Cambridge Policy Consultants

An Economic Evaluation of BBSRC's Translational funding

Final Report

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CONTENTS

LIST OF ACRONYMS

Acronym	
AHDB	Agriculture and Horticulture Development Board
AHRC	Arts and Humanities Research Council
BBSRC	Biotechnology and Biological Sciences Research Council
CPC	Cambridge Policy Consultants
DPFS	Developmental Pathway Funding Scheme
DRINC	Diet and Health Research Industry Club
ECR	Early Career Researcher
EPSRC	Engineering and Physical Sciences Research Council
ERA	European Research Area
ERC	European Research Council
FEC	Full economic cost
FoF	Follow-on Fund
FTMA	Flexible Talent Mobility Account
GSE	Greater South East
GM	Genetic Modification
GVA	Gross Value Added
HAPI	Horticulture and Potato Initiative
HE-BCI	Higher Education Business and Community Interaction
HEIF	Higher Education Innovation Funding
IAA	Impact Acceleration Accounts
iCURE	Innovation-to-Commercialisation of University Research
IP	Intellectual Property
IT	Information Technology
Je-S	Joint electronic submission
KTP	Knowledge Transfer Partnership
MRC	Medical Research Council
NBIC	National Biofilms Innovation Centre
NERC	Natural Environment Research Council
NIAAH	National Institute for African American Health
NIBB	Networks in Industrial Biotechnology and Bioenergy
PI	Principal Investigator
PoC	Proof of Concept
RCUK	Research Councils UK
RO	Research Organisations – UK Universities and Research Institutes
sLoLa	strategic Longer and Larger grant
STFC	Science and Technology Facilities Council
TRL	Technology Readiness Level
TRO	Translational Research Offices
TTO	Technology Transfer Offices
UKHSA	UK Health Security Agency
UKRI	UK Research and Innovation

EXECUTIVE SUMMARY

Background

1. In March 2023 the Biotechnology and Biological Sciences Research Council (BBSRC) commissioned Cambridge Policy Consultants (CPC) to conduct a strategic evaluation of the outcomes and impact of BBSRC's investment in translational funding. The BBSRC programmes, namely Follow-on Fund (FoF) and Impact Acceleration Accounts (IAA), are designed to support researchers to translate their fundamental research ideas into practice including through the development of a spin-out company, social enterprise or a licensing agreement. The evaluation examined a number of questions including:

   - what is the breadth of the types of outputs, outcomes and wider impacts that have been delivered due to BBSRC investment in translational funding?
   - what is the impact of BBSRC's translational funding programme in terms of Gross Value Added (GVA)?

2. The evaluation covers BBSRC's £61 million investment in translational funding since 2004, including £54.9 million through FoF awards (2004 to 2021) and £6.5 million through IAA awards (2019 to 2022).

3. The BBSRC FoF programme was introduced in 2004 and supported three types of award:

   - Standard FoF awards introduced in 2004 provide funding for up to two years (min £76,000, max £250,000)
   - SuperFoF awards introduced in 2012 with a value of up to £2 million (subsequently decreased to £800,000 in 2018 due to budgetary reasons)
   - Pathfinder FoF awards of up to £10,000 introduced in 2008 to support small scale market research (discontinued in 2019)

   All FoF[1] awards are assessed by an expert panel and in addition, the SuperFoF awards are subject to an additional peer review stage using experts with relevant experience.

4. IAAs are strategic block awards providing funding to research organisations (ROs) to use creatively for a wide range of impact activities. They introduce agility and flexibility for ROs to take strategic-level decisions about how best to invest IAA funding to progress research outputs towards impact.

5. IAAs were launched in 2018 and awarded to 15 ROs. Each RO is responsible for managing its own internal application process, assessment and allocation of individual awards to researchers. A second cohort of 22 ROs were awarded BBSRC IAA funding in 2022 but these are not included in this report.

6. The research involved a number of fieldwork elements carried out between June to September 2023:

   - a video survey of 61 Principal Investigators (PIs) awarded one or more FoF grants. There was a deliberate bias towards larger and multiple awards than are prevalent in the population. The details of the sampling strategy are included in Annex B

[1] The term 'FoF' is used throughout the report to refer collectively to all three types of FoF awards (i.e., Standard FoF, SuperFoF and Pathfinder FoF)

- an online survey with 51 PI responses sent out to those FoF recipients who were not in the sample for the face-to-face video survey
- a video survey of 44 PIs who secured one or more IAA awards
- discussions with stakeholders in RO Technology Transfer Offices (TTOs) (including those not currently benefitting from IAA support), Translational Research Offices (TROs), current and former members of BBSRC FoF Committee and individuals with experience of investment into new commercial operations and venture capital.

7. For this report, the analysis of BBSRC translational funding support is primarily conducted at the level of FoF and IAA translational projects rather than individual awards. A translational project refers to the work to progress the translation of a specific research idea or innovation and may be supported by more than one individual award.

Effectiveness of BBSRC translational process

8. The fieldwork programme with PIs, TTOs and other stakeholders highlighted the importance of BBSRC translational support funding to the innovation process:

- **scale**: PIs overwhelmingly welcomed the support available from FoF, particularly the scale of support available from FoF and SuperFoF. Average award size was £172,000 but average translational project funding was £274,000 (i.e., taking into account translational projects supported by more than one FoF award)
- **flexibility**: The speed and flexibility of the BBSRC IAA block award was highly regarded by PIs, although many were aware that it had a limited budget compared to other UK Research and Innovation (UKRI) IAA funds
- **alternative sources for BBSRC-remit translational support:** Many face-to-face respondents noted that there were no or few alternatives available in the commercial application space when compared to funding discovery science
- **connectivity**: two in five PIs reported that their translational project had benefited from more than one FoF award and 21% of FoF award holders also received a BBSRC IAA award
- **support**: TTO support was widely praised despite some challenges around resource levels and specific commercial expertise. Translational projects take time to develop
- **progression**: on average FoF projects ran for 39 months and IAA projects for 15 months. Projects made significant progress increasing their Technology Readiness Level (TRL) by an average of 2.5 points to TRL5 (FoF) or 1.8 points to TRL4 (IAA)
- **added value**: recent cross-UKRI harmonisation of IAAs has led to increased communication and learning at the RO level. However, outside of the more formal regional collaboration between ROs, there appears to be limited communication and mutual learning on translational projects

Additionality of BBSRC translational support

9. PIs rated the additionality of FoF and IAA highly. Without BBSRC translational support, a majority of the projects would not have been undertaken as PIs considered that there were few alternative funding sources, especially for the scale of FoF funding. On average the additionality of FoF was 72% and IAA

61%. There is evidence that the additionality of FoF funding has increased over time.

10. PIs in receipt of IAA awards more often reported that they might secure alternative sources of funds and the project would still go ahead albeit on a longer timescale or with changes to the nature of the translational activities undertaken.

