanced way that did not happen before SPF, which this report explores.

Due to the impact of COVID-19, PETRAS was given a no-cost extension of six months and is due to complete in September 2023. The programme is currently focusing on synthesising the research outputs, ensuring that all research projects create societal impact, gathering evidence of impact that has already happened, and carrying out outreach and engagement activities. To support these activities, SDTaP has four synthesis fellows who are collating evidence of the outputs and outcomes, for publication by the end of the programme.

This report starts by exploring how the programme has been designed and its operational and day-to-day management. It then discusses outputs, outcomes and impact. It finishes by exploring what is expected to be seen in the final report and by the final evaluation.

B.3.3. Programme Design and Delivery

Intersectoral working and collaboration

As mentioned above, the SPF-funded programme is built on the existing PETRAS centre, which conducts the everyday operation of the programme, including the coordination of the different stakeholders. SPF allowed the continuity of the activities of PETRAS, including their dissemination and knowledge exchange activities.

PETRAS already has a good understanding of how to collaborate across various institutions but they also identified instances where SPF-funding has encouraged intersectoral working and collaboration in different ways, which are detailed below.

- PETRAS has been running events twice a year called User-Research Boards, where all academics, their industry partners, and the whole PETRAS community come together to share knowledge in panel sessions, workshops, and seminars.
- Funding calls included prerequisites of working together with an industry or government partner. In some cases proposals were received for projects involving more than one of these partners, which is considered a success. It is believed that the involvement of the IUK demonstrators programme means that researchers are connecting effectively with industry, both large and small.
- PETRAS has a Communications Team, a Business Development Team, and a Community Development Programme. Working together, these business units have played an important role in facilitating the involvement of partners in the implementation of the programme through outreach activities designed specifically to engage, and bring together, different industry sectors, government policy makers and academia.
- During the first months of the pandemic, PETRAS designed a News Digest that was sent weekly to stakeholders, and partners were coming together online to talk about it, mostly through Twitter. After the restrictions were lifted, PETRAS organised an overnight residential meeting for all partners to come together and see a poster exhibition of all their projects.
- The programme organises a monthly opt-in event open to all partners where three or four projects present their current work and what they have published. Industry partners can get to know the projects and provide input, feedback, or ask questions, and new partnerships sometimes arise from these conversations. These meeting are attended by around 100 people. These initiatives ensured both the online and offline coordination between the different partners.

EPSRC's Digital Security & Resilience theme, on behalf of UKRI, provides stewardship of the SDTaP investment, as part of its c.£120m portfolio of investments across the subject areas of cybersecurity, digital twins, and digital resilience. EPSRC works very closely with colleagues in Innovate UK, who oversee the SDTaP demonstration and commercialisation programme, as well as with AHRC, ESRC, DCMS, NCSC, and other government bodies. This stewardship includes conducting monitoring activities such as attending relevant governance board meetings, as wells as monthly meetings to discuss the actions, results, and outputs from the previous month, EPSRC commissions and oversees evaluation activities from time to time to enable it to seek assurance on the performance of its investments.

The main SDTaP board meetings with all partner organisations, including Ordnance Survey, DCMS, other companies, and SMEs, then happen twice a year and the partners are also

updated via email. SDTaP comprises 24 partner research institutions and around 135 government and industry partners in total. Considering the size of the team, this approach is felt to have worked well by those involved. Some of these organisations already worked together in the previous stage of PETRAS but SPF enabled the expansion of the team.

Multi- and inter-disciplinary approach

SDTaP had stated in their funding bid that MIDRI was a key objective of the programme. Partners believe this is a success as the funded projects involve a collaboration between a wide range of disciplines, including data science, law, physical sciences, social sciences, psychology, engineering, computer science, design, and the arts. Some of the technical fields such as engineering and computer science have much experience of working together in the field of IoT. However, the challenges that SDTaP seeks to address, which include issues of data protection, privacy, online safety and regulation, an understanding of human behaviour, and projections about imagining the future, to cite a few, require the contribution of other fields of knowledge that do not tend to work together.

The problems explored in the projects are unique in the sense that they are not purely technical or not purely behavioural, but socio-technical. This demands a strong network of experts coming from various fields to address this complexity. The size of the funding available through SPF enabled PETRAS to partner with more institutions and across more disciplines, which impacted on their capacity to address more complex and multi-faceted challenges than would normally be the case. This was built into documentation for funding calls and the development of funding panels to select high quality MIDRI proposals. The community has responded positively to the desire of more MIDRI proposals, which is demonstrated by the expansion of the PETRAS consortium from 16 to 23 universities (plus a research institution) and the growth of the variety of their research portfolio.

An example of this would be the Living Room of the Future exhibitions that were installed at the Tate Modern and the Victoria & Albert museums[9]. This exhibition emulated a living room where several appliances are connected to the Internet and to each other, some of them which are current technically possible and others which were products of artists imagination. The exhibition also collected information from how people would use and understand the implications of those technologies. This example shows the incorporation of site design fiction into technical projects in partnership with behavioural sciences, which demonstrates the high level of coordination between different fields of knowledge that do not tend to collaborate. Another interesting example is the PrivIoT research project, which deals with privacy, data protection and IoT. Fields of knowledge include criminology, power systems, IoT, psychology, and human-computer interaction. They are now moving on to the next stage of their research which is how to best communicate and visualise these threats and opportunities with domestic users. They are doing this through a citizen science approach, i.e. they will be involving volunteers from the public to conduct scientific research.

To encourage MIDRI proposals, it was very clearly stated in the open calls that interdisciplinary work was required. Socio-technical bids were also strongly encouraged in PETRAS calls, while the core 'Hub' coordinating universities had joint programme leadership, covering social and technical disciplines. The formation of a senior academic advisory group from the five PETRAS founder universities (the 'Quintet') has further supported and encouraged a MIDRI approach, with membership covering Design, Cybersecurity, Engineering and Computer Science.

[9] https://imagination.lancaster.ac.uk/update/living-room-of-the-future-at-tate-modern/

Changing needs and opportunities

Because of the COVID-19 pandemic and the lockdowns, the programme shifted some of its approach to adapt to the online environment. They realised early that carrying out shorter but more frequent events could help maintain momentum and keep the engagement between different partners. SDTaP started to release industry briefings, looking at the key trends in industrial sectors, and organised events called 'fireside chats', where an academic expert met an industry expert to talk about these briefings. During the lockdowns they also released a podcast that brought different people to talk about the same subject from a different angle. In addition, the programme also organised landscape briefings, which were short, sharp, and easy to read texts, where they tracked the use of IoT technologies in response to COVID-19.

B.3.4. Programme Outputs

The programme has been able to continue to attract high quality MIDRI projects with the help of SPF. PETRAS evaluates the final reports and decides what can be published out of that work and more than 600 papers have been published so far[10]. They identify the work of being of the highest quality, and 85-90% of the projects have been concluded until now. In addition, all the projects have been assessed and the successful ones were sent to the Advisory Board for their approval. This board is made up of various experts across academia, industry, and government and they are always very pleased with the excellence of the projects.

Programme outputs include:

- The establishment of the four synthesiser fellows, academics who work across the projects to identify what is the common learning and what can be fed into government policy or practice in industry. They are responsible for collating and disseminating findings from studies to the programme partners, including industry and government. They organised an online database of all research outputs, which are now available on PETRAS website, and are the ones who set up the knowledge exchange events described above.
- Policy recommendations have already been and will continue to be published by research originated from SDTaP. Synthesiser fellows continue to submit these to potential decision makers in government.
- PETRAS takes part in conferences in the field of IoT where they identify current and potential stakeholders in industry and government to share outputs and hear feedback from them. One example was the exhibition stand that PETRAS hosted in the 2022 CYBERUK[11], the flagship event of the UK National Cyber Security Centre (NCSC) in Wales on May 2022.

It is still early to present more concretely how outputs have been relevant to end-users, but PETRAS organisation and participation in outreach and dissemination activities is promising.

B.3.5. Programme outcomes and impact - R&I to address priorities

SDTaP includes a research wing that is coordinated by the PETRAS team and an innovation wing, which is maintained by Innovate UK. The innovation wing is comprised of two elements: the business lead demonstrators and the commercialisation element. IUK gives the research partners the tools to help them to create products, services, or technologies that are close to market needs. In this sense, projects that are funded by SDTaP/PETRAS are strongly connected with the demands of the industry partners and often these industry partners sit on the advisory

[10] All project outputs can be found on PETRAS website: https://petras-iot.org.

[11] https://petras-iot.org/update/petras-at-cyberuk2022/

board for the project throughout the delivery. BMW and Volkswagen, for example, are involved in projects related to the application of the IoT to vehicles, whereas Cisco, Microsoft, Airbus, and Telefonica, to cite a few, have strong links with projects related to the development of new IoT systems.

Additionally, £1million from the £11 million IUK budget was separated to fund numerous small start-up businesses in the field of cybersecurity, costing £60,000 per project. This was implemented to make sure that the research has real world impact, and would not have been possible without the SPF funding. One example that illustrates the high social and economic impact of the contributions comes from a small project that was funded by PETRAS combining academic and industry experts. It was acquired by Siemens, who helped them to expand their customer base and to showcase the outputs from the SDTaP programme to potential partners around the world.

Another example of a high-scale impact includes the publication of the PETRAS Little Books of IoT, a series of books that seek to convey concepts to children related to the IoT that can sometimes be difficult to understand in an approachable and simple manner. The series is featured as part of the World Economic Forum's (WEF) Global Action Plan, as an example of how communities can engage with cybersecurity, and was the result of a joint effort between the SDTaP team and WEF. A further example is the aforementioned podcasts, which are still being downloaded several months after their release. This demonstrates the longevity of many of these outputs, which become part of the online archive and continue to be relevant to end-users. Outputs are related to healthcare, culture and arts, charity, supply chains, food production, children's toys, and many other areas that IoT can contribute to.

In addition, PETRAS produced several policy recommendations related to cybersecurity and IoT, including, for instance, on the ethics of using IoT sensors in public places. DCMS and DfT have adopted policy advice in official positions[12][13], and industry has absorbed learning in their product and service development. The research council partners believe they are highly influential in terms of informing government and industry. The impact is already felt by most of the partner organisations, while others such as the Home Office expect to see impacts of the programme only in a few years. They are looking at results for products and services, such as the further development of the British automated border control system (eGates) present at 15 air and rail ports. The Home Office partners believe that SDTaP is laying the groundwork for this project. Overall, it is believed that SPF has given gravity and focus to demonstrators, whilst things were more dispersed before it.

B.3.6. Programme outcomes and impact – ecosystem change

One of the challenges identified by the stakeholders consulted related to the size of the programme, which involves more than 100 academic and industry partners, and maintaining close communication between the academic colleagues and wider stakeholders. SDTaP enabled the development of a new protocol of cross-institutional communication and collaboration across the board detailed above. The team from PETRAS believes that they will take forward this high-level coordination protocol to future developments of the programme. For example, SDTaP inherited Impact Champions from the first PETRAS programme but changed their name to Business Development Executives. These are two staff members whose job was to maximise the impact of the projects. Their main tasks were to understand the projects, talk to the researchers and take those ideas to the public and private sectors to

[12] https://petras-iot.org/wp-content/uploads/2022/02/Full-Policy-Briefing-here.pdf

[13] https://petras-iot.org/wp-content/uploads/2022/02/MASS-policy-briefing-short.pdf

maximise their impact. This ensured the smooth flow between the different partners. They also introduced the four synthesis fellows, already mentioned above, who identify where there is common learning, which can then be fed into government policy, or practice in industry. Each fellow is responsible for a different sphere of the programme: ethics, cybersecurity, artificial intelligence, and public outreach. Finally, PETRAS created a cyber federation with other centres and institutes where they share events and arrange meetings for partners to get together, which catalyses more value out of the pre-existing partnerships. All these initiatives are now part of the PETRAS portfolio as a legacy of SPF.

In addition, the PETRAS Team believes that SPF has enabled ecosystem change in several ways:

- The way that academics operate in relation to industry and government needs. University researchers were enabled to leave their comfort zone and transfer some of their interesting ideas to being closer to the marketplace. They started to think more about market. segmentation and return on investment and learnt how to pitch an idea before an investor.
- Industry partners are also now more willing to identify problems in their processes and ask academics how to solve these. As a result, representatives from industry have also now gained a better understanding of the work performed by academics.
- SDTaP has also enabled new ways of working together across disciplines that have little history of working together, such as design fiction and engineering, and they expect these partnerships to continue beyond SPF.

Other examples of ecosystem change are less immediately clear and will likely be felt 3-5 years from now, but it was noted that the feedback that the coordination team received from collaborators was outstanding and helped to increase the programme visibility and reputation.

Representatives from the Councils believe that SDTaP is successful in bringing different disciplines together and allowing government and industry representatives to work closely with academia to produce research that addresses complex challenges and government priorities. Government departments are also pleased to take recommendations from the programme and are looking forward to seeing tangible results after the programme is finished.

B.3.7. The Future

Looking forward, Government partners are expecting that concrete outputs from research funded through SDTaP will be available for uptake, including policy recommendations and services and products that can be commercialised. Several projects are going to come to an end that have clear relevance and potential for impact, including a system to protect elderly and vulnerable people from spam emails and unwanted phone calls through artificial intelligence and another to improve the eGates system for border control. The complexity of the management of the programme will also be described in an academic paper to be submitted to Harvard Business Review.

There is also an ongoing discussion within PETRAS about what they want to do next, after the current SPF funding comes to an end. There is a desire for continuity to PETRAS 3 which would be even more closely integrated with the innovation pathway, so the co-bidding between industry and academia is simplified. However, there is currently uncertainty about where future funding will come from.

B.3.8. Stakeholders interviewed

- *Gregory Smith, Portfolio Manager in Digital Security & Resilience, EPSRC*
- *Mark Gaskarth, Head of Theme for Digital Security & Resilience, EPSRC*
- *Georgios Papadakis, Senior Innovation Lead, Innovate UK*

- *Rupert Shute, Government Department Partner, Home Office*
- *Jeremy Watson, Director of PETRAS, UCL*
- *Eleri Jones, Head of PETRAS, UCL*
- *Peter Novitzky, Senior Responsible Officer, UCL*

B.4. Productivity Institute Programme

SPF Wave 2	**SPF funding amount**: £42.4 m	**Programme Start and end date** 01/08/2019 - 01/07/2026
Lead Council / PSRE: ESRC	**Other Council / PSRE**: IUK	**Government departments**: HMT, BEIS, DWP
Other partners: University of Manchester, with the University of Cambridge, the University of Glasgow, King's College London, the National Institute of Economic and Social Research, Queen's University Belfast, Sheffield University, the University of Warwick, Cardiff University and Oxford Brookes University. Plus the London School of Economics, Universtiy College London, the University of Aston, Oxford Bookes University and the Institute for Fiscal Studies.		

Key objectives

Primary Objectives

- To create a step-change improvement in productivity research and innovation in the UK by establishing sustainable world-leading structures and capabilities delivering a coordinated and comprehensive programme of work directly addressing the challenge of improving productivity;
- To become a recognised world leader in productivity research, providing world-class thought leadership that encourages new approaches that may reshape the field of productivity research and transform our understanding of it;
- To improve the systematic and sustained generation and use of evidence and the capability to embed research within policy and practice across regions and sectors to improve UK productivity;
- To develop solutions and interventions for improving productivity based on high-quality evidence, that can inform policy and be embedded within organisations;
- To look at un- and under-explored sectors, places and groups, including addressing strong spatial dimensions and understanding the long-tail, challenges and successes of larger businesses and those at the productivity frontier;
- To form an interdisciplinary community taking a coordinated, interdisciplinary approach to productivity research and policy addressing long-term productivity challenges;
- To forge mutual, lasting engagement between the UK productivity-related research community and policy-makers, practitioners and business;
- To create an agile mechanism to provide rapid and timely advice to policy makers and businesses.

Secondary Objectives

- Increased capability of social scientists working directly with business;
- Increased capability of business and policy working with the research base;
- Increased understanding of policy making processes in social scientists through learnings from embedding researchers within policy making bodies.

Main phases

- The Productivity Institute: a £32 million investment headquartered at the Alliance Manchester Business School at the University of Manchester brings together world-leading experts from a range of disciplines and works with policymakers and businesses to better understand, measure, and enable improvements in productivity across the UK.
- The Programme on Innovation and Diffusion: a £5 million programme is based at the London School of Economics (LSE) carrying out research on how to boost productivity through nurturing innovation and how to diffuse these ideas across the economy.
- Seven thematic investements: £1.5-2 million programmes funded through a call 'Research to improve UK economic productivity' to add to the portfolio of ongoing productivity research.

B.4.1. Summary

The Productivity Institute Programme is one of the largest ever investments made by ESRC. It consists of nine separate investments that seek to tackle the productivity puzzle, which is one of the most important issues for the UK economy.

Those consulted for the case study agreed that the SPF funding has made it possible to bring together a diverse set of disciplines and actors on an unprecedented scale to address complex and multifaceted challenges around productivity. All investments employ a multi- and interdisciplinary research agenda, which was a criterion in the calls. Different government departments have been involved in the programme from the bid development stage. Together with ongoing dialogue, this has ensured that the investments are not only addressing government priorities but are also helping the government identify what is required to improve the productivity of the UK.

A programme-level evaluation is ongoing and the report from the first phase (Framework and Baseline) has recently been published on the UKRI website (April 2023). Those consulted for this case study have suggested that the key outcomes from the investments so far include the following:

- The Productivity Institute Programme has successfully set up and refined its thematic research programmes that respond to long- and short-term priorities and opportunities. It has also published several research outputs that are considered by those consulted for this case as "intriguing", "of high-quality", and "relevant for many potential end-users".
- The Productivity Institute has successfully established mechanisms for long-term intersectoral collaboration and multi- and interdisciplinary working: the Regional Productivity Forums, the Policy Commission, and the Productivity Lab.
- Some early signs of ecosystem change and examples of outputs being taken up by end users were reported, yet the wider impact of research outputs as well as intersectoral collaboration is to be demonstrated.

B.4.2. Introduction

Compared to many of the UK's peer nations, such as France, the USA and Germany, UK productivity is lower, by some estimates up to 20% lower, with significant impacts on public finances, wages and resources. As the productivity of a nation is directly linked to its overall economic performance and to citizens' living standards, stimulating productivity is a significant challenge faced by the UK. Raising productivity levels across the UK is a concern for many businesses and policy makers, but tackling it is a complex 'wicked' problem with no easy solutions. Years of investment in productivity research has not yet yielded a systematic understanding of what would be effective for individuals, firms, and wider policy to close the UK's productivity gaps.

There have been two related programmes supported through SPF to tackle this productivity puzzle. The first programme (running from 2018 – 2023) was examined as a case study at the baseline stage of the Fund evaluation. The purpose of that programme was to galvanise a multi- and interdisciplinary community, and early findings and learnings also fed into the development of the bid for the Wave 2 programme (the Productivity Institute), which is the focus of the case study developed for the interim evaluation. The key features and progress of

the nine investments[14] (funded under three separate strands) comprising the Productivity Institute Programme (PIP) are explained below:

3. **The Productivity Institute** (TPI), headquartered at the Alliance Manchester Business School at the University of Manchester and spread across partner institutions around the UK[15]. The Institute began in September 2020 and is funded for 60 months. It was reported that the launch phase of TPI and setting-up the Institute and its activities took longer than planned, mainly because of the COVID-19 pandemic, but also resource constraints amongst partners. Despite this, the programme is now making good progress and functioning as expected. Two years into the programme, TPI has successfully set-up its basic management and core functions and collaborations with policy and business partners (see next section). It has also set-up its research activities and formulated its research agenda that stretches across eight research themes, which are led by theme leaders from the partner institutions. During the first year, the Institute brought together 40 co-investigators and employed 12 post-docs. By July 2022, 25 research projects had been started (10 of which have already been completed). TPI has also allocated the first grants for its fellowship programme (with two other fellowship calls in preparation).
4. **The Programme on Innovation and Diffusion** (POID) is independent of TPI but works complementarily to it. POID began in September 2020 and will run for 60 months. Since its inception POID has made good progress. It has set-up its organisation and built its research agenda which is organised around nine research project themes. POID's senior researchers come from universities in the UK, US and France. It also employs post-docs, pre-docs, and research assistants. The director and deputy director of POID together with the theme leaders decide on the distribution of funding across the research agenda.
5. **Seven thematic investments** listed in the table below have started in spring 2022 and will run for 36 months.

Investment	Research organisation
Productivity, Wages and the Labour Market	Institution for Fiscal Studies
Diversity and UK Firm Performance	University College London
Diversity and Productivity: from Education to Work	London School of Economics and Political Science
Understanding how constraints on access to finance and under-investment impact on productivity growth in smaller firms	Oxford Brookes University
Understanding how servitization can impact UK economic productivity and environmental performance	Aston University
Productive and Inclusive Net Zero: opportunities and barriers in the transition to sustainable and equitable growth	Imperial College London
Mental health and well-being practices, outcomes and productivity: a causal analysis	University of Warwick

[14] https://www.ukri.org/what-we-offer/browse-our-areas-of-investment-and-support/the-economy/productivity/

[15] University of Manchester, with the University of Cambridge, the University of Glasgow, King's College London, the National Institute of Economic and Social Research, Queen's University Belfast, Sheffield University and the University of Warwick.

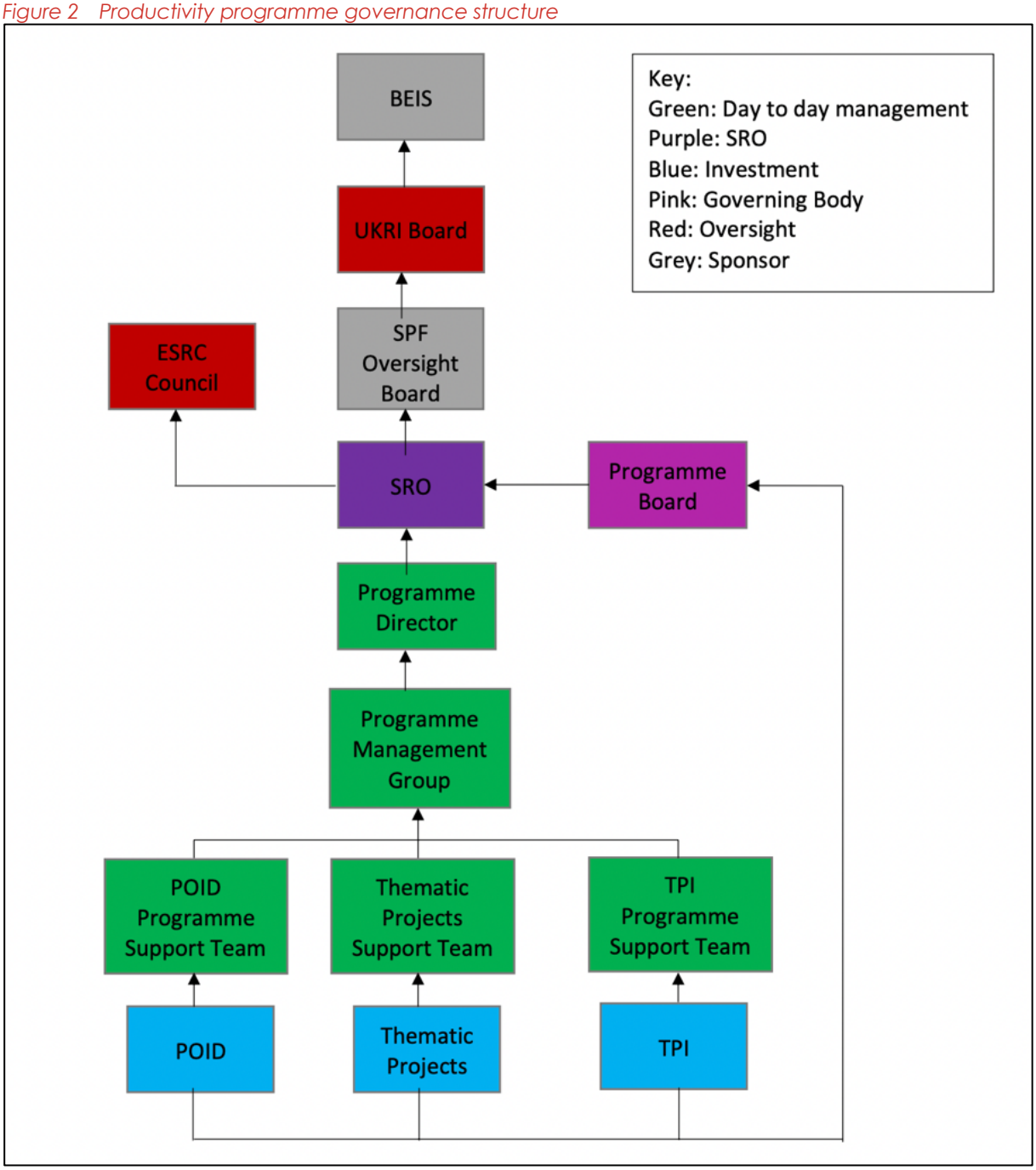
The consulted stakeholders emphasised that the scale of the PIP, and especially TPI as an Institute (rather than a project), allows it to address complex and multifaceted challenges in ways that would not have been possible otherwise. The SPF funding has made it feasible to bring together a diverse set of disciplines and actors on a scale not seen before. For example, a systematic approach to government priorities such as levelling up and net zero would not have been viable with small-scale grants. Furthermore, the multi- and interdisciplinary research & innovation (MIDRI) approach taken in the programme has allowed some government priorities, such as wellbeing and work, to become part of the productivity narrative, giving these issues greater prominence.

The primary focus of this report is on TPI, it being the largest and most advanced investment in the portfolio. Insights from POID are also included to some extent, while the seven new thematic projects are only referred to on a few occasions (as these were only just beginning at the time that the fieldwork was taking place).

B.4.3. Programme design and delivery

The governance structure of the PIP is presented in Figure 1. The programme is governed by the Programme Board that has members from ESRC, UKRI, government departments and independent members. The Programme Board meets quarterly, and its main role is to provide strategic delivery oversight and advice and guidance to the Senior Responsible Officer as well as make connections to policy and look at how research can be synthesised. There are plans at the programme level to host coordination and synthesis workshops to bring together knowledge across the nine investments. An introductory session was held in September 2022. Apart from these workshops, there are no mechanisms for the different investments to collaborate at the programme level. For example, TPI and POID are not expected to work together, but they do co-ordinate their research agendas through discussions to make sure they work complementary of each other. The seven thematic investments have also expressed interest in working together, but as they only began work in Spring 2022 no concrete plans have yet been made.

Figure 2 Productivity programme governance structure



Source: Adapted from ESRC internal document

Intersectoral working and collaboration

TPI seeks to build a network and connect relevant people and actors to address the productivity challenge. Although the launch phase of the Institute took longer than expected, stakeholders agreed that TPI now has a comprehensive system of governance and intersectoral collaborations in place to support its mission and objectives. The management team of TPI consist of the Managing Director, Research Director, an Engagement Lead and an

Operations Lead. The table below explains the wider governance of TPI and the intersectoral collaboration in the delivery of the programme[16]:

Table 7 TPI governance – role and intersectoral involvement

Governance structure	Role and tasks	Intersectoral involvement
Management	Executive Team is responsible for Institute strategy and strategic decisions; Executive Committee is responsible for operational decisions; Management Team is responsible for daily management and tactical execution (support by programme staff).	Management team and representatives from other participating universities
Governing Council (GC)	Oversees the strategic direction of Institute, signs off on financial decisions for unallocated budgets; oversees performance of three members of management team; oversees dispute resolution (and advises ESRC where needed); represent Institute at occasions	Members from academic and business communities as well as representatives from the University of Manchester, SC, ESRC and government partner (BEIS).
Advisory Committee	To garner insights from a wide range of experts in academia, policy and business to help TPI develop and implement an effective programme of activities and research	Members from academia, business and policy, plus international and independent members.
Internal Oversight Board	Provides overall oversight on internal matters to support the operational delivery of the objectives and finances of the Institute and make certain the overall success of the Institute. The Oversight Board will recommend matters, as required, to the Governing Council for further consideration.	Members from academia, businesses, and policy actors as well as independent and international members.

https://www.productivity.ac.uk/wp-content/uploads/2022/10/TPI-Annual-Report-2021-22-FINAL-031022.pdf

The overall impression among those consulted for this case is that the different partners work together well and complement each other in terms of their expertise and capacities. To strengthen further the collaboration between academics and businesses, TPI has chosen to work with business partners such as 'Be the Business' and 'Confederation of British Industry' that are well established with large networks. Dialogue between businesses and academia is a known challenge and turning academic work into usable workplans for businesses is difficult. Using these well-established organisations as intermediaries is expected to deepen the links between academia and businesses and help in translating research into applicable ideas for businesses. With the funding from SPF, TPI can provide a platform for this type of work. Partnerships with the intermediary organisations have been established and the development of a workplan is underway.

POID is managed and governed by its Directorate (Director, Deputy director & administrative team) and Advisory Committee, which includes members from academic and business communities, government departments, research councils and international organisations[17]. The Committee advises the director and deputy director on the progress and strategic direction of the programme. It is also responsible for monitoring the progress of projects against the agreed objectives, quality assurance and contributing to the communications and dissemination strategy of the outputs. It meets regularly twice annually. As part of the delivery

[16] https://www.productivity.ac.uk/wp-content/uploads/2021/10/TPI-Annual-Report-2020-21-FINAL.pdf

[17] https://poid.lse.ac.uk/textonly/_homepage/POID-annual-report_2020-21_FINAL.pdf

of its research agenda, POID collaborates with businesses, policy makers and other organisations through connections and networks that have been built over decades of research. POID seeks to create new knowledge and change the conversation around productivity – and bring this knowledge to the policy makers and businesses.

Multi- and Inter- Disciplinary (MIDRI) Approach

Both calls launched by ESRC were framed in such a way that the MIDRI criteria were evident. For example, a requirement to include disciplines beyond economics was explicitly written in the call text and a specific criterion for peer-reviewers was to consider the level of multi- and interdisciplinarity of the proposals. For the thematic investments call, the MIDRI criteria were formulated through internal discussions at the ESRC and looking at other SPF calls. The ESRC-led panels included members from academia, policy and business. The panel composition was seen as significant in securing a selection of projects that are multi- and interdisciplinary and fit to the interests of different partners. Due to the large size of the PIP, there were challenges in finding peer-reviewers who were not already associated with the programme, especially within the thematic investments call. As finding peer-reviewers was challenging, the funder had less time to explore new ways of improving the MIDRI focus of the panel. This is recognised as an area for future improvement.

The overall impression among the partners was that the research conducted by the investments covers a good range of disciplines, although the main body of researchers are economists. POID's research agenda includes researchers from disciplines such as geography, climate science, management and history. At TPI, a key factor contributing to the MIDRI approach is that it has taken a business school approach as opposed to traditional economics approach to adopt a broader orientation around productivity. Apart from economics, disciplines such as management and innovation, political science, healthcare, digital, geography, and public sector are brought together under the eight research themes of the Institute. TPI has identified two disciplines, 'hard' sciences and behavioural sciences, that are not included in the research agenda but would have great potential in questions around productivity. The Institute is planning to put more effort in incorporating these two disciplines in their research programme. Some concerns about methodological diversity were expressed among the stakeholders - particularly the limited use of qualitative methods. The inclusion of behavioural sciences is recognised as an opportunity to also increase the methodological diversity.

Changing needs and opportunities

Recent developments (e.g. the pandemic, geopolitical conflicts, energy crisis and rising inflation) mean that the macro environment is very different from two years ago when the first investments, TPI and POID, were launched. Both investments have been responsive to this changing context, for example by conducting research on the impact of COVID-19 on productivity. Furthermore, TPI has shifted its approach to research from the 'bottom up' to a more directed and focused approach with the aim to optimally engage with business communities and policy makers. The Executive Team has identified 7-8 specific programmes that will be developed over the next three years. TPI also recognised a demand for short-term flexible projects that can respond to business needs on specific questions. For this, they developed 'Innovation Sandpits' that are short (two week) collaborations between researchers and businesses to identify and solve a specific problem.

B.4.4. Programme outputs

MIDRI proposals and projects

Two proposals were submitted in the main call for funding of the Productivity Institute. Both were interdisciplinary in nature and considered strong proposals by the peer-reviewers and the panel. The decision to fund TPI was based on it being more of an institution in its structure and more targeted on UK productivity. POID was a work package in the unsuccessful bid for the Institute and was granted £5 million to do work on innovation and diffusion (which TPI was not doing). For the thematic call to fund smaller investments, ESRC received 20 proposals - well beyond expectations. The final decisions were based firstly on academic excellence and secondarily on ensuring that research gaps in the existing portfolio were filled and research was not duplicated.

The MIDRI requirement embedded in the programme has brought together diverse disciplines such as economics and mental health, as well as encouraged research communities to work more closely with businesses. Within TPI, the establishment of the RPFs are a good example of this MIDRI approach.

The scale of TPI is needed for an interdisciplinary research agenda and to create networks and forms of collaboration across academia, businesses, and policy. Those consulted reported that without the funding from SPF some of the ongoing work would have been taken up and funded elsewhere, but it was particularly the MIDRI requirement and the scale of the investment that has made it possible to address the complex productivity puzzle that the SPF funding enables.

R&I outputs

Results from the completed and ongoing research projects at TPI and POID have been published in academic journals and edited collections, working papers, insight papers, blog posts and briefing papers. A book on *The Economics of Creative Destruction* has also been published that includes 25 papers from a conference in 2021. The book was seen by those consulted as an intellectual landmark in the field of productivity and growth.

Both investments use various channels and mechanisms to collate and disseminate outputs. All research outputs are collated and thematically organised on their websites[18] and highlights are included in newsletters and social media postings. Both investments run seminar series and research results have been presented across various academic conferences and public events. TPI has held annual conferences for research and business and hosts a new podcast 'Productivity Puzzles'[19]. The podcast has total of 7,000-8,000 downloads and is a good example of a wider societal dissemination of the work done at TPI. Furthermore, the investments reported that they had met with high-level politicians and attended various meetings with businesses, policy makers and international organisations.

Within TPI, the RPFs and the PC are especially important in identifying and engaging relevant end-users. The eight RPFs are key in bringing together and engaging with regional and local businesses, policy makers, and research institutions. Six out of the eight RPFs have published working papers to identify productivity issues in the regions[20]. The next stage for the forums is to

[18]https://www.productivity.ac.uk/; https://poid.lse.ac.uk/

[19] https://www.productivity.ac.uk/resource-centre/digital/

[20] https://www.productivity.ac.uk/wp-content/uploads/2021/11/PIP007-Wales-Productivity-Challenge-FINAL-011221.pdf; https://www.productivity.ac.uk/wp-content/uploads/2021/10/PIP009-East-Anglias-Productivity-Challenge-FINAL-250122.pdf; https://www.productivity.ac.uk/wp-content/uploads/2021/11/PIP006-Scotlands-Productivity-Challenge-FINAL-011221.pdf; https://www.productivity.ac.uk/wp-content/uploads/2021/11/PIP003-The-North-West-of-Englands-Productivity-Challenge-FINAL-301121.pdf; https://www.productivity.ac.uk/wp-

define a programme and research areas that helps them to move their agendas forward. TPI also facilitates a network of RPFs which is a space for the forums to learn from each other and share knowledge and good practices. They hosted a successful webinar in June 2022 bringing all eight forums together to discuss topics about productivity in business, digital transformation and the four-day work week. The webinar will become a regular feature.