Estimates of economic impact of BBSRC translational support

11. Commercial pathways arising from BBSRC translational support include:

- a commercial outcome was reported in just under half the FoF projects (46%) – either a spin-out or a licensing deal to date with a further 30% indicating that commercialisation was still in prospect in the future. A quarter of FoF projects had ended with a lack of funding, failure of technology or lack of commercial viability given as reasons
- for IAAs, 25% of projects reported a commercial outcome with 45% suggesting future commercialisation will be possible. IAAs are more recent awards and smaller, so proportionately more commercial outcomes are expected in future. Some 30% of IAA projects had ended

12. Based on the responses where a commercial impact has been identified to date the estimates of the economic impact from FoF and IAA projects have been calculated on (i) the lifetime impacts arising to June 2023 and (ii) the projected accumulated impacts of translational projects over a 10 year period[2]:

- **net additional GVA**: using the additionality rates from the survey and grossing these up to the programme level gives a net additional GVA of £192 million lifetime and £652 million over a ten year period[3]
- **net additional return for BBSRC investment in translational support**: the economic analysis indicates a net return of £2.65 lifetime and £9.00 over a 10 year period per BBSRC £1 invested in the translational support programme (in real terms)[4]. This is a significant impact given that only part of the known impacts could be quantified and are set against full BBSRC translational support costs
- **private investment**: in addition, interviews with PIs provided data on the private investment in BBSRC translational project commercial outcomes. This totals over £71 million or £2.49 per BBSRC £1 invested in the translational process. A net calculation based on survey additionality gives approximately £54 million net private investment that would not have occurred without the BBSRC translational funding support or £1.89 per BBSRC £1
- **regional distribution**: The regional distribution of translational projects has been estimated for Greater South East (GSE) and the rest

2 The ten year period is calculated for each project from when the first FoF or IAA award commenced. Measuring the economically valuable lifetime of a knowledge asset depends on several factors including the potential lifetime of any intellectual property protection (a patent is valid for 20 years from date of filing), but market conditions are subject to many more factors. We have therefore assumed that IP assets involved in BBSRC translational projects will retain their value in the market for half the time period of typical IP protection (i.e. 10 years).

3 Equivalent GVA impacts excluding multipliers are £130 million for the lifetime and £442 million for the 10 year scenarios.

4 Equivalent figures excluding multipliers are £1.80 for the lifetime and £6.10 for the 10 year scenarios.

of the UK (ex GSE) based on the location of the host RO. Total net GVA in GSE was estimated at £104 million compared to £88 million exGSE for the lifetime model and £447 million GSE and £205 million exGSE in the 10 year model

13. These impact estimates are unfortunately partial. Confidential licensing deals significantly restricts the capture of the commercial benefits from translational support. In addition, the estimates also exclude the potential commercial outcomes in future from FoF and IAA projects that cannot be currently quantified. Furthermore, there has been no attempt to quantify the wider benefits arising from the range of health, environmental and policy impacts due to BBSRC translational research.

Wider non-commercial impacts from BBSRC translational support

14. PIs from both programmes report a range of health, environmental and policy impacts that will add further value to a wide range of stakeholders and society in general:

- three-quarters of FoF projects (75%) have realised or have potential for future 'public good' impacts
- almost three-quarters of the 44 IAA projects (73%) have realised or have potential for future 'public good' impacts
- a fifth of FoF and IAA projects have contributed to policy impacts. FoF PIs were more likely than IAA PIs to report policy impacts in the agriculture and animal health sectors through guidance on government committees and membership of industry advisory bodies

Reflections on BBSRC translational support

15. Our reflections are focused on the discussions with PIs and their views on where BBSRC translational support might be improved from their perspective:

- the economic impact estimates strongly suggest that BBSRC should continue to support translational research in future:
  - BBSRC translational support generates a range of impacts not all of which can be quantified either because they are confidential, will occur sometime in the future or will arise through health or environmental benefits that are themselves challenging to quantify. Nevertheless, the estimates of GVA impact from FoF and IAA still generate a positive return to date and especially over a ten year period
- pro-active support could encourage more researchers operating in BBSRC remit to translate the outputs of their research to practical application:
  - a number of ROs have started to introduce TRO teams or at least TTO staff with a TRO remit with a view to reaching out to BBSRC remit researchers to explore their research activities and outline the range of support available for potential translational project ideas. BBSRC should encourage more ROs to adopt such pro-active approaches and work with ROs to assess their effectiveness
- a continuum of support may help translational projects progress:
  - PIs report a number of interlinked issues that are combining to make the translational pathway more challenging and longer than in the past (i) commercial partners are demanding more evidence (and a higher TRL) to de-risk their investment, (ii) current funding arrangements can mean the process is somewhat episodic with

translational research results leading to further funding applications to achieve the required results. Together these combine to limit the adoption of fail fast approaches

  - BBSRC could consider how best to support the translational pathway through a continuum of support, along the lines of the Medical Research Council's (MRC) Developmental Pathway Funding Scheme (DPFS) where translational projects are assumed to move to their next stage of funding subject to meeting clear milestone targets

- a fail fast approach may have greater impact on saving translational costs:
  - a greater emphasis on planning for critical "go/ no-go" stages would sit better within this broader funding envelope where the translational pathway can be assessed as a whole at the outset and key stages in the research process can be highlighted with potential options for alternative approaches/ or ceasing the project can be fully discussed
  - the projects with the longest average duration[5] are those which reported potential commercial outcomes that may arise in future which run for almost twice the length of projects that reported commercial outcomes. It is these 'potential impact' projects where a fail fast approach could play a greater role and BBSRC might consider how these projects can be best supported in future
- BBSRC could have a role in disseminating good practice:
  - not all PIs have a full understanding of the respective roles of BBSRC and Innovate UK and how the support available to progress commercial ideas could draw on the latter. This has a very practical impact in translational research when commercial partners are keen to see the public sector de-risk their investment
  - while practice is developing at the individual RO level it is not clear that this is being shared more widely. Key elements of the process including access to expert mentors etc, key contacts for commercial partner searches and licencing terms are areas that would strengthen the negotiation strategies of individual TTOs in securing the best deal available for the IP generated by BBSRC research

5 For this evaluation, project duration is defined as the total time taken from the first award commencing to the last award completing. It includes any breaks in the translational project due to, for example, delays in recruitment or waiting for the next funding call. As such, it is not a strict measure of the duration of translational project research activity.

1. INTRODUCTION

1.1. Research objectives

1.1.1. The objective of this research assignment is to conduct a strategic evaluation of the outcomes and impact of BBSRC's investment in translational funding since 2004. The BBSRC programmes FoF and IAA support researchers to translate their fundamental research into real world value through various pathways such as licencing or spin out companies to deliver economic, social and policy impact.

1.1.2. This research assignment aims to capture evidence to support and answer the following evaluation questions:

- at the translational funding portfolio level (comprising IAA and FoF), what is the breadth of the types of outputs, outcomes and wider impacts including the role of translational support in securing fail fast approaches[6], that have been delivered due to BBSRC investment and support for translational funding?
- what is the impact of BBSRC's translational funding programme in terms of GVA?
- what is the counterfactual to BBSRC's translational funding? i.e. what would have happened if this funding did not exist?
- what is the balance and coverage of the translational funding portfolio including for example, regionally, market sector and by nature of impact (e.g. venture creation, employment, licensing, defining policy and practice)?
- what impact has FoF and IAA funding had on the development of the regional capability for bioscience innovation?
- to what extent have translational funding investments supported training and capacity building in knowledge exchange and commercialisation?

1.1.3. BBSRC has invested around £61 million in translational funding, including £54.9 million through 490 Follow on Fund (FoF) awards (2004 to 2021) and £6.5 million through 364 Impact Acceleration Accounts (IAA) awards (2019 to 2022).

1.1.4. A theory of change for BBSRC translational support is set out in Annex A.

6 Derived from the lean startup and Agile software development methodologies, fail fast is adopted by businesses when developing new products faster and with lower financial risk. This typically involves verifying customer demand through each stage of development, being flexible on development pathways with fewer fixed ideas, address key risks as early as possible in the development process so potential failures come early.