On the policy side, the PC was established with the aim to develop and support national debate on productivity and promote robust and consistent policies. To date the PC has held three evidence sessions and published its first evidence report in June 2022[21]. After publication, they were invited by the Department for Levelling Up, Housing & Communities (DLUHC) to discuss the insights of the report.

B.4.5. Programme outcomes and impact – R&I to address priorities

Overall, all those consulted considered the research outputs from the investments were intriguing and of high quality, however some suggestions for improvement were made. In the future, the investments are hoped to produce more novel perspectives on productivity and bring in more unconventional ideas for future directions. Furthermore, among the representatives from government some concern was expressed about how to make data more accessible for different users, and how to keep an overview of the large volume of R&I outputs and data. It is believed that the Productivity Laboratory that TPI launched in January 2023 will be beneficial in collating and bringing together a diversity of data sources and facilitating access to those data. The Lab is the Institute's 'engine room' for data, surveys, and expertise on creating and using datasets for the purpose of research and application[22]. Once fully operational, it is expected to collate data and knowledge in a systematic manner in an institutional level, which would not have been possible without the SPF funding.

Stakeholders also believe that the research findings have been read and seen by many possible end-users and are relevant in addressing questions in areas that are important to government and businesses (e.g. concerning impact of COVID-19 to productivity; net zero; regionality and levelling up; innovation and enhancing innovation; skills and talent; wellbeing at work; industrial restructuring across regions). Many stakeholders stated that the impact of the high-quality research was not yet evident; firstly, because research is still being carried out, and secondly, because of the non-linear process between research and policy impact. TPI and other stakeholders, however, highlighted the importance of improving the synthetisation of research outputs into targeted messages and recommendations that can be implemented by policymakers and business communities. A problem in this regard identified by TPI is the narrative around productivity. Productivity, being a multifaceted concept, means different things to different actors, which makes engaging all relevant actors challenging. TPI has launched functional productivity projects to explore different ways of thinking about productivity across business functions and to incorporate all these elements into the productivity narrative. The aim of the projects is to make the concept of productivity relevant, operational, and useful for all business functions. TPI is holding a business conference in

content/uploads/2021/11/PIP004-Northern-Irelands-Productivity-Challenge-FINAL-171121.pdf; https://www.productivity.ac.uk/wp-content/uploads/2021/10/PIP010-Midlands-Productivity-Challenge-FINAL-070122.pdf

[21] https://www.niesr.ac.uk/publications/productivity-uk-evidence-review?type=uk-productivity-commission

[22] https://www.productivity.ac.uk/wp-content/uploads/2021/10/TPI-Annual-Report-2020-21-FINAL.pdf

September 2022 which is centred on the productivity narrative and will disseminate the results of these project to businesses and policymakers.

As mentioned, it is too early to assess to what extent R&I outputs have been taken up by the end-users, but there are, nevertheless, examples to show some early use of the outputs:

- TPI has engaged in various discussions regarding government's levelling up priority through its research and public engagements. For example, research conducted at TPI was referenced in the Levelling Up white paper[23] published by the DLUHC and recognised by the Academy of Social Sciences in their recent policy report 'The Place to Be: How social sciences are helping to improve places in the UK'[24]. Further discussions with DLUHC about the engagement of TPI in helping to achieve the goals and objectives identified in the white paper are ongoing.
- Both TPI and POID have both contributed to the 'Jobs, growth and productivity after coronavirus' report[25] published by the House of Commons Treasury Select Committee. TPI and POID researchers gave oral evidence to the committee on various questions related to productivity, for example improving skills, increasing equality in housing, adoption of technologies, remote working, and training of managers.
- POID researchers are involved in the Resolution Foundation Economy 2030 Inquiry[26]. It seeks to help the UK government to understand better and navigate economic change in the 2020s. As part of this contribution a representative from POID was invited to take part in a panel discussion together with representatives from BEIS and Resolution Foundation.
- POID has contributed to the government's 'Help to Grow' programme[27] by conducting research on the management practices and discussing the research results with various policy makers.

B.4.6. Programme outputs and impact – ecosystem change

The programme participants have experienced a variety of challenges during the first two years of the programme. These experiences have resulted in a number of learnings and improvements in the implementation of the programme/investments. At the programme level, the lack of prior experience at ESRC in managing a programme of this size has presented its challenges. For example, a Gateway 4 review suggested that a stronger team and adequate training for ESRC staff working on the programme would be beneficial in managing the programme more efficiently. These recommendations were acted upon swiftly by providing training for staff and establishing a new team 'Productivity and Growth'. Furthermore, the lack of platform and space to share knowledge and best practices across the Councils and SPF investments is viewed as a missed opportunity.

To strengthen intersectoral work TPI has adjusted its approach in the selection of partners to work with. TPI aroused great interest among many parties since its inception. They first tried to be responsive to all interested parties but that did not always result in good and beneficial collaboration. TPI has learned to be more strategic in choosing the partners they work with,

[23] https://www.gov.uk/government/publications/levelling-up-the-united-kingdom

[24] https://acss.org.uk/wp-content/uploads//Academy-of-Social-Sciences-The-Place-to-Be-Policy-Report-2021-v.0.pdf

[25] https://committees.parliament.uk/publications/23031/documents/168790/default/

[26] https://economy2030.resolutionfoundation.org/

[27] https://helptogrow.campaign.gov.uk/

especially regarding business partners. Key in this has been to choose partners that complement each other's work. For example, 'Be the Business' has good knowledge about SMEs while they lack research capacity. Another challenge brought up by many stakeholders is the balancing between the short-term needs of business and policy and the long-term focus of research. The 'Innovation Sandpits' at TPI were developed to answer to the short-term needs of businesses.

In terms of MIDRI approach, the stakeholders recognise challenges such as academic practices and publishing incentives that do not encourage research in interdisciplinary work. Considering these challenges, the requirement for MIDRI approach in the SPF is seen as essential in the inclusion of a diversity of disciplines in the investments. To advance further the interdisciplinary work conducted at TPI, the Executive Team has decided to put stronger emphasis on interdisciplinary research teams in topics around productivity and healthcare, employment, and net zero as these are core elements in tackling the productivity puzzle.

A main challenge in addressing government R&I priorities discussed by all stakeholders is the breadth of the topic (productivity) and it being relevant across many government departments. Here the challenge is not only to identify the changing government priorities and to navigate in a volatile political environment but also to help the government to understand what their priorities are. As a response to this challenge, TPI has, on the one hand, adopted a more directed approach in its research strategy to have more focused topics to engage with policy makers. The work around digital and net zero are good examples of this more focused approach. On the other hand, the PC was founded to help the government to identify their priorities. The PC is still in an early stage, but its work has been promising so far.

It is still early to identify many structural changes brought by the programme. Nevertheless, there are some promising early signs, for example with the RPFs having created new connections and partnerships that are intended to have a long-lasting impact.

B.4.7. The Future

All investments will continue pursuing their research agendas and will continue to develop dissemination and engagement activities. For POID future highlights include the renewed and piloted World Management Survey in 2022/23. At TPI, future highlights include the implementation of the research fellowship programme which will bring more early-career researchers into the research community as well as turn more focus on policy and practice.

As part of TPI's business and innovation programme, the remaining £1.4 million funding is planned to be used on Business Transformation projects to focus on issues such as digital and net zero among businesses. This case study approach is expected to include around 100 companies over the next two years.

Before the SPF, a weakness in the UK productivity research and policy has been that there are no durable institutions around it, and question and solutions are scattered across different research institutions and government departments. While there have been many great ideas and high-quality research on productivity in the UK, the long-term problem has been the execution of these ideas in collaboration with research community, policy makers and businesses. TPI is the first-time different needs, priorities and research outputs are brought together under one institution. The SPF funding has enabled setting up the Institute and establishing its place among the research community, businesses, and policy makers. Within the five-year period, it is possible to get people involved and build stable relationships between

TPI and its partners, but that is only a beginning. The question for the future is whether the investments can continue to deliver against their objectives and whether the programme model and investments are the right way to sustain and continue these in future.

B.4.8. Stakeholder interviewees

- Programme manager, Madeleine Parsley, ESRC
- Programme director, Damien Smith, ESRC
- Programme partner, Geeta Nathan, Innovate UK
- Government partner, Mike Daly, DWP
- Government partner, Dan Mawson, BEIS (and PIP Programme Board member)
- Programme partner, Bart Van Ark, The Productivity Institute, University of Manchester
- Programme partner, John Van Reenen, Programme on Innovation and Diffusion, London School of Economics

B.5. Modern Slavery and Human Rights Policy and Evidence Centre

SPF Wave 2	**SPF funding amount**: £10 m	**Programme Start and end date** 01/09/2019 - 31/03/2024
Lead Council / PSRE: AHRC	**Other Council / PSRE**: ESRC	**Government departments**: Home Office

Other partners

- The Bingham Centre for the Rule of Law
- The Rights Lab (University of Nottingham)
- The Wilberforce Institute (University of Hull)
- The Centre for the Study of International Slavery (University of Liverpool)
- The Bonavero Institute on Human Rights (University of Oxford)
- The Alan Turing Institute

Key objectives

- Propose evidence-based approaches to preventing modern slavery, through the identification of research gaps and further targeted research.
- Address slavery in business supply chains, through co-design of early evaluations of public procurement, and identification of priority areas for scrutiny and interventions.
- Understand survivors' needs and the effectiveness of interventions, through commissioned evaluations into the needs of adults and children who have been enslaved, and the effectiveness of interventions designed to help them.
- Support legal enforcement measures, through novel research into the best use of information across sectors, including banking, business, legislative and criminal justice.

Main phases

- Call 1: The impact of COVID-19 pandemic on modern slavery
- Call 2: Victim and survivor recovery and support
- Call 3: Rapid research call: assessing the potential of interventions to prevent modern slavery in the UK
- Call 4: Responsive research call: visibility of long supply chains
- Call 5: Links between modern slavery and wider laws and policies
- Call 6: Responsive research call: distributed technology for survivors
- Call 7: Responsive research call: legal advice for survivors
- Call 8: Improving equality, diversity & inclusion within modern slavery research in the UK
- Call 9: Responsive research call: Identification of survivors
- Call 10: Addressing modern slavery with data science methods

B.5.1. Summary

The Modern Slavery and Human Rights Policy and Evidence Centre (MS PEC) programme was funded to enhance understanding of modern slavery and transform the effectiveness of law and policies designed to address it. To realise its mission and the objectives of the SPF Fund, the key findings of the evaluation of this case study are summarised below.

Multi-and interdisciplinary research (MIDRI) approach

The MS PEC has developed a coherent MIDRI approach that has been employed across a portfolio of funded research. Key to this approach is:

- The inclusion of new academic disciplines in the research on modern slavery
- The requirement for academics to collaborate with non-academic partners (along with a funding structure that supports more equitable partnerships)
- An application and evaluation processes that are more accessible for diverse actors and supportive of policy relevant evidence
- Engagement with people with lived experience

The approach is considered by stakeholders to be successful in increasing and diversifying the pool of researchers involved, helping to form new partnerships, and address the multifaceted problem of modern slavery. At the same time, however, stakeholders also felt that the quality of research proposals is a mixed bag and there could be greater collaboration across the Centre's consortium members.

Quality and relevance of outputs

Stakeholders agreed that the research outputs from the projects were of high quality and relevant to end users. They address enduring questions around modern slavery (such as survivor engagement) as well as responding to new and emerging issues (such as those relating to COVID-19). The high quality and relevance of the outputs were largely attributed to the MIDRI approach, the early alignment of the research agenda with stakeholders' needs and the strong engagement with the Home Office. It was also reported that the dedicated policy impact resources at the Centre were proving essential in making the outputs more accessible to end users and in promoting and strengthening the dialogue between the Centre (including the research teams) and policymakers.

Impact and future

The Centre has been successful in providing a framework for various research projects and in collating and disseminating research outputs systematically, which would otherwise be scattered across research silos. Mid-way through the programme, there are already several examples of outputs being taken up by end-users and early signs of ecosystem change[28]. Given the substantial budget available for the remaining duration of the programme, the stakeholders have high expectations for further achievements of the MS PEC.

[28] The Modern Slavery PEC has recently published its first impact report, setting out what the Centre has done and achieved from 2019 to 2022. See: https://modernslaverypec.org/resources/impact-report

B.5.2. Introduction

Modern slavery traps 40m people worldwide, costs the UK economy £3.3-£4.3bn a year and was described by the [then] Prime Minister, Theresa May as "the great human rights issue of our time". The UK is widely recognised as world leading with its comprehensive legal and policy response, including its 2015 Modern Slavery Act and accompanying strategy[29]. However, despite some positive developments, modern slavery is not widely understood or adequately addressed by existing laws and policies, and the existing legal, economic and cultural systems are not doing enough to protect people from exploitation. The MS PEC programme was funded to address these issues and to transform the effectiveness of laws and policies designed to overcome modern slavery. It brings together academics, policymakers, businesses, civil society organisations and the public on a scale not seen before in the UK to work towards solving this global challenge.

The MS PEC itself is a consortium of six research institutions, led by the Bingham Centre for the Rule of Law (see table at start of case). The Centre opened its doors in September 2020 and delivers research through four mechanisms:

- Open Research Calls: Commissioning of research through open calls, administered directly by AHRC. The calls are focused and targeted to a specific research priority of the MS PEC and look at broader themes around modern slavery, over a longer period of time.
- Responsive Research Calls: Research calls funded and administered directly by the MS PEC, where researchers are commissioned to answer specific questions and evidence gaps through responsive and agile research projects.
- Partner-led Work Strands: Research undertaken by the six Consortium partners involving multiple pieces of work, such as evidence reviews and rapid response policy briefs, carried out around set themes.
- Commissioned Research: Funded research where the MS PEC needs to respond quickly to an urgent need and feels it is best placed to do so through a short, discrete project, working closely with one, or a small number of researchers.

The programme is still catching up with its original timeline after delays in setting-up the Centre, but all its functions and research agenda are now in place and running. Over the last year, the Centre has commissioned seven calls and during its lifetime it has funded 36 research projects involving academic and research organisations, third sector organisations, industry and others.

The baseline stage case study focused on the development of the business case for the MS PEC and the setting-up of the Centre, plus initial feedback related to these processes. At this interim evaluation stage, the case has been updated and revised to focus on the developing activities of the centre and the outcomes and impacts to date.

[29] Bid document

B.5.3. Programme Design and Delivery

Intersectoral working and collaboration

A key objective of the MS PEC is to build and sustain an inclusive 'network of networks' of producers and users of modern slavery research. Thus, building partnerships and deepening collaboration across different sectors is a guiding principle.

To support this, the MS PEC has embedded key partners in its governance structure[30] (see figure below). The Senior Management Board (SMB) comprises representatives from the six main partners, as well as the Centre's Senior Leadership Team and AHRC's Senior Responsible Officer. It meets quarterly and is responsible for strategic direction, outputs and impacts of the Centre. The Advisory Group of the Centre then comprises representatives from academia, civil society, NGOs, Home Office, international organisations, and independent members. It is consulted and offers advice and guidance to the Centre for consideration when developing or delivering its work. The Survivor Standing Committee is consulted and offers advice and guidance to the SMB and the SLT to ensure that the work of the Centre is survivor-informed. The Steering Committee (SC) is then accountable to UKRI for the outcomes of the investment and for ensuring that funds are spent appropriately, effectively and efficiently. It is made up of senior members of staff from AHRC and ESRC, and acts as the final decision maker for the Centre.

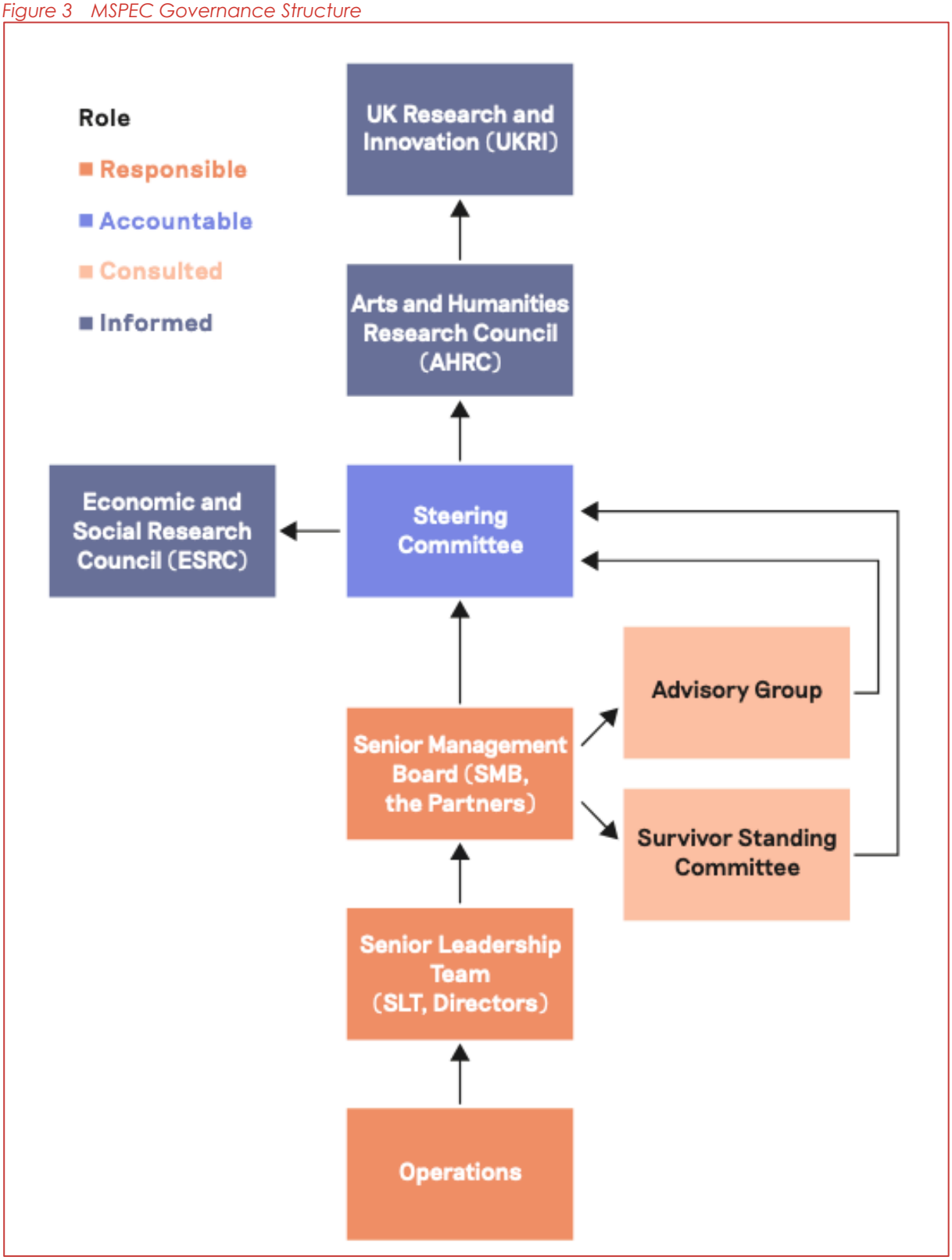
The Centre is also committed to act as a platform between researchers and policy makers. Stakeholders agreed that the dedicated policy impact resources (Director of Policy Impact and Policy Impact Manager) are key in leading this. The Centre has regular engagement with policymakers across government departments including the Modern Slavery Unit at the Home Office, relevant officials at the Foreign and Commonwealth Office and the Scottish and Welsh Governments. Because of this regular dialogue with a range of policy stakeholders, the Centre has been able to develop a good understanding of the existing landscape and its research priorities to address these.