1.2. Overview of the programmes

Follow-on Fund

1.2.1. The BBSRC FoF programme, introduced in 2004, is designed to support the translation of fundamental research into practical applications, including through the development of a spin-out company, social enterprise or a licensing agreement. FoF was one of the first Research Council funding programmes to attempt to support translational research and the approach was subsequently adopted by other Research Councils including Natural Environment Research Council (NERC) and Science and Technology Facilities Council (STFC).

1.2.2. The current objectives of the FoF programme are:

- to help researchers maximise the commercial, societal and economic benefits of their research. The FoF is a research translation programme to support bioscience innovation and provide funding where further work on an idea will take it through to a stage where the route to application is clear. This may include, for example, a spin-out, licensing opportunity or the creation of a social enterprise
- to increase and accelerate the uptake and practical application of past bioscience research outputs to deliver benefit and impact
- to enable researchers to further develop their understanding of potential routes to impact, including identifying opportunities and markets, engaging directly with key stakeholders, customers, enablers and users
- to support translation activities, including collaborative projects with industry, the third sector and other users
- to enable researchers to develop their enterprise and entrepreneurial skills and capabilities

1.2.3. BBSRC has supported three types of award through the FoF programme:

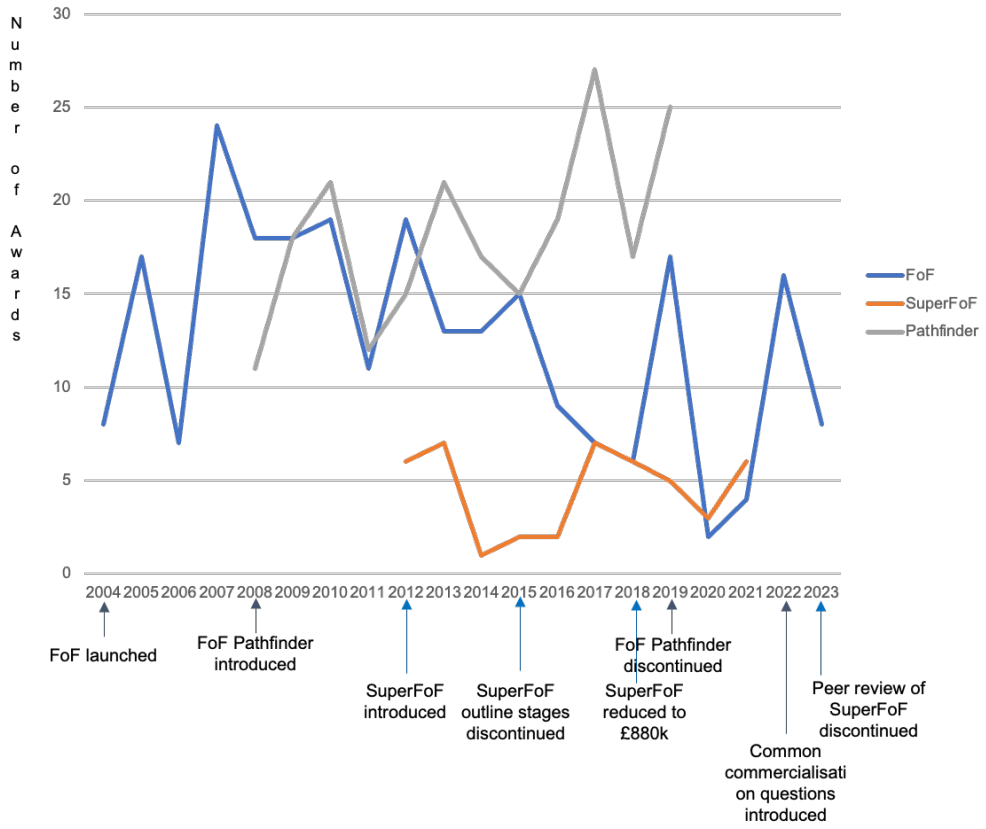
- **Standard FoF awards** introduced in 2004 provide funding for up to two years (min £76,000, max £250,000). They enable researchers, with a sound understanding of the market opportunity of their intellectual assets, to execute a programme of work that has clearly defined objectives. Applications for Standard FoF awards are assessed by an independent panel
- **SuperFoF awards** were introduced in 2012 as BBSRC recognised that some translational activities required more resources. When these were first introduced the award value was up to £2 million, however this was reduced to £800,000 in 2018 due to budgetary constraints. Prior to the panel assessment stage, SuperFoF awards are reviewed by experts with relevant experience, to provide further assurance on the quality of proposals

- **Pathfinder FoF awards** were introduced in 2008 to support small scale market research with a maximum award value of approximately £10,000

1.2.4. Pathfinder FoFs were discontinued in 2019. Standard FoF awards were also reformed, in 2023 and applicants may now apply for between £100,000 and £800,000 full economic cost (FEC). The change to the minimum amount reflects inflation, while the change to the maximum is intended to simplify the fund by removing the need for a separate SuperFoF award. The maximum duration of 24 months has remained the same.

1.2.5. Figure 1.1 provides an overview of the development of FoF and the number of awards in each year.

Figure 1.1: FoF timeline



Source: BBSRC grants data

1.2.6. Projects considered through the FoF programme must draw substantially on current or previous expert-reviewed, BBSRC supported research (or other

type of BBSRC research investment)[7]. FoF grant applications must demonstrate that the:

- project is based on a sound understanding of the market need and opportunity that the proposed product, service or technology aims to satisfy
- proposed work programme is robust and designed to optimise the commercial and societal benefit derived from the grant
- proposal has a substantial link to previous peer reviewed BBSRC research funding

Impact Acceleration Accounts

1.2.7. IAAs are strategic block awards providing funding to ROs to use creatively for a wide range of impact activities. They introduce agility and flexibility for ROs who are empowered to take strategic-level decisions about how best to invest IAA funding within their specific context. This includes the opportunity to build upon, across and between individual projects to progress research outputs and outcomes towards impact.

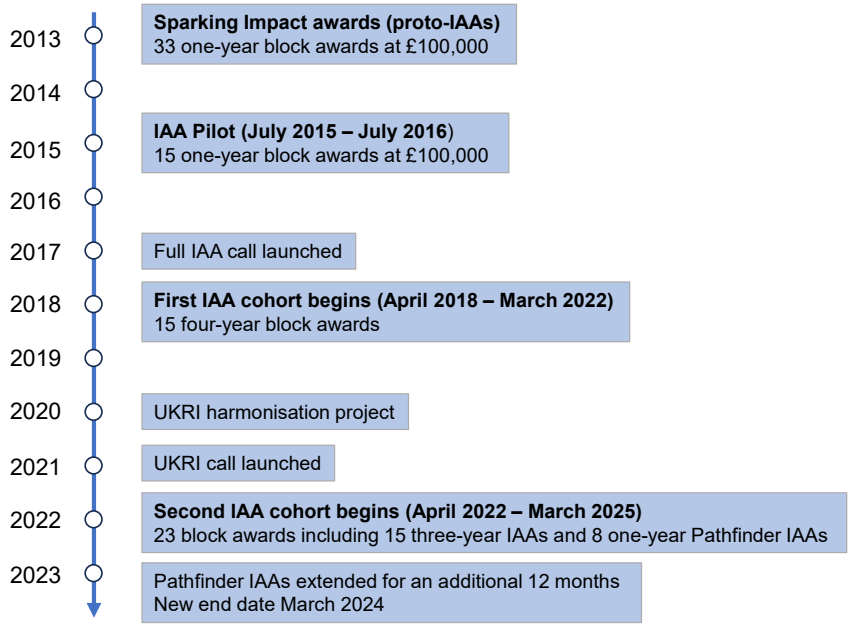
1.2.8. The current aims of the BBSRC IAAs are to:

- strengthen engagement with users (non-academic partners) in order to accelerate the translation of research outputs into impacts
- support, develop and foster strategic partnerships for knowledge exchange and impact, including across disciplines and sectors
- build and maintain an environment and culture that enables effective and ambitious knowledge exchange and impact, including development of skills, capacity and capability within research organisations
- provide early-stage support for progressing research outputs towards the next stages in the impact pipeline, for example:
  - proof of concept projects
  - commercialisation
  - market validation
  - activities targeting policy, business and the third sectors
- drive continuous improvement in impact by supporting innovation, enabling 'fail fast' and capturing learning through appropriate mechanisms
- enable flexible and adaptive approaches to knowledge exchange and impact, including the ability to respond quickly to emerging opportunities

[7] This criterion is currently under review but was in place for awards being evaluated in this report.