Finally, the Centre is committed to increasing the role and voice of people with lived experiences of modern slavery (PWLE) and those who work closely with them in the intersectoral collaboration. These people are involved across call processes, in research projects and in discussions with policymakers and businesses. The Centre is also in the process of hiring two staff members with lived experience of modern slavery to steer and inform its work.

The consulted stakeholders reported that while some partners (for example, research institutions and government departments) had been working together before the programme, the Centre has also brought together partners that did not collaborate before. For example, businesses and the Home Office have found it difficult in the past to work with practitioners and PWLE because of the sensitivity of the topic and trust issues. The Centre has been successful in mediating these new partnerships. Overall, the stakeholders agreed that the MS PEC has diversified the pool of people and organisations working together, created communication channels, and accelerated the processes around intersectoral working. The Centre has for example, organised workshops on building partnerships between researchers and the third sector and chaired roundtable discussions with research teams, policymakers and PWLE.

[30] https://modernslaverypec.org/assets/downloads/Modern-Slavery-PEC-Strategy.pdf

Figure 3 MSPEC Governance Structure



Source: MSPEC Strategy

Multi- and inter-disciplinary approach

Modern slavery is a complex and multifaceted challenge covering various forms of exploitation embedded across different sectors of society. The MS PEC has tackled this complex challenge by developing a research agenda that brings together different academic disciplines and sectors.

Modern slavery as a subject is inherently interdisciplinary and includes a number of disciplines from across the humanities and social sciences such as sociology, anthropology, criminology, law and health sciences. All these disciplines are included in the research conducted at the MS PEC. In addition, as explained by the programme partners, the Centre has brought some new disciplines to the research on modern slavery. For example, experts on digital inclusion and digital inequality were part of a project that explored the impact of providing digital technology to survivors of modern slavery. Another example is a recent research call on addressing modern slavery with data science methods that will add both methodological and disciplinary diversity. Stakeholders reported that the research community were already aware of the relevance of wider disciplines and some of this research may have been pursued anyway, but not to the extent that it has been here.

Besides academic disciplines, the MIDRI approach in the programme is also understood in terms of involving multiple stakeholders in the research process, which is a key element of the work delivered by the Centre. In addition to research organisations and academics, the funded research project teams consist of NGOs and third sector partners, business associations and PWLE and affected communities (as discussed above). The aim of this MIDRI approach is to increase the diversity of actors in the modern slavery sector as well as in the UK R&I sector as a whole and to enhance the role and knowledge contribution of third sector organisations (often from non-traditional or non-academic backgrounds) in generating policy-relevant evidence.

To encourage this MIDRI approach, the Centre has developed its application and assessment processes based on discussion and feedback from stakeholders and researchers from funded projects. These processes align closely with the Centre's Equality, Diversity and Inclusion (EDI) Strategy and Action Plan[31], and include:

- A requirement that project teams must comprise academic institutions and another non-academic organisation (e.g. third sector). Teams are also encouraged to include survivors in their project as appropriate.
- In collaboration with UKRI/AHRC, the Centre has refined its approach to funding research. The standard UKRI funding model requires an academic lead on all projects, and maximum of 30% funding (of the total budget) to a non-academic/third sector organisation. The new funding model implemented by the MS PEC allows UK registered charities as lead organisations in the projects and increases up to 50% the total budget that can go to third sector organisations.
- To reduce barriers and encourage applications from those who would not normally apply, the Centre has introduced a simplified application process, which includes: an easy-to-use application form on Submit.com; using accessible language and terminology in call documentations; and running webinars for calls with a Q&A session.

[31] https://modernslaverypec.org/resources/edi-strategy-action-plan

- A two-stage application process, which allows teams to first submit a shorter expression of interest to which they will receive feedback on its appropriateness for stage two. For teams who progress to stage two, detailed feedback is offered to help them better align their full application with the aims of the call. Integrating feedback into the application process is different to the standard processes used in UKRI/AHRC (although not unique to MS PEC).
- The Centre has introduced pre-panel meetings where policymakers and PWLE are invited to review and offer feedback on submitted proposals (including expressions of interest), which is then shared in the main panel meeting. This is found to be hugely beneficial, especially among the policymakers in increasing the policy relevance of the research.

Changing needs and opportunities

The programme has made several adjustments to its priorities and approach since the launch of the MS PEC and the baseline evaluation of the case. Many of these changes have been the result of an extensive consultation undertaken in 2020 with a wide range of stakeholders from across the sector to inform the Centre's approach and research priorities[32]. Based on the consultation, the Centre defined four research priorities (prevention; survivor support; supply chains; effectiveness of legal enforcement) that are closely aligned with the policy needs in the UK and internationally (for example, with the Home Office's 2015 Modern Slavery Strategy). Thus, the consultation improved the alignment of the research programme with stakeholders' needs. This was followed by a shift in how research is commissioned, from mostly 'open research calls' (administered by AHRC) to mostly 'responsive research calls' (administered directly by the MS PEC), to ensure that research projects are in line with MS PEC priorities and identified evidence gaps (including the application and assessment processes outlined in the section above).

Another example of changing priorities, mentioned by all stakeholders consulted, is the stronger engagement with survivors and PWLE and those who work closely with them. This came about as a result of the consultation, and discussions with the Advisory Board, which highlighted the importance of including the voices of PWLE in the Centre's work to help inform ethical research and ensure meaningful change.

B.5.4. Programme Outputs

MIDRI proposals and projects

The partners agreed that the programme has attracted more MIDRI proposals than usual, which was largely attributed to the funding structure, i.e. having the funding tied to collaboration. This requirement was found to be important and has resulted in diversifying the pool of people conducting modern slavery research across the UK.

The quality of the proposals, however, was seen as a mixed bag, with fewer high-quality proposals submitted to some calls than expected. Several reasons were identified by the programme partners. For example, modern slavery is a relatively new field of research and the size of community is small – but the Centre is not able to grant funding for PhDs or fellowships to help develop and enlarge the community. Also, the amount of funding and the duration of

[32] https://modernslaverypec.org/resources/report-consultation-on-the-modern-slavery-pec-research-priorities

the projects (max. £250,000 and 12 months) and no possibility for continuity of funding is seen as a limitation for high-quality research on the 'challenge-led' area of modern slavery.

According to stakeholders, the 'responsive research calls' (administered directly by MS PEC) have been less competitive, with some having to reopen due to low number of applications and insufficient quality. By comparison, the 'open research calls' (administered by AHRC) have tended to attract a high number of competitive proposals and diverse applicants in terms of universities and career stages. The combination of high expectations and tight timeline (both application and conducting the research) is considered as a major factor in limiting the number of proposals in the former. Some adjustments to these points have been made in the reopened calls.

R&I outputs

All consulted stakeholders agreed that the Centre has developed a robust framework to collate, synthesise and disseminate its outputs. In addition to academic publications, results from the 36 funded projects and from the in-house research conducted by the consortium members are published in research summaries, interim outputs, policy briefs, blog posts and podcasts. Furthermore, members of research teams and the MS PEC team have spoken in numerous events and conferences.

All research teams are asked to co-produce shorter research summaries with the MS PEC team to synthesise findings and make them more accessible to different stakeholders. Policy briefs are particularly tailored for the use of policymakers – not only synthesising research and evidence, but also rating the quality of the evidence, and where relevant, making specific recommendations. The Centre has published six policy briefs[33] on topics such as impact of COVID-19 on modern slavery, and the effectiveness of forced labour import bans. In addition, the MS PEC has made three written submissions to public consultations[34] based on the findings and evidence in the funded research projects. For example, for the Director of Labour Market Enforcement (DLME) call for evidence on the Labour Market Enforcement Strategy[35], the Centre's submission drew on findings from a research project on the experiences of Romanian and Bulgarian workers in the UK agriculture industry during the pandemic (among others).

In the MS PEC strategy[36], the key end-users of the outputs are identified as policymakers, lawmakers, businesses, and practitioners. These and other groups (for example PWLE and the public) engage with the outputs through various activities and events as well as in regular meetings. Already, the MS PEC and consortium members have organised public events, workshops and roundtables to discuss findings, facilitate information sharing and collaboration in the sector, and support capacity building within funded research teams and the wider community. For example, the Centre hosted a workshop bringing together nine projects to discuss how they involved people with lived experience of modern slavery in their research.

[33] https://modernslaverypec.org/resources?type=briefing

[34] https://modernslaverypec.org/resources?type=submission

[35] https://modernslaverypec.org/assets/downloads/Modern-Slavery-PEC-response-to-DLME-Call-for-Evidence-23-24.pdf

[36] https://modernslaverypec.org/assets/downloads/Modern-Slavery-PEC-Strategy.pdf

According to the director of the programme, capacity building of partners has been an essential part of the work that the MS PEC has done. Some partners had little experience in how research is conducted and what is achievable by research. The Centre has therefore facilitated capacity building, especially with frontline practitioners, to increase their understanding of the possibilities of research and identifying research questions. Another important area of capacity building is enhancing researchers' understanding of policy relevant research and the role of evidence in policy making. The MS PEC team offers tailored support to research teams, such as regular meetings and sharing outputs with the MS PEC team for comments and feedback, as well as co-producing research summaries and policy briefs and coaching researchers on how to chair roundtable discussions with policymakers.

While the capacity building activities are currently an integral part of the work done at the Centre, some partners mentioned that the long setting-up period has meant that it has not been able to provide these activities to all funded research projects teams.

B.5.5. Programme outcomes and impact - R&I to address priorities

All stakeholders found the research outputs to be of a high quality and relevant to end users, while also addressing the complex issues underlying modern slavery. Three factors were identified as being particularly crucial in contributing to the quality and relevance of the results. Firstly, the alignment of the research priorities with the needs of the end-users, followed by the consultation undertaken during the first year of the programme. Secondly, the inclusion of more diverse voices and the requirement to work collaboratively with non-academic partners in the research projects have changed the nature of the outputs and made them more relevant for practitioners and policymakers. Thirdly, strong engagement with the Home Office from the bid development stage and the ongoing dialogue has resulted in a trusted partnership and ownership of the programme, which has then increased take-up of the outputs.

Although research is still being carried out, there are examples of R&I outputs that are being utilised by different end users:

- Following the publication of the policy brief on the effectiveness of forced labour import bans[37], the Centre was invited by the UK Department for International Trade to give an expert contribution to a technical discussion with G7 partners focused on addressing forced labour in global supply chains.
- The Centre's submission[38] to the Joint Committee on Human Rights (JCHR) call for evidence on the Nationality and Borders Bill was cited in parliamentary debates and in the JCHR's report on the Bill.
- The Centre's Director of Research gave oral evidence to the International Development Sub-Committee on the work of the Independent Commission for Aid Impact (ICAI) which was subsequently cited in the government's response to the review[39] and the ICAI's 2022 Impact report[40].

[37] https://modernslaverypec.org/assets/downloads/ImportBans_briefing-updated-final.pdf

[38] https://modernslaverypec.org/assets/downloads/Modern-Slavery-PEC-JCHR-submission-Nationality-Borders-Bill.pdf

[39] https://committees.parliament.uk/publications/8768/documents/88765/default/

[40] https://committees.parliament.uk/publications/7735/documents/80648/default/

- Research findings from the project on supply chains and PPE during COVID-19 prompted extensive governmental and parliamentary discussions about amending the legal framework of public procurement.
- The MS PEC was invited to a workshop organised by a working group on cross-vulnerabilities (part of Home Office's public safety group) together with other organisations that do work on different areas of exploitation (such as crime reduction and child abuse). The participants found the workshop useful and decided to meet quarterly in the future to share knowledge, good practices and create linkages across different areas of vulnerabilities.

Furthermore, the Centre has contributed extensively to the revision of the UK government's Modern Slavery Strategy. The Home Office relies heavily on the evidence and research findings from the projects funded by the MS PEC in drafting the strategy, and the Centre has also produced a special briefing[41] for the strategy with recommendations. Furthermore, in 2021, the Centre was invited by the Home Office Modern Slavery Unit to co-host a roundtable that brought together academic and third sector researchers, plus research council representatives with policymakers, to inform considerations around research and evidence in the new strategy. The Home Office also approached the MS PEC for feedback on the new strategy's research annex. The expertise of the Centre was used, for example, in assisting policymakers in framing the research needs and priorities.

B.5.6. Programme outcomes and impact – ecosystem change

During the Centre's lifespan, several challenges and barriers have been encountered. Some have proved more difficult to resolve, while others have resulted in the improvement and development of processes and the way the programme is implemented.

The programme partners emphasised that the main challenges in terms of intersectoral working are related to the collaboration between the Centre and the consortium members. One limitation in facilitating collaboration between the MS PEC and the consortium partners has been a lack of funding for inhouse research. During the development of the business case for the MS PEC, the funding resources for the consortium partners were cut in half. This has restrained the overall research capacity of the consortium and has had implications for the research and innovation activities, even though some partners have been able to co-fund research fellow posts within their organisations to contribute to the work of the Centre. For example, the Centre has not been able to mobilise a MIDRI approach within the consortium partners systematically, which limits the capacity of the programme to address the complexity of modern slavery. Furthermore, the lack of inhouse research capacity has constrained the ability of the Centre to mobilise research quickly, which is an important asset in matching research and policy timelines and to increase the policy impact of the research.

Besides the limited research collaboration within the consortium members, some members find the engagement with other consortium members somewhat disappointing. The members had higher expectations for a more coordinated and systematic collaboration across the consortium. Currently the members only work directly with the MS PEC and not with each other. Furthermore, some members find that the SMB's involvement in decision making and steering of the Centre is limited, and that decision making is entirely concentrated within the Centre's Senior Leadership Team. The baseline evaluation of the programme reported on tensions

[41] https://modernslaverypec.org/resources/modern-slavery-strategy-briefing

between the consortium members, likely because of the means of establishing the pre-determined structure of the MS PEC (instead of an open call). Some tensions were still evident as the examples mentioned here demonstrate.

Stakeholders identified two main challenges in addressing government R&I priorities.

The first is about the different timelines in which the research process and policymaking operate. In order to respond to stakeholders' research needs in a timely manner, the Centre created a 'responsive research call' mechanism, where MS PEC commissions researchers to answer specific questions and evidence gaps through responsive and agile research projects. Nevertheless, as previously noted, the calls have not always been successful due to the shorter timeframes required. Although some adjustments to the timelines have been made, feedback received by the MS PEC indicates that collaboration amongst research team members (and partners) has not been as meaningful as it could have been if there were longer timeframes.

The second challenge is about the changes in government priorities – particularly the shift in political rhetoric around modern slavery and the politization of the topic. This has made it more difficult for the Centre to build trust among partners, especially between government partners and third-sector organisations. The MS PEC, as an impartial evidence centre, has to be considerate of how to navigate and position itself within this broader policy environment shift.

The MIDRI approach employed in the programme is generally regarded as successful in attracting new people to the field, forming partnerships, and addressing the multifaceted problem of modern slavery. However, some challenges were also reported - particularly in relation to the assessment of submitted proposals. For example, finding peer-reviewers and people for assessment panels has been challenging due to the limited size of the research community and conflicts of interests. The Centre is currently setting up a Peer Review College, which will be useful in dealing with this issue. Moreover, the policymakers emphasised the importance of a framework and clear criteria in the initial review of applications (including expressions of interest and pre-panel assessment) to increase transparency and consistency among the large number of people assessing the proposals. The MS PEC is expected to develop the assessment processes in future calls based on this feedback.

It is still early stages to identify many structural changes brought about by the programme. Nevertheless, there are interesting examples of practices developed by the MS PEC that are being implemented elsewhere, as well as early signs of ecosystem change:

- According to the policymakers, the close involvement of government departments in the programme has resulted in better understanding of evidence in policymaking among government partners and is believed to help in creating better and more inclusive policies. This is demonstrated, for example, in the Home Office's new strategy on Modern Slavery that will include a whole section on the role of evidence in tackling modern slavery, which did not exist to this extent in the previous strategy. Overall, the partnership with the MS PEC has increased the confidence in ministers to continue evidence-based policymaking.
- The mechanisms and approach developed in the MS PEC for commissioning research that addresses longer term policy challenges has informed AHRC's discussions with other government departments regarding future investments. Particularly, AHRC seeks to learn from the processes for the ways in which different stakeholders are involved in research commissioning and the research process itself, as well as how government departments are involved in the governance structure so that independence of academic research is

maintained but also government needs are expressed. Discussions are ongoing, for example, with DCMS regarding a policy and evidence centre for galleries, libraries, archives, and museums, where such processes could be implemented.