1.2.9. Figure 1.2 details the development of the IAA programme.

Figure 1.2: IAA timeline



1.2.10. Sparking Impact awards were the initial prototype IAAs. Thirty-three ROs were each awarded £100,000 for one year to encourage and support translation. The IAA scheme was formally piloted in 2015 and 15 ROs took part. The scheme is promoted as BBSRC IAA and the internal application process, assessment and awards are managed by each RO within the guidelines set out above. As a consequence, there are some slight variations in the delivery of IAAs depending on local arrangements[8].

1.2.11. In 2018 the first cohort of 15 ROs on the IAA programme commenced with funding for three years (which was subsequently extended by one additional year). The first IAA cohort supported 364 individual awards with a total value of £6.5 million.

1.2.12. In 2020, the UKRI Harmonisation Project brought together IAA funding from five participating councils (AHRC, BBSRC, EPSRC, MRC and the STFC), harmonising the application processes and timelines for ROs. Where appropriate, UKRI encouraged ROs to take advantage of the strategic opportunities afforded by the alignment of IAA awards across disciplines. The

8 BBSRC's IAA application process includes a review of each RO's strategy and plan for using the IAA, including the RO's own internal processes. It is expected that there will be some variation in the approach to using IAAs across ROs, reflecting each RO's strategy.

second cohort of 23 ROs commenced in 2022 and included 15 three-year IAAs and 8 one-year Pathfinder IAAs[9].

1.2.13. The initial IAA funding round stipulated that eligible projects had to be directly related to previous BBSRC funding. In the second round this requirement has been removed, although funded projects are still required to sit within the remit and aims of BBSRC (in line with UKRI harmonisation of IAAs).

Fieldwork programme

1.2.14. The fieldwork programme involved the following elements:

- a face-to-face video survey of 61 PIs who secured one or more FoF awards was carried out between June to September 2023. There was a deliberate bias towards larger and more multiple awards than are prevalent in the population. The details of the sampling strategy are included in Annex B
- an online survey with 51 PI responses sent out to those FoF recipients who were not in the sample for the face-to-face video survey or did not respond. This was emailed to potential respondents in September 2023. The online questionnaire is shorter and there are also some differences in the composition of the two samples the main one being that 79% of the online survey respondents involved a single FoF award compared to 43% of the face-to-face survey respondents[10]
- a face-to-face video survey of 44 PIs who secured one or more IAA awards
- discussions with stakeholders in RO TTOs (including some in those not/ no longer benefitting from IAA support), TROs, current and former members of BBSRC FoF committee and individuals with experience of investment into new commercial operations and venture capital

9 Pathfinder IAAs were introduced as part of the second cohort of IAA funding in response to the large number of high-quality IAA applications received. They were awarded to ROs who had applied for standard IAA funding using the same competitive assessment process. Pathfinder IAAs provide funding for one year.

10 This is due to the sample selection for the face-to-face survey including PIs with multiple FoF and IAA awards.

2. CHARACTERISTICS OF BBSRC TRANSLATIONAL SUPPORT

Section summary

- PIs report that their focus on FoF and BBSRC IAA funding is primarily due to their research remit. Most FoF award holders reported that they first learnt about the support through the BBSRC website with RO TTOs being a significant source of information (particularly so for IAAs) alongside their academic colleagues.
- Biotechnology and Human health sectors received a majority of awards (59%) with most of the remainder in Agriculture, Animal health and Food and drink sectors (39%).
- PIs benefitting from FoF awards reported that on average their translational project involved 1.6 awards, with 59% being single awards and 41% of projects involving two or more. Almost a quarter of FoF projects also secured an IAA award.
- Almost all translational funding awards FoF (98%) and IAA (97%) were invested in projects with a relatively low TRL – below TRL5.
- Alternative funding sources considered by PIs were RO internal funds or a commercial partner but both these were deemed to be insufficient to meet translational project needs and/or the research was at too early a stage or too risky to attract commercial interest.

2.1. Follow-on Fund

How PIs became engaged with FoF

2.1.1. Most respondents first learned about FoF through BBSRC newsletter or website and information on FoF provided by their TTO was also an important source. Network contacts are also an important source of information on the FoF scheme.

Table 2.1: How did PIs first learn about FoF?

Source of information	Video survey	Online survey
BBSRC website/ newsletter	49%	36%
Information from RO technology transfer office	15%	30%
Academic colleague or partner organisation	19%	12%
BBSRC contact	4%	10%
Research Organisation website/ newsletter	4%	8%
As member of BBSRC committees	2%	2%
Can't remember	8%	2%
Total responses	53	50

Source: CPC face-to-face survey of 61 FoF recipients and Online survey of 51 FoF recipients.

2.1.2. There was no evidence of PIs coming to FoF following unsuccessful applications elsewhere (for example, to the Engineering and Physical Sciences Research Council (EPSRC) or MRC) and the vast majority of PIs did not apply for any other translational funding schemes prior to the FoF. Many PIs noted that their research was firmly within BBSRC's remit and so FoF was the most appropriate route for translational support. Many face-to-face respondents noted that there were no or few alternatives available in the commercial application space when compared to funding discovery science. In the limited number of cases where alternative routes were rejected before the PI applied for FoF, sources included the Wellcome Trust, internal institutional funding and the Bill & Melinda Gates Foundation.

Table 2.2: FoF project and award expenditure by sector

	Total funding	Total projects	Average funding per project	Total awards	Average funding per award
Agriculture	£6,169,876	16	£385,617	31	£199,028
Animal health	£2,036,171	14	£145,441	18	£113,121
Biotechnology	£7,097,361	36	£197,149	50	£141,947
Food and drink	£4,080,911	10	£408,091	20	£204,046
Human health	£10,972,710	35	£312,220	56	£195,138
IT	£318,806	1	£318,806	3	£106,269
Total responses	£30,675,835	112	£273,891	178	£172,336

Source: Combined CPC face-to-face and online surveys of FoF recipients

2.1.3. Discussions with PIs in the FoF face-to-face survey established the number of individual FoF awards for a particular translational project. Each translational project consisted of an average of two FoF awards with 43% receiving a single award, 30% receiving two awards, 21% receiving three awards and 7% receiving four or more awards. The online survey contained a much higher proportion of single award projects (79%). Together the two surveys have 59% single award projects and 41% multiple award projects (Table 2.3)[11].

[11] Comparison of FoF survey sample against the population of awards is included in Annex C.

Table 2.3: Number of awards per translational project by sector

	Mean awards	1	2	3	4+	Total
Agriculture	2.1	8	5	1	2	**16**
Animal health	1.4	9	5	0	0	**14**
Biotechnology	1.5	25	6	4	1	**36**
Food and drink	2.1	3	3	4	0	**10**
Human health	1.6	21	8	5	1	**35**
IT	3	0	0	1	0	**1**
Total responses	1.6	66	27	15	4	**112**
		59%	**24%**	**13%**	**4%**	**100%**

Source: Combined CPC face-to-face and online surveys of FoF recipients

2.1.4. Projects in the Agriculture and Food & drink sectors received the highest average number of awards.

2.1.5. Face-to-face interviews found that 13 of the 61 FoF projects (21%) also received one or more BBSRC IAA awards (and five received one or more IAA awards from other Research Councils).