- The MS PEC has been an important source of learning (alongside other initiatives, such as GCRF) for AHRC's wider development work around equitable partnerships and the involvement of people with lived experience
- The MS PEC's decision to invest in dedicated policy impact resources (Director of Policy Impact and Policy Impact Manager) is something AHRC is keen to learn about and is interested in involving professional knowledge brokers in other relevant investments as well to generate more non-academic impact. Although still in the early stages, AHRC is (in collaboration with other councils) exploring how to equip these knowledge brokers and what their training and development programme might include.

B.5.7. The Future

The MS PEC still has a sizable research budget left and will continue pursuing its research programme, commissioning a series of further calls. As the examples above illustrate, many outputs have already been employed by end-users. As such, stakeholders have high expectations for the Centre's future and long-term impact. However, they also acknowledge that within the timeframe of the SPF funding, it is unrealistic to expect changes in policies or laws.

According to the programme director, one strategic focus of the Centre's work for the remaining period of funding is to increase the internationally focused work. More resources are being directed to research that focuses on the international and global level. The Foreign, Commonwealth and Development Office (FCDO), alongside the Home Office, have been and will continue to be important partners in working towards this aim. The FCDO, for example, commissioned the MS PEC to assess the nature and effectiveness of survivor engagement in international policy and programming on modern slavery[42].

All stakeholders emphasised the importance of the continuity of the MS PEC beyond the SPF funding period. The Centre has already contributed a great deal to increasing the awareness of modern slavery across different sectors and has shown it is possible to conduct high quality policy relevant research in an extremely sensitive area. The funder expects the Centre to develop a sustainability plan that takes it beyond SPF funding. AHRC recognises the value of MS PEC and is currently exploring what future iterations might look like after the current funding period. The MS PEC team hopes to see more involvement and contribution from UKRI in developing a long-term funding strategy.

B.5.8. Stakeholders interviewed

- Programme Lead - Matt McCallum, AHRC
- Programme Partner – Alison Park, ESRC
- Programme Government Partner - Lisa Mynors, Home Office

[42] https://modernslaverypec.org/research-projects/survivor-engagement-international-programming

- Programme Directors – Murray Hunt & Olivia Hesketh, The Modern Slavery Policy and Evidence Centre, Bingham Centre for the Rule of Law
- Programme Partner – Trevor Burnard, University of Hull
- Programme Partner – Katarina Schwarz, University of Nottingham
- Programme Partner – Christos Kypraios, University of Oxford

B.6. Space Weather, Innovation, Measurement, Modelling and Risk (SWIMMR) programme

SPF Wave 2	**SPF funding amount**: £20 m	**Programme Start and end date** 02/09/2019 - 31/03/2024
Lead Council / PSRE: STFC	**Other Council / PSRE**: NERC & Met Office	**Government departments**: BEIS, MoD and DfT
Other partners • UK Universities: Averystwyth, Bath, Birmingham, Central Lancashire, Durham, Lancaster, Leeds, Leicester, Northumbria, Reading, Sheffield, Southampton and Surrey, plus Imperial College London and University College London. • UK Research Institutes: Rutherford Appleton Laboratory, AEA Harwell, British Antarctic Survey, British Geological Survey, UK Met Office (MOSWOC) • Industry / Overseas Partners: BJSS Ltd., CACI International, CVUT Prague, D-Orbit, Know.Space, Merrion Systems, Rhea-UK		
Key objectives • To mitigate potential space effects on economic and societal activities (i.e., communication, electric power distribution and on satellites and aviation operations)		
Main phases • Launched in April 2019 and will run until 2025. • The six projects delivered through STFC, for a total of £9.35 million. • NERC's first call for projects was launched at the end of 2019 for a total value of £8.7 million. • All projects are now underway and predicted to meet the extended project deadlines.		

B.6.1. Summary

The Space Weather, Innovation, Measurement, Modelling and Risk programme (SWIMMR) is a £20m initiative, funded under the second wave of SPF. It was launched in April 2019 and will run until 2025. Space weather is a topic that spans many different scientific fields under the remit of two research councils. This characteristic necessitates that space weather research projects are multi and inter disciplinary. There have been a number of steps taken, including an annual symposium, which help to ensure multi and inter-disciplinary research will continue after SWIMMR. All projects funded by SWIMMR are now underway and most anticipate being on track for the extended project deadlines.

B.6.2. Introduction

The Space Weather, Innovation, Measurement, Modelling and Risk programme (SWIMMR) is a £20m initiative funded under the second wave of SPF. It was launched in April 2019 and will run until 2025. It is led by the Science and Technology Facilities Council (STFC) in partnership with the Natural Environment Research Council (NERC) and the UK Met Office. Other partners to the programme are Surrey Space Centre (SSC) at University of Surrey and Surrey Satellite Technology Limited.

The programme aims to provide a strategic UK approach to Space Weather, enabling the Met Office to better predict space weather events and reduce their threat to economic and social activities. It will do so by meeting two objectives:

- Improving capacity to predict severe weather events; and
- Supporting the translation of the UK's pioneering research into practical solutions that will protect against adverse disruptions caused by sever space weather.

The programme facilitates the development and deployment of new products, processes and services through a series of activities managed by either STFC or NERC. The UK Met Office provided in-kind support at the proposal stage and is continuing to do so throughout project delivery to ensure the successful translation of research into its operational models and forecasts. To date, the programme has delivered one funding call that focused on research into space hardware and satellites to address problems caused by space radiation, which presents significant risks to critically important UK infrastructure (e.g. communication systems used in aircrafts and power grids). It also funded research to address space weather effects at lower altitudes, such as radiation effects on aviation, and on the Earth's surface, such as Geomagnetically Induced Currents (GICs) in power grids. A second call was expected to run in September 2020 but was delayed by the COVID-19 pandemic.

The Government was interested in this area of research because of the UK's increasing reliance on space-based systems for communications and time-keeping and its ambition to become a global leader in the development and commercialisation of space assets. SWIMMR involves collaboration with and across government departments, including the Department for Business, Energy and Industrial Strategy (BEIS), Department for Transport (DfT) and the Ministry of Defence (MoD).

B.6.3. Programme design and delivery

Space weather is a topic that spans many different scientific fields under the remit of both STFC and NERC. This characteristic necessitates that space weather research projects are multi and inter disciplinary. The programme is being delivered through a series of open calls for research projects managed by either STFC or NERC as appropriate. To ensure inputs are evenly distributed between the two councils, SFTC and NERC have split the available budget equally and six research projects are being delivered though STFC grants while the remaining five are being delivered through NERC. The councils, government and the Met Office are working collaboratively on delivery.

The £19.9 million fund is supporting a total of eleven research projects (see below), to be completed over four years (2019-2023).

The six projects delivered through STFC, for a total of £9.35 million, are as follows. Projects S1 to S3 are mainly executed by STFC staff, with the support of the Met Office and universities.

- S1: In-situ radiation measurements for space and aviation (budget £5.7M)
- S2: Support for technology testing and modelling (budget £655k)
- S3: Support for the transition from research to operations (budget £920k)
- S4: Forecasting from the Sun to L1[43] (budget £450k)
- S5: Support for a ground radiation monitoring network (budget £1.4M)
- S6: Production of an updated space weather impact study (budget £300K)

NERC's first call for projects was launched at the end of 2019 for a total value of £8.7 million. The five topic areas where proposals were sought were:

[43] L1 is defined as the Lagrange point, these are defined as points near two orbiting bodies. Normally, the two objects exert an unbalanced gravitational force at a point, altering the orbit of whatever is at that point.

- N1 Satellite risk forecasts (£1.9M)
- N2 Aviation risk forecasts (£1.6M)
- N3 Global Navigation Satellite System (GNSS) and HF aviation forecasts (£2M)
- N4 Ground effects forecasts (£2M)
- N5 Satellite drag forecasts (£1.1M)

As the governance of SWIMMR encompasses several different bodies it is structured such that councils and government departments are working collaboratively to ensure that SWIMMR projects are successfully delivered and link up effectively with government research priorities. In particular, the Programme Board is responsible for the programme's strategic direction and the delivery of its objectives. To this end it comprises representatives of: STFC, NERC, BEIS, DSTL, DfT and the UK Met Office. The activities of the Programme Board are supported by the Strategic Advisory Board, through the provision of technical and scientific advice. Its members are: Imperial College, Civil Aviation Authority, UK Met Office, Boston College, Airbus UK, Rolls Royce, National Grid and Defence Science and Technology Labs.

In terms of specific ways of working together, stakeholders generally had positive views about multi and interdisciplinary and intersectoral collaboration under SWIMMR. The evidence gathered through the consultations highlighted the following key points:

- ***Involvement of two councils*** - Stakeholders note that as two different research councils are involved in the programme, a degree of intersectoral and interdisciplinary working is necessary. SWIMMR has led to an improvement for both councils in terms of knowledge of how the other operates. It also helps others to navigate funding, as they previously may have had to navigate separate systems which could have led to projects with duplicating objectives. Stakeholders also noted that this may have been challenging to achieve without SPF.
- ***Bridging academic divides*** – Stakeholders noted, that although scientists from different disciplines were interacting to some extent prior to SWIMMR, SWIMMR has helped to bridge some divides. Sub-projects have meant academic partners working together that might not have done so previously. Stakeholders noted an annual symposium run by the programme also helps to bring together stakeholders from across industry.
- ***Concerns around sustaining momentum post funding –*** There were some concerns, particularly in academia, around how to sustain momentum in multi-disciplinary working after SPF funding finishes.
- ***Procurement–*** Although the councils were seen to be working well together, they did put out calls separately. A joint call may have improved participation and further MIDRI proposals.

B.6.4. Programme outputs

The onset of the pandemic has significantly delayed the laboratory activities associated to the SWIMMR project deployment. Consultees reported issues in hiring the right candidates to progress the projects as well as accessing laboratory facilities. To address this, the research councils asked for a formal project extension for an additional year. However, all projects are now underway and most anticipate being on track for the extended project deadlines.

B.6.5. Programme outcomes and impact - R&I to address priorities

The SWIMMR projects aim to address important national challenges related to space weather events and their link with the functioning of UK energy, transport and infrastructure. Following on from the discussion of outputs above, the outcomes and impacts of R&I are yet to be observed due to the early stage of the SWIMMR projects. However, information gathered during stakeholder consultations confirmed that the research conducted under SWIMMR appears to be on track to meet the anticipated outcomes and impacts. The key messages from stakeholders are noted below.

- ***Space strategy*** – The SWIMMR programme is heavily connected with aspects of the UK's space strategy and government's strategic thinking in this area. Space weather is high on the national security risk assessment and there is a clear need to mitigate this. It was noted that historically government departments did not have a great awareness of the risks of space weather, but as academics have been raising this with government departments, it has gained momentum. As this focus has largely been led by the research community, academic research priorities and governments strategic priorities are clearly aligned.
- ***Met Office*** – One of the key aims of the SWIMMR programme is to bridge the gap between academic data and information, and data in a format that the Met Office can use. Interviewees thought that positive progress was being made on this front. The Met Office itself is funded by BEIS, so interviewees were of the view that it is attuned to the relevant BEIS priorities.
- ***Consolidating the UK's position as a science superpower*** – Space weather was noted as an area where the UK has a lot of capability, and SWIMMR will help to enhance that. It was noted that the programme has very close relations with their US partners, who are taking a great interest in some of the SWIMMR activities. The UK is seen to have European leadership in this area and is second only to the US globally. One of the priorities of SWIMMR was changed relatively early on to reflect areas of importance to international stakeholders, where the UK could lead the way internationally. If the Met Office and academics continue to build relationships off the back of the programme, there is even greater potential for the UK to be seen as an expert in this area.
- ***Energy security –*** Stakeholders believed that the programme will enable capability that has great potential for energy security in the future which could have a significant impact.
- ***Some sectors are further ahead than others –*** Some areas are better understood by the academic community or have more traditionally been the focus of the Met Office and as such have progressed faster than others. For example, it was noted that the rail industry is not as engaged yet, so may not be as far along by the end of the programme as governing departments may have wished, but this is partly to do with getting the correct contacts and increasing awareness of the impacts of space weather in this sector. There might have been a role in these sectors for government departments to be more active in connecting the right contacts at the beginning stages of programmes.

B.6.6. Programme outcomes and impact – ecosystem change

Overall, SWIMMR is on track to achieve the wider outcomes and impacts that were foreseen. Stakeholders viewed the SWIMMR programme as different from other SPF programmes, in that it is very directed. As a result, everything that was planned is currently underway.

In general, participants positively rated their experience of the programme. Some further insights emerged during the consultations in respect to the collaborative relationships established among the various SWIMMR partners:

- ***Symposium*** – The SWIMMR symposia has helped improve understanding across the sector of government priorities. BEIS has presented at these, which has helped to ensure engagement and improve understanding of government priorities and policies.
- ***Concerns around end of funding*** - It was noted that although research councils are working well together, and have a greater understanding of each other, they may still go back to working separately once the funding ends. The programme will need to continue to demonstrate the benefits of the councils working together in order for future R&I to benefit from this joined up working.
- ***Better working between Met Office and academics –*** One of the aims of SWIMMR is taking academic findings and making them fit for met office to implement as forecasting tools. In general, it was viewed that there has been significant progress already in improving understanding amongst the academic community of what Met Office needs are (for example in how models need to be built, data formatting etc).
- ***Substantial progress in certain sectors*** – There has already been some progress in the transport space, with consultees noting that some initial results coming out of certain strands are useful and interesting. Some models in the aviation space are nearly fully functioning and fully integrated into the Met Office.
- ***Governance meetings -*** Governance meetings could also help bring together more contacts – it was noted that it could be helpful to get technical specialists, or those closer to managing infrastructure, in the room for progress updates
- ***Crowding out effect***- The SWIMMR programme attempts to be universal, and whilst it generally has quite good reach, some UK based researchers are not part of SWIMMR programme. There were concerns that this means that the SWIMMR programme runs the risk of marginalising other research. It was suggested that for the final evaluation, views are collected from this section of the academic community.

B.6.7. The future

Based on consultations, SWIMMR appears to be on track to deliver on its objectives and to respond to strategic priorities for the UK by the end of the programme and final evaluation in 2025. Everything planned is underway, but a key thing will be making sure that each strand of the programme reports on impacts and benefits. Evaluation leads were confident that there would be a lot of good data coming through by the time of the final evaluation, as anticipated in evaluation plans.

In general, there was some concern from interviewees that uncertainty around future funding could slow down progress after the scheme ends. However, given that the programme seems to be on track to show that it was value for money by the final evaluation period, it was thought that other opportunities for funding would arise.

B.8. Clean Air

SPF Wave 1&2	**SPF funding amount**: £42.5 m	**Programme Start and end date** 15/10/2018 - 31/03/2025
Lead Council / PSRE: NERC & Met Office	**Other Council / PSRE**: EPSRC, ESRC, IUK, MRC, NPL	**Government departments**: Defra, DfT, DHSC, Scottish Government, Welsh government
Key objectives • Drive forward new multidisciplinary research and innovation • Leverage existing UK investments and enable a challenge-focused multidisciplinary community to work together • Inform implementation of the UK government's Clean Air Strategy • Develop new solutions to reduce emissions of atmospheric pollution • Present information to stakeholders and the public • Build a new UK interdisciplinary community at the interface of indoor/outdoor air quality emissions, exposure and health impacts.		
Main phases • Wave 1: Clean Air: Analysis and Solutions programme • Wave 2: Clean Air: Future Challenges		

B.8.1. Summary

The Clean Air programme is currently in its 4th year of delivery. The funding (spread across two waves of SPF investment) has been allocated in full by all partners (NERC, Innovate UK and Met Office). Wave 1 projects have already been completed or are near completion, Wave 2 projects are still underway with staggered project closing dates until the end of the programme in 2025. The programme has not highlighted any risks of delivery and, having now awarded the next wave of funding for Champion-led activities, it is now moving towards delivering its Benefits, Outcomes and Legacy commitments[44].

The Clean Air programme has been effective at adapting and using existing processes and systems to encourage high-quality Multi- and Interdisciplinary Research and Innovation (MIDRI) applications. This included the co-creation of funding calls, gathering views from the Steering Committee and Programme Board, as well as changing the assessment process to include assessors that work in the interface of disciplines as well as field specialists. This 'push' for MIDRI has enabled projects to bring in additional expertise or to tailor their outputs so that they can be used by others outside their discipline. This includes the engagement with behavioural experts to develop products with the end-user in mind or to develop air quality measurement tools which have further capabilities to be used in assessing health impacts. The programme has recognised that more can be done as there is still more to do to bring more disciplines involved.

Given the long-term nature of the programme, it was at times difficult to design funding calls and react to policy changes, however, these changes were considered as part of the remit of the second funding round of Champions and through the design of Wave 2 calls. Aspects of

[44] See Clean Air Science Plan for details on these

the programme did manage to react to the emerging needs created by COVID-19 and support the drafting of the 2022 Chief Medical Officer Annual Report. Although the programme was not reactive it did provide a specific role to Government departments to support the design and specify their research needs, and now some departments are waiting for projects to be complete to incorporate these within the development of policies and strategies.

B.8.2. Introduction

The Clean Air: Analysis and Solutions programme, within the SPF, is led by the Natural Environment Research Council (NERC) and the Met Office, with an overall budget of £42.5m across both waves of the Fund (£19.6m awarded through Wave 1 and £22.9m awarded through Wave 2). The programme was launched in late 2018 and will run until 2025. Delivery is supported by the Economic and Social Research Council (ESRC), Engineering and Physical Sciences Research Council (EPSRC), Innovate UK, Medical Research Council (MRC), National Physical Laboratory (NPL) and the Science & Technology Facilities Council (STFC). Government departments overseeing and involved with the project are the Department for Environment, Food and Rural Affairs (Defra), Department for Health and Social Care (DHSC), Department for Transport (DfT), Scottish Government and Welsh Government.

The Clean Air programme aims to bring together the UK's research base to develop solutions to current air quality issues and future air quality challenges. Specifically, it seeks to bring together leading researchers from across atmospheric, medical, and social sciences to better predict exposure to air pollution and its effects on vulnerable groups (e.g. children and the elderly), as well as identify practical and usable solutions to air pollution that can help policymakers and businesses protect the public's health and work towards a cleaner economy.

The specific objectives of the programme are to:

- Drive forward new multidisciplinary research and innovation
- Leverage existing UK investments and enable a challenge-focused multidisciplinary community to work together
- Inform implementation of the UK government's Clean Air Strategy
- Develop new solutions to reduce emissions of atmospheric pollution and protect public health, whilst avoiding perverse consequences
- Present information to stakeholders and the public in an accessible way

The issue of air pollution and air quality can be classed as a "wicked problem"[45], which means that it cannot be addressed in isolation, and the likely prevalence of spillovers is high. It was noted through our review that it is common that air pollution issues/challenges are often addressed in isolation through a particular focus on specific activities, pollutants, or sectors. One of the aims of the SPF programme was to bring cohesiveness to the problem by working together across different stakeholders and fomenting a multidisciplinary approach toward research, and it was highlighted that such a cohesive approach would likely not have been possible without the programme. Similarly, while it was stated that government priorities could have been addressed in the absence of the programme, the Clean Air programme enabled these to be addressed collaboratively. However, this resulted in compromises where partners had to find a middle ground with other partners as it could only address some and not all of

[45] A wicked problem is a social or cultural problem that's difficult or impossible to solve because of its complex and interconnected nature. Wicked problems lack clarity in both their aims and solutions, and are subject to real-world constraints which hinder risk-free attempts to find a solution.

them. After reviewing publicly available monitoring records, all Innovate UK-funded phase 1 and phase 2 feasibility and depth prototyping/testing projects have been completed with the last ones closing late-July 2022. NERC-funded research projects are all underway with two already closed. The MetOffice has also allocated all of its funding with all wave 1 projects closed. In July 2022 the Wave 2 support for SPF Clean Air Champions – "Addressing the Challenge of the Indoor/Outdoor Continuum" was granted. All Wave 1 projects are expected to complete over the next 12 months and Wave 2 will continue until 2025. It was mentioned by the programme management team that although everything seems to be progressing as planned, there have been some delays related to COVID-19 and the overall impact on the programme timescales is as yet uncertain. However, internal monitoring reports indicate that the portfolio is progressing as intended with no highlighted risks of delivery.

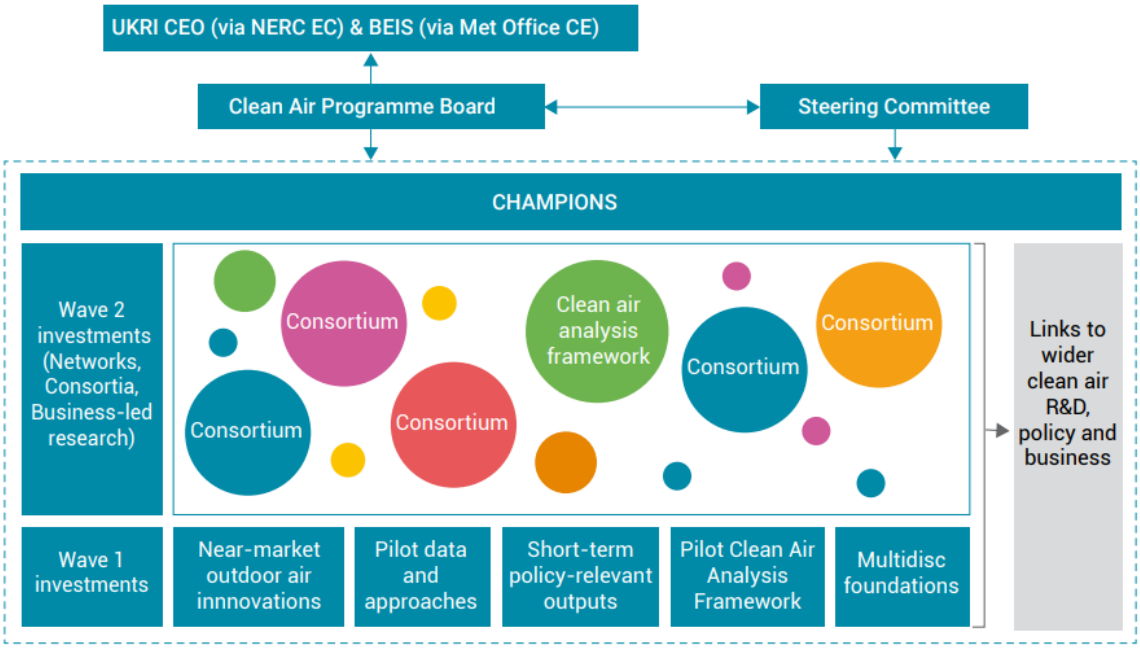
The Clean Air management team with a focus on the next stages of the programme are now shifting to the outcomes, legacy and benefits activities, including developing an outputs repository (to be published in September 2022) and continuing conversations with relevant stakeholders so that the information and knowledge can be useful and impactful.

B.8.3. Programme design and delivery

Intersectoral working and collaboration

The Clean Air programme is comprised of a comprehensive and diverse list of stakeholders, listed above. These form part of the programme's governance through the Programme Board and a Steering Committee. The Programme Board is responsible for providing the strategic direction for the programme and the delivery of the programme's objectives, and it is the ultimate decision-making authority for the programme. It comprises the programme's delivery partners including NERC and the Met Office as co-Chairs, alongside EPSRC, ESRC, MRC, Innovate UK, Defra, and the National Physical Laboratory. The Steering Committee provides strategic advice to the Programme Board in support of the programme's objectives. The Programme Secretariat comprises a secretary, based at NERC Head Office, providing administrative support to the Programme Board and Steering Committee.

Figure 4 SPF Clean Air Governance Structure



Source: SPF Clean Air Science Plan

Partners involved in the implementation of the programme have mostly worked together previously and so are building on existing relationships. Some new relationships were created with different teams across government departments and devolved administrations, but this was enabled and facilitated by the alignment of the Clean Air programme research with their interests. It was highlighted that charitable/social enterprise organisations have been more involved than anticipated. This group was not originally considered to be a significant stakeholder, but through champion-led public engagement activities, as well as a Met Office funded project led by Global Action Plan (a charity) and other Network activities, they have become more central to the programme.

As previously mentioned, the majority of partners have collaborated previously and have already introduced mechanisms and specific ways of working. The main distinction identified is that programme-level decisions are not made unilaterally, as there are several 'responsible budget holders' not only one. The SPF enabled partners to have more input through the Programme Board allowing partners have a larger influence in the shape of the programme. Despite using standard ways of working the SPF programme enabled partners to see what these are and what they entail, enabled partners to increase their knowledge of standard operating procedures from other organisations.

Multi- and Inter- Disciplinary (MIDRI) approach

The programme has brought together several disciplines that may not necessarily come together as a whole, albeit these do have frequent bilateral collaboration, including; environment, health (medical sciences and patient care), chemistry, engineering, data science and social sciences.

The programme team and partners supported MIDRI through the design of calls and by promoting and facilitating the creation of MIDRI teams. The teams ran community events to facilitate the formation of MIDRI partnerships, as well as it being specified through call briefing sessions. Across all competitions and calls for proposals, MIDRI proposals have been explicitly encouraged through the call/competition text. In one of our interviews, it was mentioned that this is different from standard NERC practice where MIDRI is not a requirement but builds on a common practice for cross-council initiatives where MIDRI approaches have been promoted.

Some additional processes were put in place to assess MIDRI, particularly on the composition and approach to application assessment. NERC sought to appoint panel members with an appreciation of MIDRI research (not just experts from different disciplines). This was in recognition of MIDRI applications being at the interface of disciplines, and that's where the novelty lies. This was a shift from standard approaches as previously the focus was to have discipline experts reviewing sections of a proposal and assessing the proposal on its merit against their discipline of expertise.

It was highlighted that the role of the Champions was and will continue to be fundamental in bringing people together and creating a better understanding and recognition that addressing air quality challenges required several disciplines working together rather than individually addressing the problem in isolation. For instance, following a workshop led by the Champions and the Met Office, GPs and primary care specialists started to engage with data science experts in the context of air quality. For the 2nd Wave of work, the influence of the Champions has been further bolstered by linking more strongly with the Met Office and the appointment of several Regional Champions, who collectively work to draw in a national approach to the development of solutions.

In one of our interviews, it was recognised that although there was diversity in disciplines, more could have been done to have a larger breadth of coverage, as it was acknowledged that some of these are still missing, for example data science, behavioural science, psychology. Much effort is however being made to rectify this during the Wave 2 funding period.

It was mentioned in one interview that the MIDRI nature of the programme was not only showcased through the calls/competitions but that the programme was attesting to this principle by collaborating and engaging with partners, all involved with different disciplines. It was also recognised that there is a very important role for champions and the central NERC and Met Office teams to have that oversight of the different activities to see where outputs from some areas might be valuable in others. Although still in development we can see that there is also progress in this area as the programme plans shift towards benefits realisation, dissemination and legacy activities.

Changing needs and opportunities

Across the delivery of the programme, the strategic rationale hasn't shifted significantly to emerging needs per se but it has been utilising the learnings from Wave 1 and embedding them into Wave 2 to address the existing and emerging gaps in the research. Similarly, context changes mainly COVID-19 and the UK hosting COP 26, only strengthen the role of the Champions to keep Clean Air discussions on top of the policy and research agendas, and it allowed for some research projects to include this within their delivery. The OSCA project developed data that supported short-term analysis around the impacts of the spring 2020 lockdown, and ANTICIPATE has developed a Participatory System Map (PSM) 'Mapping the Covid-19, Carbon and Air Quality Trilemma in Personal Transport', which is now being used by the Department of Transport (DfT).

B.8.4. Programme outputs

MIDRI proposals

The programme managed to attract a diverse set of MIDRI high-scoring applications, however, it was noted in our interviews that there wasn't a systematic approach towards embedding MIDRI across the programme and it was often left to the interpretation of partners, research or project teams. From the received applications it was possible to see that this encouragement for MIDRI permeated through. As an example, there was a consortium between public health academics and an architect collaborating on the delivery of a research project. Similarly, business-led projects have included health expertise from the outset, others have included usability expertise within the project team (social sciences), involving end-users bringing different perspectives into the feasibility and prototype design. The collaboration with NPL has enabled projects to have a specific partner for testing and benchmarking. Allowing the programme to address more complex/multi-faceted challenges, as stated "The Clean air programme allows a lot more focus around the key issues and has brought different organisations to work together rather than all delivering in isolation"

R&I outputs

It is yet too early to assess the level of outputs that have emerged from the different research and business projects given that most of them are currently underway or recently finished. As the programme starts to shift towards delivering its Legacy and Benefits Realisation activities, they have planned to collate, synthesise and disseminate information at the programme level through the development of an outputs log; identify the relevant stakeholders and work collaboratively with them to develop material that useful to them and end-users. For instance, several of the Mat Office funded projects were designed to interconnect with one another, and to therefore attract the interest of several stakeholders. One such Met Office lead project

MAQS-Health (Multi-Model Air Quality System for Health) which takes air quality concentrations from a regional atmospheric chemistry model and calculates air quality concentrations at a street level resolution, will be used by another Wave 1 tool to calculate local personal exposure levels to investigate impacts on health. When combined with the output from another Met Office project investigating indoor air quality concentrations, will provide the means of estimating total exposure to a range of pollutants found across the indoor/outdoor continuum. The project now looks to engage with a broad range of stakeholders to explore its wider usability.

The role of the Champions has been to identify relevant end-users (incl. policy / decision makers), in addition to the engagement that already exists through the steering committee. This has been showcased through two key engagements led by champions, the Met Office and NPL, Air Pollutant Round Table and Joining Forces to Improve Air Quality and Health workshop[46].

The programme enabled projects to have direct interaction with end-user of their innovations helping address and overcome usability issues of the new products being developed, meaning that adoptions risks can be mitigated early, elements which would not have occurred otherwise. For instance, household air quality monitors being developed have now incorporated a rating mechanism to determine if the values shown are good or bad in simple terms, allowing end-users to take remedial action more effectively.

B.8.5. Programme outcomes and impact – R&I to address priorities

It is yet too early to assess how programme outputs have been taken up by end-users, as these are currently being developed. However, the experience of being involved in the programme has encouraged a greater involvement from government departments, one of which is now looking to co-fund a further competition run for a business-led competition, and for a devolved administration to fund a research proposal which directly aligned to their priorities. The programme team was also part of a special briefing to the Chief Medical Officer on air quality, highlighting and utilising the outputs from the Clean Air programme. The CMOs Annual Report (2022) focused on evidence for potential solutions to reduce the public health impacts of air pollution and will offer recommendations based on this evidence. The report was published in the summer 2022.

Emerging outputs from some projects have been seen to have broader relevance to end-users, for example, Breathing City: Future Urban Ventilation Network, was originally developed for the city of Bristol but now there are other counties that used the outputs for their infrastructure and transport planning. Similarly, another award revealed the urgent need for research into air pollution solutions for vulnerable groups after the engagement of a cross-disciplinary community of academics and non-university stakeholders including industry, research institutes and the public which has now led to immediate action to develop follow-on research bids, strengthen the links to industry and undertake further public engagement.

Modelling projects (mainly delivered by the Met Office) have been intended to have internal end-users, which were consulted during the call scoping stages and outputs have been used to deliver the Met Office meteorological work more broadly, such as is the development of a tool which enhances the modelling systems for pollution modelling

Wave 1 projects have engaged with end-users for its broader deployment for instance one project (CAGE – Clean Air Gas Engine), which aims to support energy generation in

[46] https://www.ukcleanair.org/publications/

construction sites has been tested in HS2 construction sites, similarly, another project has directly engaged with large supermarkets to test their last mile refrigeration delivery technologies.

B.8.6. Programme outcomes and impact – ecosystem change

Through the programme delivery, there are clear challenges and opportunities, as well as lessons, learnt, through our stakeholder interviews some of these have been identified which we will explore in more detail below.

Intersectoral working

The programme managed to bring a diverse set of stakeholders together, covering different areas and disciplines to address the multifaceted and complex nature of the programme.

- *Programme size*: One of our interviewees stated that this level of collaboration was made possible due to the programme size and its longevity allowed it to approach these complex issues which are mainly rooted in the isolated approach towards addressing clean air challenges. However, it was also noted that the size and complexity of the programme made it difficult for some partners to engage, creating a disproportionate level of input across partners. This also lead to having multiple voices and opinions which at times caused delays to decision-making, but ultimately these have strengthened the collaborative approach towards delivery. The programme team highlighted that they need to account for additional time during the design stages of calls/competitions, as well as additional time for all involved to become embedded before the multidisciplinarity really becomes effective.
- *Governance and programme design*: the programme governance allowed for collaboration to take place, with a clear Science Plan determining the structure and delivery requirements of the programme. However, it was perceived that collaboration could have been stronger between partners as at times it felt like separate workstreams rather than a cohesive programme. This is attributed partially to the dual nature of the SROs of the programme (UKRI and Met Office), partners not knowing the processes and procedures of each other, which at times prevented programme board members to input or influencing specific calls. Similarly, a barrier was identified due to the difference in processes and ways of working across the programme board organisation members. The steering committee was set-up to provide strategic steer to the programme board, with members across different organisations, including senior public servants such as the Chief Scientific Advisors and their officials across different departments. It was recognised that although it was great to have their representation, it sometimes proved a challenge to get their full commitments (particularly during COVID-19), and these tasks were delegated to other colleagues who at times did not have the right level of strategic perspective to provide input into the programme. The programme team have recognised that getting the right representations (at the right level) of seniority is crucial to maximise the effectiveness of the steering committee.

  It was also mentioned in our interviews that given the fast-paced nature to deliver funding to projects, it was not possible to have a fully integrated approach with staggered research and a pipeline of activities that takes abstract concepts to commercial innovations.
- *Supporting collaboration*: The role of the Champions was to bringing disciplines, sectors and organisations together to create a system change on the way air quality/pollution issues are addressed. It was noted that the engagement with the health community worked well, especially in primary care and working with GPs, which are now a consolidated group which engages with the Clean Air programme.

Supporting and encouraging MIDRI

The programme across its different funding streams have acted as advocates of MIDRI, and have promoted and encouraged MIDRI applications. Across NERC and Innovate UK funded

projects it is possible to see a combination of disciplines, across Met Office projects given the highly technical nature of some of these i.e. modelling, it was necessary to have a monodisciplinary team, however the outputs from these were noted will support and enhance the research across several disciplines.

- *Governance and programme design*: the governance through the incorporation of different actors and stakeholders provided the right environment to foment MIDRI activities. The nature of the programme allowed for it to focus on the interface between disciplines making it part of the core remit of programme delivery. The MIDRI focussed design was indicated that supported the design of other programmes such as the Fund for International Collaboration (FIC) also led by UKRI. Given that this was a NERC led programme but a UKRI initiative. It was mentioned through one of our interviews that there was anecdotal evidence that there was some apprehension for researchers to be out of scope as it was funded under the NERC 'banner', this was subsequently mitigated through the introduction of the UKRI funding finder website. Equally, it was noted that there isn't a harmonised UKRI approach towards cost eligibility and scope requirements, which could have deterred researchers which are not familiar with the NERC processes.
- *Calls and Application*: It was noted through an interview that the community showcased some degree of nervousness in submitting MIDRI applications that could have been considered too novel, probably jeopardising their chances of success. As mentioned earlier there were some areas that were underrepresented, this is because to create a MIDRI application additional time is required to engage and build new relationships. However, based on feedback, the teams provided more time and opportunities in the second wave to allow MIDRI partnerships to form (scoping workshops, webinars, networks etc)
- Assessor and Assessment: as mentioned a different approach to assessment was implemented however one of the main barriers are still identifying reviewers/panel members who identify as interdisciplinary researchers, although this number seems to be increasing. The team has tended to rely on a core cohort of panel members with a good understanding of what the programme is trying to achieve, sometimes drawing from the programme steering committee.