How far was the technology developed when the FoF project commenced?

2.1.6. Almost all FoF projects (98%) were at TRL4 or less when they first received FoF funding. Twenty seven percent were at TRL1 (basic research) and a further 28% were at TRL2 (technology formation). Twenty nine percent were categorised as TRL3 (applied research with the first lab tests completed) and 15% were at TRL 4 (a small scale prototype in a lab environment).

Table 2.4: FoF project Technology Readiness Level at inception

TRL	2004-15		2016-21		All FoF projects	
1) Basic research – no experimental proof available	16	27%	13	27%	29	27%
2) Technology formation – concept and application formulated	18	31%	12	24%	30	28%
3) Applied research – 1st lab tests completed; proof of concept	17	29%	14	29%	31	29%
4) Small scale prototype – in lab	8	14%	8	16%	16	15%
6) Prototype system – close to expected performance			1	2%	1	1%
7) Demonstration system at pre commercial scale			1	2%	1	1%
Total responses	59	100%	49	100%	108	100%

Source: CPC face-to-face and online surveys of FoF recipients. Percentages may not sum due to rounding.

2.1.7. Over time, FoF projects have tended to have somewhat more advanced starting points with projects since 2016 showing a shift to higher TRLs. High TRLs tend to be associated with Pathfinder FoF projects focusing on determining the form and operations of spin-out companies after the technology has been proven.

Where else could projects have gone for funding?

2.1.8. Prior to getting FoF funding all the 61 projects had benefitted from some form of BBSRC funding including responsive mode funding, PhD studentships, specialist programmes (e.g. National Biofilms Innovation Centre (NBIC), Diet and Health Research Industry Club (DRINC), Horticulture and Potato Initiative (HAPI)) and BBSRC institute strategic funding.

2.1.9. In addition to BBSRC funding, ten projects had also received funding from another research council (EPSRC in nine cases, NERC in one case) and four projects had received Innovate UK funding (including the Industrial Biotechnology Catalyst). Other funding sources included European funding (two projects) and private industry funding (six projects).

2.1.10. Companies in the Biotechnology sector were the most likely to have received non BBSRC funding prior to FoF with 50% receiving other funding awards prior to FoF (Table 2.5)[12].

Table 2.5: Proportion of PIs receiving non-BBSRC funding prior to FoF

Sector	Yes	Funding Sources cited
Agriculture	22%	ERA-CAPS, private (industry)
Animal health	29%	Agri-Tech Catalyst, AHDB, private (industry)
Biotechnology	50%	EPSRC, NERC, IB Catalyst, ERC, private (industry), NERC, RO
Food and drink	14%	EPSRC, Innovate UK
Human health	32%	EPSRC, Innovate UK, RO, Charitable Trust, private (industry)
IT	0%	-
Total responses	33%	

Source: CPC face-to-face survey of 61 FoF recipients

2.1.11. Online survey respondents were asked to identify what other sources of funding they considered when making their FoF application. Internal funding sources and commercial partners were actively considered by a third or more

12 It was not possible in the time available for the interview to map the amounts of funding from these sources.

of FoF recipients but both these sources were deemed to be insufficient to meet all the translational project needs and/or the research was at too early a stage and therefore too risky to attract commercial interest.

Table 2.6: Alternative funding sources PIs considered to FoF

Sector	Yes	Reason rejected as a source
EPSRC	8%	Vast majority felt project was clearly BBSRC remit
MRC DPFS	6%	As above, BBSRC remit
ICURe	4%	More than a quarter of respondents were not aware of ICURe, others reported it was not relevant or project too large for budget limit
ERC PoC	2%	Applied after securing FoF award
Wellcome Foundation	8%	Project too preliminary/ did not fit scope
RO internal funds	35%	Insufficient funds to support project
Commercial partner	33%	Two in five PIs reported that their translational projects was too early TRL stage or too high risk to attract commercial interest
Total responses	94%	

Source: CPC online survey of 51 FoF recipients

2.1.12. Reasons why these sources were not pursued further include:

- early stage projects were seen as being too risky to secure funds from commercial partners (a high proportion of online respondents received a Pathfinder FoF award only)
- internal funding sources were too small to fund the translational project
- the translational research was BBSRC remit so alternative sources were not in scope.

2.2. Impact Acceleration Accounts

How PIs became engaged with IAAs

2.2.1. ROs are the primary source of information for PIs on IAAs. The combination of TTO/TRO and RO websites and other communications account for almost three-quarters of IAA recipients first contact with IAAs. Most PIs report that BBSRC IAAs were highlighted to them by TTO staff, either in regular updates (often IP/Patent management meetings) or when they approached the TTO/TRO with a potential idea requiring translational support. This reflects the different administration model for IAAs where ROs manage the funds locally.

Table 2.7: How did PIs first learn about IAAs?

Source of information	Number of PIs	%
BBSRC website/ newsletter	0	0%
Information from RO technology transfer office	18	41%
Academic colleague or partner organisation	3	7%
BBSRC contact	0	0%
Research Organisation website/ newsletter	14	32%
As member of BBSRC committees	2	5%
Can't remember	7	16%
Total responses	44	100%

Source: CPC face-to-face survey of 44 IAA recipients

2.2.2. Discussions with PIs emphasised the speed and flexibility of IAA awards that meant they could respond rapidly to unsuccessful applications for other translational funding (often FoF awards) where the loss of funding might threaten the integrity of their research team with key members of the research team potentially leaving in response to a funding 'gap'.

2.2.3. A total of 44 PIs were interviewed about their IAA translational projects. Each translational project consisted of an average of 1.6 IAA awards (Table 2.8). This represents total IAA funding of £1.3 million (19.5% of total IAA spend). Average funding per IAA award in the survey is £18,800 and average funding per project of £29,900, so considerably below funding support provided through FoF awards.

2.2.4. Four of the 44 IAA projects also received FoF or SuperFoF funding post IAA. Almost a third of IAA projects (32%) were in the Biotechnology sector (35% of total IAA funding), with a further 23% in Human health (18% of funding). Agriculture and Animal health together account for 36% of projects but 33% of funding. Detailed comparisons against the IAAs is included in Annex B.

Table 2.8: IAA awards by sector

	Total funding	Total projects	Average funding/ project	Total awards	Average funding/ award	Average awards/ project
Agriculture	£198,319	8	£24,790	9	£22,035	1.1
Animal health	£236,101	8	£29,513	13	£18,162	1.6
Aquaculture	£141,084	1	£141,084	5	£28,217	5.0
Biotechnology	£454,241	14	£32,446	23	£19,750	1.6
Food & drink	£51,182	3	£17,061	4	£12,796	1.3
Human health	£234,091	10	£23,409	16	£14,631	1.6
Total responses	£1,315,018	44	£29,887	70	£18,786	1.6

Source: CPC face-to-face survey of 44 IAA recipients

How far was the technology developed when the IAA project commenced?

2.2.5. Almost all IAA awards (97%) were at TRL4 or less when they first received IAA funding. Thirteen percent were at TRL1 (basic research) and a further 34% were at TRL2 (technology formation). Thirty nine percent were categorised as TRL3 (applied research with the first lab tests completed) and 11% were at TRL4 (a small scale prototype in a lab environment).

Table 2.9: IAA award Technology Readiness Level at inception

TRL	IAA awards	
1) Basic research – no experimental proof available	5	13%
2) Technology formation – concept and application formulated	13	34%
3) Applied research – 1st lab tests completed; proof of concept	15	39%
4) Small scale prototype – in lab	4	11%
5) Large scale prototype – in intended system	1	3%
6) Prototype system – close to expected performance		
7) Demonstration system at pre commercial scale		
Total responses	38	100%

Source: CPC face-to-face survey of IAA recipients

2.2.6. There are too few responses from IAA award holders to provide further detail with sufficient robustness.

Where else could IAA projects have gone for funding?

2.2.7. Prior to receiving IAA funding all the 44 projects had received some form of BBSRC funding including responsive mode funding, PhD studentships and specialist programmes (e.g. sLoLa, LINK, FTMA and NIBB):

- in addition to BBSRC funding, four projects in the Biotechnology and Human health sectors had also received funding from another research council (EPSRC and MRC)
- other funding sources included Innovate UK funding (IB Catalyst – two projects). European funding (one project), Wellcome Trust (two projects), British Heart Foundation (one project), UKHSA (one project) and private industry funding (six projects)
- projects in the Agriculture and Animal health sectors were the most likely to have received non BBSRC funding prior to the IAA award with 63% receiving other funding awards prior to the IAA award.

Table 2.10: Proportion receiving non-BBSRC funding prior to IAA

%	Yes	Funding Sources cited
Agriculture	63%	Marie Curie, ERA, Newton Fund, Scottish Enterprise, private industry
Animal health	63%	Wellcome Trust, private industry, EU, Bill & Melinda Gates Foundation, National Veterinary Research Institute
Aquaculture	100%	-
Biotechnology	50%	EPSRC, MRC, Wellcome Trust, British Heart Foundation, private industry
Food and drink	33%	UKHSA
Human health	50%	MRC, US NIAAH, RO
Total responses	55%	

Source: CPC face-to-face survey of 44 IAA recipients

3. IMPACTS ARISING FROM BBSRC TRANSLATIONAL SUPPORT

Section summary

- PIs involved in translational projects consistently report that their core motivation was to see their ideas come to fruition.
- At the end of their BBSRC translational support the projects have increased their TRL by an average of 2.5 points to TRL5 (FoF) or 1.8 points and TRL4 (IAA).
- Translational projects take time to develop. On average FoF projects ran for 39 months and IAAs 15 months. FoF projects with reported future commercial potential had by far the longest duration of almost 5½ years. There was much less variation in durations across IAA projects.
- Among FoF projects just under half (46%) reported a commercial impact to date with a further 30% saying that commercialisation was still in prospect in the future.
- A quarter of IAA projects report a commercial outcome to date with 45% suggesting future commercialisation will be possible. IAAs are more recent awards as well as being smaller in scale and proportionately more commercial outcomes are expected in future.
- PIs rated the additionality of FoF and IAA highly. On average the additionality of FoF was 72% and IAA 61%. There is evidence that additionality of FoF funding has increased over time.
- PIs stated that there were few alternative funding sources, especially for the scale of FoF funding. In the absence of FoF most projects would not have happened (43%) or their progression to the next stage of their translational pathway would have been placed in doubt (31%).

3.1. Introduction

3.1.1. PIs involved in translational projects consistently report that their core motivation was to see their ideas come to fruition – whether that be improving public health, the environment or contributing to policy or regulatory affairs. Commercial outcomes play a part in this process but are not the sole focus of translational projects.

3.1.2. Fifteen BBSRC translational support case studies from a range of sectors that set the progression of research ideas into wider economic and societal impacts are included in Annex C.

3.2. Progress of translational support projects

3.2.1. Table 3.1 maps the views of FoF and IAA respondents in the face-to-face interviews on the progression and current and future commercial potential of their projects. The results reflect the longer timeframe available to FoF

projects to secure their next steps – particularly in relation to commercial pathways. A total of 46% of FoF PIs report a current commercial impact compared to 25% of IAA award holders. IAA PIs were more likely to report future potential in their translational projects (45%) compared to FoF PIs (30%). The proportion of award holders reporting that their project had ended[13] was similar (25% FoF and 30% IAAs).

3.2.2. Although numbers are small, IAA PIs report more than double the number of projects lacking commercial viability or having no commercial impact (23%) compared to FoF PIs (8%). More than a third of IAA projects also report that their future commercialisation prospects are dependent on further funding (34%) compared to 20% of FoF recipients.

3.2.3. The 61 FoF projects were coded in relation to progression since the FoF funding ended:

- just under half (46%) of projects were generating an economic impact through a combination of licencing, service agreements or through the establishment of a spin-out with employment
- in 30% of cases the project had potential for a future economic impact but one or more barriers were evident
- in 25% of cases the project had ended or changed direction:
  - in 3% of cases the project was continuing but was no longer directly based on the original research
  - in 19% of cases the project had ceased with no impact – either due to a failure of technology/lack of commercial viability or lack of funding/personnel issues
  - in 3% of cases the project had ceased but had generated a non-commercial/public goods impact

3.2.4. The 44 IAA projects were coded in relation to progression since the IAA funding ended:

- in 25% of cases the project was generating economic impact through a combination of licencing, service agreements or through the establishment of a spin-out with employment
- in 45% of cases the project had potential for a future economic impact but one or more barriers were evident. In the vast majority of these cases further research was required

13 In most cases 'ended' means that there is currently no viable route forward due a range of potential reasons – commercial, technical or funding. This may not mean that with further research in future that the pathway might re-open in future. For example, one project that ended in 2013 had recently been revived as a result of related research demonstrating an alternative technical solution.

Table 3.1: Progression of translational support projects

	FoF		IAA	
	Count	**%**	**Count**	**%**
No economic impact				
Project ended - lack of funding/personnel issues	4	7%	-	-
Project ended - failure of technology	4	7%	1	2%
Project ended - lack of commercial viability	3	5%	3	7%
Project ended - non-commercial impact	2	3%	7	16%
Project changed direction - failure of original approach	2	3%	2	5%
Total	**15**	**25%**	**13**	**30%**
Future economic impact possible				
Future commercialisation possible - growth reliant on existing industrial partner	3	5%	1	2%
Future commercialisation possible - seeking industrial partner(s)	3	5%	4	9%
Future commercialisation possible - spin-out needs funding / further research /product development	3	5%	1	2%
Future commercialisation possible - no spin-out project needs funding / further research /product development	9	15%	14	32%
Total	**18**	**30%**	**20**	**45%**
Current economic impact				
Licencing or service agreement - growth static	5	8%	1	2%
Licencing or service agreement - growth barriers (funding/ further research /product development)	-	-	1	2%
Licencing or service agreement - growth barriers (seeking acquisition/commercial partner)	-	-	1	2%
Licencing or service agreement - increasing sales/scaling up	5	8%	3	7%
Spin-out - growth static	2	3%	-	-
Spin-out - growth barriers (funding/ further research /product development)	3	5%	1	2%
Spin-out - growth barriers (overcome regulatory barriers)	1	2%	3	7%
Spin-out - growth barriers (seeking acquisition/commercial partner)	6	10%	1	2%
Spin-out - increasing sales/scaling up	6	10%	-	-
Total	**28**	**46%**	**11**	**25%**
Total projects	**61**	**100%**	**44**	**100%**

Source: CPC face-to-face survey of 61 FoF and 44 IAA PIs

- in 30% of cases the project had ended or changed direction:
  - in 5% of cases the project was continuing but was no longer directly based on the original research
  - in 16% of cases the project had ceased but had generated a non-commercial/public goods impact
  - in 9% of cases the project had ceased with no impact – either due to a lack of commercial viability or failure of technology

3.3. Impact of translational support on Technology Readiness Levels

FoF impact on TRL levels

3.3.1. Table 3.2 summarises the impact of BBSRC translational support on TRL. At the start of FoF all projects were below TRL4 (Small scale prototype – in lab). Fifteen percent were at TRL1 (basic research) and a further 30% were at TRL2 (technology formation). Thirty four percent were categorised as TRL3 (applied research with the first lab tests completed) and 21% were at TRL4 (small scale prototype in a lab environment).