Addressing government priorities

- *Governance and programme design*: The SPF gave the Government departments a stronger role in specifying research. This experience has increased their knowledge and engagement with UKRI and given all partners an understanding of how the different organisations work. However, it was mentioned that stakeholder expectations could have been better communicated, as some government departments saw the programme as an extension of their research budgets, on occasions wanting to have a greater say in the programme's project selection.
- Additionally, the nature of the UKRI business-led calls (using a pre-commercial procurement framework through the Small Business Research Initiative[47]), can allow for easier adoption of these emerging innovative outputs and technologies into the public sector.
- The Central Programme team mentioned that government partners are awaiting to see the emerging outputs, resources or tools of the programme, and through the utilisation of these develop or adapt policies and strategies. Currently, the programme team is compiling an outputs catalogue to share across different departments, and through the programme's legacy workplan develop mechanisms to share this information with end-users.
- *Changing priorities*: the programme started to be developed in 2018, and government priorities have changed since, for instance, the introduction of the Clean Air strategy in

[47] SBRI aims to support public sector organisations solve challenges by connecting them with innovative businesses to develop cutting-edge and cost-effective solutions.

2019, followed by the 2018 National Atmospheric Emissions Inventory (NAEI), published in 2020[48], which led to specific policy action, new targets for particulate matter (PM2.5) under the Environment Act 2021 among others. Given the long-term nature of the programme, it was at times difficult to design funding calls and react to policy changes, however, these changes were considered as part of the remit of the Champions and through the design of Wave 2 calls, and individual projects have adapted some of their work packages to mainly include emerging needs arising from COVID-19.

- *Supporting further delivery of research and innovation*: the collaboration with partners, government departments, devolved administrations and other organisations has served as a mechanism to enable learning. It was noted that the involvement with the programme has led to further conversations with other teams in Government Departments wanting to understand how they could develop a collaborative programme emulating the Clean Air model.

It was also noted among interviewed stakeholders that currently the lessons and knowledge obtained through the delivery and implementation of the programme are currently held by those involved with the programme and that there is not yet a systematic way to centralise these for future opportunities. However, the programme central team is currently developing mechanisms to formally consolidate lessons learnt as it is recognised that the different mechanisms implemented through the programme are robust and sustainable there was a continuation of the programme i.e. wave 3 or other similar opportunities.

B.8.7. The future

As funding calls/competitions have finished, the programme efforts have now shifted to its 'legacy' elements, which aim to create a UK unified, strengthened and expanded air quality and health research community, increase awareness and reach of air quality with health professionals and the public, improve the evidence base to inform policy decisions and better data and modelling tools. The expectation is that emerging outputs from R&I will start to be disseminated as they emerge across the different stakeholder groups. In order to achieve this, it is planned that:

- Develop an outputs catalogue from the different R&I projects
- Champions and Programme Leads will continue and expand stakeholder engagement to develop the right knowledge and output-sharing forums
- Champions and Programme Leads work with partners to develop content that is useful and impactful, making it accessible across different audiences.

A series of Task and Finish Groups have also been convened to further consider legacy questions - especially as they relate to the continued use of tools and resources created through the SPF Programme and how best to ensure they remain fit for purpose going forward.

Business-led innovation is expected to transition to commercialisation either by the public sector adopting these new technologies through public procurement or for organisations to commercialise and exploit their innovations in the marketplace.

The Met Office expects to see a level of influence in policy based on the outputs from the programme and deliver a Clean Air Framework tool by 2025.

[48] https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-summary

B.8.8. Stakeholders interviewed

- Programme lead, Ben Williams, NERC
- Programme lead, Met Office
- Partner Council, Kevin O'Malley, Innovate UK
- Programme Champion (no longer in post) – Jenny Baverstock, University of Southampton

B.9. Adolescence, Mental Health and the Developing Mind

SPF Wave 2	**SPF funding amount**: £35 m	**Programme Start and end date** 01/08/2019 - 31/03/2026
Lead Council / PSRE: MRC	**Other Council / PSRE**: AHRC and ESRC	**Government departments**: DfE, DHSC and the Scottish and Welsh governments
Other partners • The McPin Foundation		
Key objectives • Establishment of a UK-wide multidisciplinary and multi-sector research community in adolescent mental health and the developing mind. • Delivery of high quality, novel research programmes that generate new knowledge of adolescent mental health and the developing mind. • The development and adoption of novel methodology, tools and resources to support the broader field of adolescent mental health research • Long-term potential for contributing to evidence-based policy and practice in adolescent mental health and wellbeing • The promotion of Patient and Public Involvement and Engagement (PPI&E) in adolescent mental health research.		
Main phases • Community building and stakeholder engagement • Flagship research programmes • Methodological development • Cross-cutting knowledge mobilisation		

B.9.1. Summary

Poor mental health in adolescence can negatively influence lifelong mental health, educational attainment, identity, social relationships, and behaviour. The Adolescence, Mental Health and the Developing Mind programme aims to support and fund research that, amongst other things, examines how mental health problems emerge, what makes some young people more susceptible or resilient than others, and how to intervene early to promote positive mental health and wellbeing. The £35m programme is led by the Medical Research Council (MRC), jointly delivered with the Arts and Humanities Research Council (AHRC) and the Economic and Social Research Council (ESRC). It will run until early 2026.

The programme has largely progressed as planned with nearly all the funding now fully committed, primarily through four research calls. The programme has actively sought collaboration across multiple disciplines including medicine, biology, psychology, social science, arts and humanities, environmental research, engineering, and digital science. This was built into documentation for funding calls and the development of funding panels to select high quality MIDRI proposals. Overall, interviewees were positive that the programme had achieved this and noted that the programme was bringing together medicine and biology with arts and humanities more than usual.

Young people's mental health is an established priority for the government, meaning research in the field would likely have taken place in the absence of the programme. However, it does appear to be funding more complex and multi-levelled research projects than usual and at a

greater scale than normally possible. Involvement in the programme has increased partners' confidence in investing in MIDRI and led to new collaborative opportunities.

B.9.2. Introduction

Poor mental health in adolescence can negatively influence lifelong mental health, educational attainment, identity, social relationships, and behaviour. The aim of the programme is to support and fund research that examines how mental health problems emerge, what makes some young people more susceptible or resilient than others, and how to intervene early to promote positive mental health and wellbeing. There are five linked objectives (which are listed at the top of this case study).

Young people's mental health is an established priority for the government, which was reiterated in their response to the Health and Social Care Committee's report on children and young people's mental health published in March 2022[49] and further emphasised by an evidence review showing the damaging impacts of the pandemic[50]. Young people's mental health cuts across several Government departmental remits. For example, the Transforming Children and Young People's Mental Health Implementation Programme[51] is a joint and collaborative programme led by the Department of Health and Social Care (DHSC), Department for Education (DfE) and NHS England and NHS Improvement (NHSE/I). The Department for Culture, Media and Sport (DCMS) also aims to tackle key issues around loneliness in young people, youth provision in communities, and digital influence.

Given its importance, interviewees agreed that research on young people's mental health would have been funded in the absence of this programme but that it would likely not have been as multi-disciplinary or at the same scale. Interviewees emphasised that the nature of the topic, which encompasses genetic, physiological, social, and cultural factors, has meant that there are existing ways of working for multi- and inter-disciplinary research in the field. However, this often requires larger budgets and more diverse teams, which makes it more challenging to implement. As such, the programme appears to be funding more complex and multi-levelled research projects, at a greater scale, and with more cross-Council working than usually possible through previous/existing mechanisms.

Interviewees reported that the programme has largely progressed as planned with nearly all the funding now fully committed. This has primarily been distributed across four research calls:

1. Engagement awards: 11 awards totalling £1.06m in February 2020.
2. COVID-19 rapid knowledge mobilisation: 2 awards totalling £400k in September 2020.
3. Substantive research programmes: 7 awards totalling £24m in September 2021.
4. Methodological innovation research projects: 12-13 awards totalling £8.15m set to commence in November 2022.

Other key activities have included:

- Establishing a Young Persons Advisory Group in collaboration with the McPin Foundation.

[49] https://www.gov.uk/government/publications/children-and-young-peoples-mental-health-government-response/the-governments-response-to-the-health-and-social-care-committee-report-children-and-young-peoples-mental-health

[50] https://www.gov.uk/government/publications/covid-19-mental-health-and-wellbeing-surveillance-report/7-children-and-young-people

[51] https://www.gov.uk/government/publications/transforming-children-and-young-peoples-mental-health-provision

- Collaborating with the Wellcome Trust as part of the community-building workstream to produce resources for researchers on best practice for involving young people in research on mental health. The tender for the initial mapping activity was awarded to Science Practice in September 2022, with the outputs expected in Summer 2023.
- Commissioning the National Children's Bureau as part of the stakeholder engagement and knowledge mobilisation workstream to support the development and dissemination of outputs from the seven research programmes. Following some commissioning delays, this work started in Spring 2022 and includes mapping common themes across the projects and identifying key stakeholders and audiences to support translating evidence into policy and practice.

B.9.3. Programme Design and Delivery

Intersectoral working and collaboration

Intersectoral collaboration is built into the programme's governance and management with the involvement of the three Councils and representatives from governmental departments (DfE and DHSC) and devolved governments (Wales and Scotland). Most partners had previously worked together, so involvement in the programme strengthened these relationships through deeper understanding and richer engagement and also generated new relationships between MRC and AHRC. Furthermore, partners were more likely to have worked together bilaterally or in smaller arrangements in the past. Interviewees also highlighted the additional value of working with the Wellcome Trust.

As the lead Council, MRC is the key liaison across partners. Key points for collaboration have typically coincided with shaping the programme in early stages, feeding into the calls for research, and as part of the assessment of proposals. Beyond cross-council collaboration through regular Executive Group meetings, collaboration is primarily done through the Research and Stakeholder Advisory Board (RSAB), which includes government departmental representatives, academics, practitioners and third sector stakeholders. In addition, the programme's young person's advisory group also feeds int the RSAB.

In general, the ways of working were seen as fairly typical of other collaborations on complex projects (e.g. oversight procedures) and interviewees described positive working relationships across partners. Unsurprisingly, there were some challenges around 'not speaking the same language' – for example, health sciences and arts and humanities may interpret terms such as methodologies, expected outputs/outcomes, qual/quant differently. Despite this, interviewees were mainly satisfied that the views and priorities of their organisation were sufficiently considered and incorporated, while also broadening their awareness of other discipline approaches. One interviewee described making conversations more frequent and less transactional to raise this awareness of thinking in interdisciplinary ways. Other interviewees noted that opportunities to engage in the programme had been somewhat light-touch and that they would be willing to provide a greater amount of input. While this was not seen as a problem, it might suggest that intersectoral collaboration on the programme could be enhanced by increasing involvement across the Councils and government representatives.

Multi- and inter-disciplinary approach

The programme aims to address a lack of multi-disciplinary programmes able to explore complex issues, for example, the interactions between biological, genetic, environmental and social factors affecting people during adolescence and the high degree of inter-individual heterogeneity. To do so, the programme has actively sought collaboration across multiple disciplines including medicine, biology, psychology, social science, arts and humanities,

environmental research, engineering, and digital science. Interviewees agreed that it was bringing together medicine and biology with arts and humanities more than usual.

The programme has supported a MIDRI approach through the design of the calls, which were informed by all three Councils and the RSAB to ensure these were developed with different disciplines in mind and so that they would be applicable and appropriate to a wider group. The calls clearly stated all three Councils involved, which was seen as key for encouraging bidders who would not otherwise engage in MRC calls. The documentation for the call for research programmes included multiple references to MIDRI, for example:

> *"We welcome applications that draw in non-traditional disciplines to mental health research or combine disciplines or sub-disciplines that have not traditionally collaborated, in order to provide novel insights and approaches. It is expected that programmes will demonstrate structural and intellectual integration of all work packages (no matter the leading discipline in those work packages), such that interdisciplinarity clearly adds value to the research as a whole."*

The programme team also delivered a webinar in which they promoted a MIDRI approach, supplied a FAQ document including a response on the level of interdisciplinarity expected, and supported the development of MIDRI research teams in some cases. The programme was clear that successful proposals would demonstrate the value of a MIDRI approach and avoid tokenism. Interviewees noted that the requirement for a MIDRI approach was more explicit for this programme than previous calls, though they have historically supported MIDRI teams and projects. One interviewee noted that the incentivisation for people to come together early on is a significant shift from previous projects and enabled teams to be more creative, which in turn, added value to the programme.

To support assessing MIDRI proposals, funding panels were assembled to represent multiple disciplines and one interviewee noted that it was useful to appoint a Chair who was not directly in the field or in a single discipline. Inviting shortlisted research teams to interviews was also critical for a truer assessment of the extent of the MIDRI approach. Panels also included young people with significant effort put in to ensure they were able to provide valuable contributions. Lessons on engaging young people in this programme have informed wider MRC processes, acting as a model for other programmes. Inclusion of young people in research programmes was also built into the assessment criteria.

Changing needs and opportunities

The key changes to the programme have primarily stemmed from the impact of the pandemic, as detailed below:

- The programme launched the COVID-19 rapid knowledge mobilisation call, which was not originally planned. The programme invited proposals to support rapid mobilisation of research on adolescent wellbeing and mental health during the COVID-19 pandemic and awarded two projects.
- The involvement of young people in the programme was affected by the pandemic, such that moving online enabled the inclusion of panellists from across the country but also created barriers for engaging younger age groups. This also led to some delays in engaging young people.
- Multiple proposals submitted for the call on research programmes included a focus on loneliness, which was exacerbated by the pandemic. However, none of the awarded programmes had a primary focus on this topic. This was recognised as a key priority area for young people, and the research programmes were encouraged to include loneliness

measures in their data collection. Furthermore, loneliness was identified as a priority area for the methodological innovation call, resulting in several awards in this area.

B.9.4. Programme Outputs

Interviewees agreed that the programme attracted high quality MIDRI proposals and that this led to the selection of seven strong substantive research programmes that tackle complex issues using a MIDRI approach. The call received 76 outline applications, of which 22 were invited to submit a full application and nine were invited to interview. One interviewee described how proposal teams were brought together through a shared interest in understanding the interplay of various aspects in young people's lives. Teams developed in different ways – for example, some individuals with existing relationships added to their consortium, while others formed more equal partnerships – which some interviewees noted as influencing team dynamics.

To date, there are limited tangible outputs from the programme as the seven substantive research programmes are only 1-2 years into four-year project timelines and methodology projects have not yet started. The MRC originally intended to run an interim evaluation in autumn 2022 but this has been moved to 2023 due to the pandemic and capacity constraints within the programme management team. The aim of this interim evaluation will be to assess whether the programme is on track to achieve its goals and objectives based on a review of the whole portfolio (given most funds are now committed). Until then, the research teams are expected to report updates regularly.

There have been some key outputs from the COVID-19 rapid knowledge mobilisation projects, including resources for young people developed through:

- CoRAY project[52] led by Professor Cathy Creswell. The resources are available on the Emerging Minds website (part of the Cross-Disciplinary Mental Health Network Plus initiative supported by UKRI), which include podcasts, short films, infographics and webcomics. They have also published evidence syntheses, webinars, and evidence-informed guidance.
- KeepCool project[53] led by Professor Andrea Danese. The resources are available online on King's College London's website, including short educational videos and practical tips on anxiety, sadness and anger. They also ran social media accounts on Twitter, Instagram and TikTok.

The engagement awards were largely focused on building partnerships and developing some pilot research, but these were significantly affected by the pandemic as the projects were due to start in April 2020. Outputs were supported the development of partnerships that subsequently submitted high quality proposals for the research programmes call.

Looking ahead to when outputs are available, the programme has commissioned the National Children's Bureau as part of the knowledge mobilisation workstream to support the a joined-up approach and targeted approach between the seven research programmes. This work started in Spring 2022 and includes mapping common themes across the projects and identifying stakeholders and audiences to support translating evidence into policy and practice.

[52] https://emergingminds.org.uk/resources-for-young-people/

[53] https://www.kcl.ac.uk/research/keepcool

B.9.5. Programme outcomes and impact - R&I to address priorities

As mentioned above, there are a limited number of outputs, so it is too early to comment substantively on how outputs have been taken up and implemented by end-users. The government representatives we spoke to had not used any outputs from the programme to date. Some interviewees were unaware of any outputs at all, suggesting there is an opportunity to share more frequently internally as well.

As mentioned above, the resources developed for young people as part of the COVID-19 knowledge mobilisation projects are available online and there have been several media articles about the projects. In general, interviewees were positive about breadth and quality of resources developed, which were seen a young person friendly and highly relevant during the pandemic, including podcasts, short films and social media posts. However, it is not clear how these have been promoted outside of the programme or levels of engagement among young people and/or practitioners who might recommend them to young people.

The programme team will conduct a synthesis of programme portfolio, including through the interim evaluation, with the outputs made transparent and available. The programme is also making substantial efforts (alongside the Wellcome Trust and National Children's Bureau) to map and build relationships with end users including young people, schools, colleges and universities, charities, children's health and social care services, and more.

Overall, interviewees felt confident that the expected outputs of the programme will address key priorities set out by the programme.