3.3.2. By the end of the last FoF award the mean TRL had shifted 2.5 points to 5.1 with more than half the projects reporting a TRL above 4. Post FoF the TRL level of projects shifted a further 1.2 points to 6.3, an average increase of 3.7 TRL points[14].

3.3.3. Just two FoF projects (3%) reported no change in their TRL (one ceased due to technical reasons and in the other the objective was to secure a commercial partner that was successful and the spin-out is operating commercially).

3.3.4. FoF projects with an initial TRL of 1 or 2 were more likely to report more progression (an increase in TRL of 3.1 and 2.7 respectively) compared to other initial TRLs (TRL3 2.2 and TRL4 2.4). Resources were relatively larger for TRL1 projects (£15,500 per month compared to an average of £9,600) and duration longer for TRL2 (a mean of 50 months compared to 39 for all FoF projects)[15].

14 Some PIs reported that this had been supported by a range of funds from other UKRI RCs, European and private sources but we do not have comprehensive information in all cases.

15 It should be noted that TRL stages are not standardised – i.e. the effort required to produce a one point change does not necessarily require an equivalent level of effort to move to the next level.

Table 3.2: Impact of FoF and IAA support on project TRL

TRL	FoF projects						IAA projects					
	Prior to FoF		End of FoF		Current (June 2023)		Prior to IAA		End of IAA		Current (June 2023)	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
TRL1	9	15%	1	2%	1	2%	5	13%	0	0%	0	0%
TRL2	18	30%	1	2%	1	2%	13	34%	0	0%	0	0%
TRL3	21	34%	5	8%	3	5%	15	39%	12	32%	8	21%
TRL4	13	21%	20	33%	8	13%	4	11%	14	37%	14	37%
TRL5	0	0%	7	11%	8	13%	1	3%	7	18%	4	11%
TRL6	0	0%	12	20%	8	13%	0	0%	2	5%	4	11%
TRL7	0	0%	12	20%	12	20%	0	0%	1	3%	5	13%
TRL8	0	0%	3	5%	11	18%	0	0%	1	3%	1	3%
TRL9	0	0%	0	0%	9	15%	0	0%	1	3%	2	5%
Total	**61**	**100%**	**61**	**100%**	**61**	**61**	**38**	**100%**	**38**	**100%**	**38**	**100%**
Mean TRL	**2.6**		**5.1**		**6.3**		**2.6**		**4.3**		**4.9**	
Change			**2.5**		**3.7**				**1.8**		**2.3**	

Source: CPC face-to-face survey of 61 FoF and 38 of 44 IAA recipients who could provide an estimate of TRL. Figures may not sum due to rounding.

IAA impact on TRL levels

3.3.5. The mean TRL of IAA projects at commencement was the same as for FoF at 2.6. This and the distribution of projects across the TRLs is very similar to that of FoF projects. All IAA projects were at TRL5 or below when they first received IAA funding. Thirteen percent were at TRL1 (Basic research) and a further 34% were at TRL2 (Technology formation). Thirty nine percent were categorised as TRL3 (applied research with the first lab tests completed) and 11% as TRL4 (a small scale prototype in a lab environment). Three percent (1 project) were at TRL5 (large scale prototype). Six projects were uncategorised as their focus was not on technology development.

3.3.6. By the end of the IAA the mean TRL had increased 1.8 points to 4.3. Five IAA projects (12%) reported no change in their TRL. Post IAA, 11 of 38 IAA projects had continued to increase their TRL with an overall increase to 4.9 points. Variation in IAA project impact on TRL levels are not discernible, in part due to the smaller sample size.

FoF project duration and change in TRL levels

3.3.7. Table 3.3 shows the reported duration by project outcome for FoF projects only[16]. Project duration is defined by the start date of the first translational award to the end date of the final award for each project. Although this is consistent across all awards, this is a not a precise measure of the time spent on translational activities as survey respondents highlighted gaps between awards for a variety of reasons (recruitment of research staff, awaiting funding rounds etc).

3.3.8. FoF projects that reported a commercial impact took an average of 2.5 years to achieve this outcome. FoF projects that reported potential commercial outcomes in future had on average been running for more than twice the time (65 months). FoF Projects that ended without an outcome[17] took on average just under two years and were amongst the shortest.

16 Data for IAA projects are not included in this analysis. Monitoring data on the actual start and end date for IAA awards is reported as the start and end year (and often the same year). This does not provide a consistent measure of the effective duration required by the translational process and so has been excluded from this analysis.

17 This was for a variety of reasons – some projects were technically unsuccessful but others established PoC and technical results but were unable to secure funding to commercialise.

Table 3.3: Duration and TRL change by FoF project outcome (months)

Sector	Nº	Project duration	TRL change	Mths per TRL
Current commercial impact	28	30	2.7	11.3
Future commercial potential	18	65	2.6	24.8
Changed direction	2	27	1.5	17.7
Non-commercial/ Non-profit	2	18	3.0	6.0
Ended	11	23	2.0	11.4
Total	**61**	**39**	**2.5**	**15.4**

Source: CPC face-to-face survey of 61 FoF

3.3.9. Mean FoF project durations do not vary significantly by sector (Table 3.4). In keeping with the views of PIs,[18] Agriculture projects are slightly longer than the average, particularly so in terms of the time taken to change the TRL.

Table 3.4: FoF Project mean TRL change and duration by sector (months)

Sector	Nº	Project duration	TRL change	Mths per TRL
Agriculture	9	44	2.0	22.1
Animal health	7	39	2.9	13.7
Biotechnology	18	36	2.4	15.0
Food & Drink	7	37	3.1	11.6
Human health	19	40	2.4	16.4
Information Technology	1	29	4.0	7.3
Total	**61**	**39**	**2.5**	**15.4**

Source: CPC face-to-face survey of 61 FoF

3.4. Commercial pathways arising from translational support

3.4.1. The FoF award holders were asked about progress in their commercial pathway. Just under three in five reported commercial outputs. The responses are presented in Table 3.5:

- there are 26 spin-outs associated with the 61 FoF projects. Four of these spin-outs were incorporated prior to FoF[19] and FoF was used to further progress the development of the spin-out
- in the remaining 22 cases, the spin-out was incorporated during or post the FoF award, 20 of these spin-outs are currently active
- in addition there are a further 10 projects where a licencing deal occurred following FoF

18 A number of PIs in agriculture highlighted that to obtain the necessary evidence to progress it was necessary to undertake translational research over two full growing seasons to demonstrate the target trait/characteristics and then evidence that this trait is passed on to the next generation.

19 This does not necessarily mean these spin-outs are not vested with IP rights from the translational project. Most were either dormant or were vested with the additional activity from the translational project.