B.9.6. Programme outcomes and impact – ecosystem change

Overall, interviewees felt the programme was working well. Key strengths included:

- **Ways of working with young people**: Interviewees were extremely positive about how the programme has been involving young people through funding calls, panels, and stakeholder mapping. They felt this had been beneficial to all stages of the programme, including a MIDRI approach, and is a model for good practice. The programme has also been responsive to the voices of young people. For example, when young people were interested in projects focused on loneliness that were ultimately not funded in the research programmes call, this was explicitly named a priority area for the methodology call.
- **Incorporating the priorities of different disciplines**: Input was sought from across partners to feed into the development of funding calls and representatives have sat on funding panels to represent individual priorities. Meeting chairs actively sought to create open discussions to raise awareness and help partners learn from one another. One interviewee stated: *"I felt well respected from a disciplinary point of view [during involvement in most recent methodology call]."* Interviewees were also satisfied that this translated into funding projects that spanned disciplines.
- **Building on previous cross-Council programmes**: The project improved and enhanced the depth and mutual respect for people's interests and made them more visible across more parts of the organisations involved.

Interviewees also noted some areas for improvement:

- **Engaging partners more regularly**: There was some sense that partner engagement could be increased, both with other Councils and government representatives (particularly devolved governments). While partners generally felt that the programme was addressing its key priorities (based on the initial shaping of the programme), the programme could potentially do more to enhance understanding of research priorities and opportunities between Councils and government departments. However, this is likely to become more

prominent as outputs emerge. One interviewee emphasised that these elements of co-design and dialogues can outlive the programmes themselves.

- **Sharing outputs:** Some interviewees were not aware of having received any communications about the programme outputs to date. As more outputs emerge, the programme should develop a strong communications plan, both internally with partners and externally.

As a wider benefit, multiple interviewees across Councils and partners described that their involvement in the programme had increased confidence around investing in MIDRI programmes. However, importantly, some interviewees described that it helped with confidence building but it has not been a paradigm shift because there was already a baseline level of working in a MIDRI way. Interviewees were not able to comment on whether confidence to apply for MIDRI funding had improved within the research community.

Interviewees also noted several new initiatives that have arisen outside of this programme, for example, the MRC has started the Adolescent Health Study and the cross-council Mental Health Platforms are upcoming. Another initiative for collaboration ultimately did not go ahead, but there has been willingness for future cross-Council working.

B.9.7. The Future

The funding calls have concluded so the programme is shifting on to early delivery, learning and outputs. To achieve this, the programme management team is increasing focus on monitoring frameworks, which will inform the interim evaluation and ongoing monitoring of the programme at a portfolio level. For example, one interviewee described current discussions around how to best measure MIDRI, including looking at the make-up of the teams involved and who leads them (PIs and Co-Is).

It is expected that outputs will be disseminated as and when they are available, supported through the role of the National Children's Bureau in knowledge mobilisation. Interviewees expected outputs in the form of reports as well as more engaging formats for diverse audiences.

Overall, interviewees expressed that by the end of the programme they want to see an increase in knowledge in the areas the programme is investigating and the ability to use this knowledge within practitioner services. This would ultimately be used to support operational changes that improve mental health and wellbeing among adolescents, but this impact was seen as longer-term.

B.9.8. Stakeholders interviewed

- Programme Director
- MRC Programme Lead
- AHRC Partner Council Lead
- ESRC Partner Council Lead
- DfE representative
- Welsh Government representative
- Advisory Group Chair

B.10. National Timing Centre

SPF Wave 2	**SPF funding amount**: £44m (incl. £14m extension)	**Programme Start and end date** 17/07/2019 - 29/03/2025
Lead Council / PSRE: NPL	**Other Council / PSRE**: IUK	**Government departments**: MoD, BEIS and DfT
Other partners • Ofcom • UKSA • BBC • JISC • And others		
Key objectives • Objective 1: Deliver a resilient UK national time infrastructure through the building of new Resilient Enhanced Time Scale Infrastructure (RETSI) facilities, with the potential to network these in the future to provide accurate and resilient time from multiple secure geographic locations. • Objective 2: Provide innovation opportunities for UK companies through funding projects in partnership with Innovate UK based on a successful NPL and Innovate UK partnership model. • Objective 3: Respond to the specialist skills shortage in time and synchronisation solutions through specialist, apprentice and post graduate training opportunities.		

B.10.1. Summary

The National Timing Centre (NTC) programme commenced in July 2019, with funding provided through to 2025. The programme seeks to develop the technologies to underpin a secure infrastructure of time distribution at dispersed locations across the country, through the building of new Resilient Enhanced Time Scale Infrastructure (RETSI) facilities.

As of the end of 2022, there is evidence of the programme having achieved some of its desired outputs, although the RETSI facilities are yet to be constructed. Despite this, the interviewees still felt that in the absence of the SPF support, this type of research would not have proceeded at the time or pace that it has.

At the end of 2022 (when stakeholders were consulted for the case) there remained some uncertainties over the delivery of outcomes, including interviewees noting that government policies would have a huge impact on the future outcomes achieved by the NTC. We have since been informed by the programme (in June 2023) that they expect a ministerial announcement shortly, endorsing recommendations from the cross-government PNT group that the NTC, as an enduring national asset, is critical to mitigate the national security and resilience risk on time for critical national infrastructure. This would then secure the longer term development and sustainability of the NTC.

B.10.2. Introduction

The National Timing Centre (NTC), which sits within the National Physical Laboratory (NPL), has a budget of £44m and is running for 6 years from 2019.

The strategic reasons for the NTC run across the entire UK economy, with various activities relying on very precise Position, Navigation and Timing (PNT) technologies. For example:

- Aircraft, ships and (increasingly) road vehicles require very accurate position and navigation data access.
- Financial transactions require extremely accurate 'date stamps' for validation and fraud monitoring and auditing – not least because automated flash trading (in particular) relies on exploiting extremely fast buy or sell opportunities.
- Similarly, the national grid and electricity markets now rely on phasor measurement units, electronic devices that measure voltage and current thousands of times per second in order to optimise generation and transmission systems. Any degradation in the accuracy of phasor measurement due to a breakdown in timing synchronisation can lead to cascading problems that, if left unstopped, can create electricity blackouts as the system of closely coupled electricity supply and demand flux management breaks down.
- Similar issues exist in telecommunications systems.

In short, a large part of a modern industrial economy (and national security) relies on PNT capability. This creates 'upside' opportunities for developing new markets, technologies and supply chains, but also 'downside' risks if PNT systems fail – or are attacked by adversaries. One estimate puts the reliance on PNT at 11% of GDP[54], a reliance likely to increase in the future.

In response to these concerns, the 2018 National Security Capability Review concluded that we are in a period of increased complexity and risk. The challenges identified in the previous 2015 National Security Strategy had grown faster than anticipated, and therefore the need for greater resilience had become a major policy concern in Whitehall. The risks faced were judged to be profound - with many important sectors demonstrating a critical dependence on PNT services for many of their operations. The National Risk Register reflected these concerns and the Cabinet Office started to take an active interest in PNT issues. The Blackett Review on satellite dependency reinforced these concerns, as did economic estimates of the potential impact on the City of London's activities should access to precise timing be unavailable (estimated at £1bn per day in losses)[55].

A further important consideration in the NTC business case was that the UK currently does not have a domestic industrial base and supply chain system in cutting-edge timing technologies. Advanced equipment must be imported, which further exacerbates national security concerns and has stimulated an interest in catalysing the growth of the domestic advanced timing equipment business 'ecosystem'.

The NTC programme aims to undertake and fund R&I activity to begin to address these issues. The programme seeks to develop the technologies to underpin a secure infrastructure of time distribution at dispersed locations across the country. As such, it will provide the technology to underpin the UK being able to become one of the first countries in the world to develop a resilient time and frequency distribution network that does not rely on satellites for a reliable

[54] Winning Moves (2017) *The National Measurement System: Customer Needs and Impact Survey*. Cited in NPL (2020) *The Economic Impact of the National Timing Centre on Collaborating Companies*. NPL Report IEA 2, Feb.

[55] London Economics (2017) *Economic impact to the UK of a disruption to GNSS*. April.

time source - whilst also supporting UK companies to innovate and develop the skills needed in this field. Note: the major national security aspect to NTC means that many key aspects of the centre's aims and activities are security classified.

A world-first, the NTC will provide additional resilience to public services and the economy against the potential impact of satellite systems failure. The centre will aim to provide accurate time to 999 responders and the energy grid without relying on satellite technologies (alongside providing accurate time to the Ministry of Defence and Front Line Commands) – which can potentially fail with major consequences for accurate timing in a modern industrial economy. The United States is now acting to emulate this type of whole-of-government approach.

NTC involves a team of researchers, based at sites across the UK, who are working together to make UK public services and the economy less reliant on satellites through a network of RETSI facilities. That is to say, clocks that use atoms and surrounding electrons to keep track of time. These will be housed at three secure locations around the UK[56].

The NTC programme has made significant progress in the past year (2021-2022) against all three of its objectives (listed in the table at the start of the case). The materials for three RETSI facilities have been sourced and delivered, and work has begun to start assembling the clocks. The NTC programme has also run two Innovate UK competitions, awarding £6.7 in grant funding to UK organisations. In addition to the competitions, NPL have undertaken research to generate a better understanding of the needs of industry and existing innovation activity. Finally, an introductory timing training course has been developed and made available through the NPL website, and research hubs have been launched in three universities.

B.10.3. Programme Design and Delivery

The programme design directly reflected the national security concerns noted above. In this sense, the NTC rationale was directly driven by a growing concern that the UK economy is vulnerable to significant disruption by antagonists, including serious organised crime – as well as solar flares that would disrupt satellite time source assets.

Given its well-established role as the UK's metrology (generic measurement) laboratory, NPL was the natural choice for delivering a response to these timing access-based national security concerns. Intersectoral and interdisciplinary working have then been promoted through:

- Multiple departments and organisations being involved in the oversight and management of the NTC, and in particular the development of the RETSI facilities, but also reviewing the content of the learning materials developed.
- Multiple organisations being aware of the programme and being able to feedback information to relevant sector bodies, organisations, and employees.
- Two innovation funding competitions supporting research relating to accurate timing across multiple sectors.

The NTC programme has made significant progress in the last year, as outlined in the previous section. However, it has also faced some barriers to delivering the programme as planned and to the required timescales. The most significant of these has been securing a site for one of the RETSI facilities. The programme had originally aimed to have one clock based within a private sector organisation – however no funding had been assigned within the programme budget for this. Although there are benefits for the private sector organisation which houses it (i.e.

[56] A revised figure within the timeline of the programme, down from four, due to the level of funding required and partner consent.

access to resilient and accurate time), there are significant costs associated with preparing the space for the RETSI facility to be located and the ongoing maintenance of the area. As such, this aim has now been descoped. The programme will now build two primary RETSI facilities at NPL and GCHQ, while a third deployable system will be hosted at at NPL, allowing the programme to test the mesh, ready to deploy in a next phase.

A further challenge in the design of the delivery was the timing of the second innovation competition. This was run close to the end of the completion of the first round, but generated fewer applications than had initially been expected. The reasons for the lower response to this call were still being investigated at the time of the research, but it was felt that wider economic factors may have contributed to the lower response rate. A lack of commitment as to how organisations could access the NTC was also highlighted as a potential reason (see section 6). The lower response rate did mean that not all of the funding for the competition was allocated, as there were insufficient high-quality bids. Therefore, the remaining funding was used to undertake research to generate a better understanding of the needs of industry and existing innovation activity.

B.10.4. Programme Outputs

There is evidence of the programme having achieved some of its desired outputs at this stage, although the RETSI facilities have not yet been constructed.

From the main R&I project (Objective 1), the following outputs have been achieved:

- Agreement for the location of two of the RETSI facilities. The locations cannot be revealed due to national security considerations.
- Procurement of all the relevant parts to construct the clocks. This was an important output to achieve, as subsequently there were significant delays in the shipping of these parts due to global economic conditions.
- The NTC team have also checked the quality of the components procured, to ensure that they can be used in the RETSI facility. It was found that the quantum sensors were unsuitable and the NTC team were able to work with the manufacturers to alter the parts.
- The NTC staff have also participated in European collaborations to verify the international consistency of the new clocks.

There have been more outputs achieved through the other two strands of activity, and through wider activity to promote intersectoral and interdisciplinary work. These outputs include:

- The development and provision of a training course, developed by NPL, to act as an introduction to timing. This is advertised as being of use to individuals working in any sector which requires accurate timing (e.g. telecoms, finance etc.) and as an introduction to specialist time, frequency and/or synchronisation (TFS). These are available online on the NPL website. At the time of research this training course had already been undertaken 150 times and this anticipated to increase to 550 by the end of the programme.
- The NTC have carried out a skills assessment, which aimed to better understand the composition of the current TFS workforce, the availability of TFS skills across topics and proficiency levels, and the requirements for future skills and training. This has been incorporated into the NTC Training & Education Blueprint.
- The NTC have established a presence in three universities (Strathclyde, Cranfield and Surrey). This presence is node access to the timing centre. This will promote interdisciplinary and intersectoral work as the nodes are based in the quantum, automotive and

automotive transport departments within the three universities – and it is therefore hoped it will promote research and innovation in different departments and different areas.

- Two Innovate UK competitions have been run, generating 40 applications for funding (26 applications for the first competition and 14 for the second) and awarding 26 grants to undertake innovation research projects (17 and 9 respectively). At the time of the research, all of the projects from the first competition had been completed. These were low TRL projects, focusing on feasibility studies and proof of concept.
- An internal research paper exploring the market has been developed (under Objective 2 of the NTC). This maps the sectors and industries that are dependent on accurate timing, the innovation activity of companies in these industries (and the barriers to and drivers of innovation), the level of awareness of the risks associated with GNSS timing provision and the requirements for future training.

Interviewees suggested that there were additional knowledge generation outputs from the activities involved in the development of the new clocks, around how these would work and what is required to connect the clocks to one another.

B.10.5. Programme outcomes and impact - R&I to address priorities

At this point evidence is not available on programme outcomes and impacts to address priorities relating to the main innovation activity (the construction of the RETSI facilities). This is because of the progress which has been made with the main R&I project (the clocks have not been constructed as of yet) – therefore there are no operational outcomes.

There have been a small number of innovation outcomes relating to the Innovate UK competitions that have been run. The first competition focussed largely on small, proof of concept / feasibility studies, at low TRLs. Therefore, the majority of outcomes from these studies were not directly usable for end users. However, five projects from the first competition have subsequently received funding from the second Innovate UK competition, suggesting that these innovations have promise and may have end user benefits in the future. One company which received funding in the first competition was able to take the results to an end-user, and the company has received funding from them to develop the technology and put it into use.

B.10.6. Programme outcomes and impact – ecosystem change

The organisations and individuals involved in the delivery of the NTC programme are from multiple organisations. However, these were known to each other beforehand, with many working together on the existing PNT working group. At this stage there is no evidence of new relationships and working arrangements outside the 'Business As Usual' context. Despite this, the interviewees still felt that in the absence of the SPF support, this type of research would not have proceeded at the time or pace that it has. This means that without this SPF support the UK's risk exposure to PNT services disruption, and the economic and national security consequences, would be greater than it currently is.

Most of the individuals working together were also of the same discipline (the same type of job roles focusing on the same areas – timing and navigation – but for different organisations). There is therefore limited evidence of multi-disciplinary working in the direct delivery of the development of the RETSI facilities and governance of the programme.

The interviewees stated that around half of the applications for Innovate UK funding had come from organisations and institutions which were already known to them as active within the timing community, while the remaining applications were from new companies not known to staff at the NTC. This suggests that the programme has made progress in supporting the development of a UK based supply chain in this area. The applications comprised a mixture of

organisations bidding together as a multi-discipline bid and sole bidders, and that most bids included an element of interdisciplinary work within them. Many of the bids were also sector agnostic, developing new forms of dissemination applicable to time and frequency requirements across sectors.

Additionally, the placing of the presence of NTC timing in three universities has been specifically selected to promote intersectoral working. The node in the University of Surrey is in the 5G innovation centre, to promote timing and telecommunications related innovation; in Cranfield, in the Transport innovation department within the University of Strathclyde to promote automotive and timing innovation and in the Quantum department of Cranfield University. There have been no innovation project outcomes utilising the NTC from these academic institutions as yet, but these intersectoral outcomes are expected in the future.

B.10.7. The Future

There is a lot of positivity around the programme and what it may achieve by the end of the funding period (in 2026) and beyond. In the absence of SPF funding, most interviewees felt that there would not have been the progress that has been made in this area, and the research would be many years behind where it currently is. Additionally, there would not have been any Innovate UK competitions, so there would have been no development of the supply chain.

The outcomes and impacts that interviewees expected by the end of the programme were:

- The provision of three RETSI facilities, at three sites, which accurately provide time readings.

  It is expected that through subsequent Government funding the RETSI facilities would then be connected with multiple time transfer methods (for resilience through diversity of failure modes). The official time of the UK would then be switched to the RETSI facility network (potentially by 2030), which would help support resilience of UK infrastructure.
- Increased use of the online training course, including by individuals from a wide variety of sectors which are dependent on time.
- Further training courses developed and made available through the NPL website.
- Intersectoral and multi-disciplinary research to take place at the three academic institutions with access to timing from the RETSI facilities, pushing the knowledge and innovations from the programme into the transport, quantum and telecommunications sectors.
- A more developed, mature, UK based supply chain which utilises the technology developed by the programme, and these technologies will be exported, as this work is globally leading (there is work in the USA, but it is less market and innovation focussed).

At the time of consultation, however, the longer-term outcomes of the programme were subject to some degree of uncertainty. In particular, most interviewees felt that Government policies would have a huge impact on the future phases and outcomes of the NTC. At the time, a cross-government PNT working group had been formed that was preparing recommendations in relation to critical national infrastructure. We understand (as of June 2023) that the NTC team are expecting a ministerial announcement shortly, endorsing recommendations from this cross-government PNT group that the NTC, as an enduring national asset, is critical to mitigate the national security and resilience risk on time.

B.10.8. Stakeholders interviewed

- Leon Lobo, SRO and Head of the NTC, NPL
- Mike King, Programme M&E lead, NPL
- Dan Veal, Programme lead, NPL
- Gabi Gorringe, Programme researcher, NPL
- Bryn James, Programme partner, DSTL
- John Beddington, Advisory Group, Independent
- Carol Sunderland, Programme partner, Innovate UK

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