- overall, in 59% of cases there was either a spin-out or licencing deal during or post FoF

Table 3.5: Commercial outcomes from translational support

	FoF		IAA	
	N°	%	N°	%
Spin-out (incorp prior to award)	4	7%	1	2%
Post award active spin-out	17	28%	2	5%
Post award active spin-out & licencing deal	3	5%	2	5%
Post award spin-out – dissolved	2	3%		
Licencing deal	10	16%	6	14%
None of the above	25	41%	33	75%
Total	61	100%	44	100%

Source: CPC face-to-face survey of 61 FoF and 44 IAA recipients

3.4.2. FoF award holders responding to the online survey reported somewhat lower levels of commercial activity (at least in part due to their focus on earlier stages of the translational pathway):

- almost two in five (39%) said that their FoF project had led to knowledge that has been or will be protected by a patent or other forms of intellectual property rights
- a quarter (25%) had reached a licensing agreement with a commercial partner or were considering doing so
- just over a quarter (27%) had incorporated a spin-out or were considering do so

3.4.3. Proportionately fewer IAA award holders reported any commercial outputs (26% cf 59% of FoF PIs):

- there are five spin-outs associated with the 44 IAA projects one of which was established more than one year prior to the IAA project
- in addition there are a further six projects with some commercial impact either from a licencing deal or from service provision
- in 75% of cases there have not (yet) been any commercial impacts from IAA

3.5. Additionality of BBSRC translational funding

3.5.1. The additionality[20] of the BBSRC translational funding support was estimated based on discussions with the PI concerning the contribution of the BBSRC translational support had on the development of the project and taking into

20 Additionality is defined as "… a real increase in social value that would not have occurred in the absence of the intervention being appraised" https://assets.publishing.service.gov.uk/media/6645c709bd01f5ed32793cbc/Green_Book_2022__updated_links_.pdf

account the availability of other funding sources that might provide equivalent support.

Additionality of FoF support

3.5.2. In 43% of cases the additionality of the FoF support was assessed as 100% as the commercial or other impacts would not have happened in the absence of the support (Table 3.6). In a further 26% of cases it was assessed as 75% because the impacts probably would not have happened in the absence of the support but funding may have been secured elsewhere. In 20% of cases the additionality was assessed as 50% in that the impacts would have eventually been realised but it would have taken longer. In 11% of cases the support was considered to have made a marginal difference to the impacts. No PI felt that the FoF support did not make a difference.

Table 3.6: Additionality of BBSRC translational support

Additionality	FoF	IAA
0% - no impact	0%	7%
25% - marginal impact	11%	16%
50% - would have taken longer	20%	30%
75% - would probably not have happened	26%	20%
100% - spin-out or further funding would not have happened in absence of support	43%	27%
Total	100%	100%
Overall additionality	72%	61%

Source: CPC face-to-face surveys of 61 FoF and 44 IAA recipients

3.5.3. Over time the additionality of FoF support has increased (70% in 2004 to 2010, 76% in 2011 to 2015 and 78% in 2016 to 2021). We have no direct evidence for the cause of this result. However, one possible reason is that as the average size of FoF awards increased over time[21] it became more challenging for researchers to secure alternative sources of funding for their translational projects.

3.5.4. There were significant differences in additionality of FoF support by sector. Projects in the Agriculture sector had the highest additionality at 94% followed by the Animal health and Food and drink sectors at 89% and 86% respectively. The additionality was lowest in the Human health and Biotechnology sectors at 67% and 64% respectively. This is primarily linked to the availability of alternative funding in these sectors with PIs in these more likely to be able to

21 The average FoF award sizes were: £64,712 (2004 to 2010), £116,518 (2011 to 2015) and £293,081 (2016 to 2021).

access EPSRC, MRC or Innovate UK funding (for example the IB Catalyst) but less likely in agriculture and animal health research areas.

> *'Without the FoF funding it is unlikely that we would have got the money to do the field trial. It needed personnel to run it, process it, do all the analyses and write it up and there is no-one else we could have gone to'. [PI Agriculture sector]*
>
> *'[If the FoF application was unsuccessful the PI indicated that they would seek alternative sources of funding] we would've tried MRC and EPSRC. Our University has also been very helpful in getting PoC funding along with funding from alumni. We wouldn't have given up on the idea.' [PI Human Health sector]*

3.5.5. The online survey of FoF award holders (Table 3.7) asked what would have happened to the translational project in the absence of FoF funding[22]. The same proportion of responses as the face-to-face survey (43%) reported that no translational activity would have occurred (i.e. 100% additionality). The remaining responses report a combination of a reduction in the quality and speed of the translational process.

Table 3.7: What would have happened in the absence of FoF funding?

Nothing, no further development of this project would have occurred	43%
Progression on to the next stage would have been in doubt on technical/ risk grounds	31%
The project would have happened but over a longer timescale	31%
The scope and scale of partnership working would have been more restricted	12%
Potential commercial pathways would not have achieved such favourable terms	6%

Source: CPC online survey of 51 FoF recipients

Additionality of IAA support

3.5.6. IAA recipients reported a slightly lower level of additionality (Table 3.6), primarily because fewer felt that the IAA was wholly additional as they considered there were other alternative sources (in most cases, the relative small size of the awards makes this somewhat more feasible to achieve) but that these may take longer to access:

22 Previous online surveys have found that respondents are reluctant to specify a specific percentage when it is not possible to discuss the different factors impacting on additionality so this question was considered to be better suited to an online survey format.

- in 27% of cases the additionality of the IAA support was categorised as 100% as the spin-out or other impacts would not have happened in the absence of the support
- in a further 20% of cases it was categorised as 75% because the impacts probably would not have happened in the absence of the support but funding may have been secured elsewhere
- in 30% of cases the additionality was categorised as 50% in that the impacts would have eventually been realised but it would have taken longer
- in 16% of cases the support was felt to have made a marginal difference to the impacts and in 9% of cases it was not felt to have made any impact

3.5.7. There are significant differences in additionality of IAA support by sector. Translational projects in the Food and drink and Biotechnology sectors had the highest additionality overall at 83% and 73% respectively. This appears to be contrary to the finding for FoF where Biotechnology had the lowest additionality. PIs in the Agriculture and Animal health sectors in BBSRC strategically-supported Research Institutes were more likely to say they could have gone to their institution or to industry for IAA funding whereas those in the Biotechnology sector appeared to consider that they had few other options[23]. Researchers in BBSRC strategically supported institutes have access to IAA support but none had the option of EPSRC/ MRC IAA funding sources and limited alternative options.

3.5.8. For most PIs, the timeliness of IAA funding was important that often enable them to maintain funding for key members of the team:

> *'If we hadn't had the IAA funding, we would've lost a talented researcher which would've slowed things down. We had another CASE studentship with a company looking at a different area, so we would probably have focused on another line of research instead' [PI Biotechnology sector]*

> *'Without the IAA it would have been extremely difficult. The funding provided the timeliness. Had it not been available it would have dragged on and we probably would have said three years later that we had missed the opportunity. I think it would have been so much effort that I would have carried on with my regular research and would not have pushed the translational so much' [PI Food and drink sector]*

23 The ease with which alternative sources of funding might be secured was a key driver in PIs' views on the additionality of BBSRC translational support.

4. ESTIMATES OF THE ECONOMIC IMPACT OF BBSRC TRANSLATIONAL SUPPORT

Section summary

- The economic impact of the BBSRC translational support has been estimated based on the current and projected impacts of the 28 FoF and 11 IAA projects that report a GVA impact that could be quantified at the time of the survey.
- A review of the remaining cases suggests a further 18 FoF projects and 20 IAA projects have prospects of delivering impacts in future but we have no way to quantify the scale of their impact at this stage.
- The 105 FoF and IAA projects delivered £73.9 million GVA over their lifetime and £204 million in the 10 year model with a return to each £1 of BBSRC translational support of £2.58 and £7.13 in real terms respectively.
- Grossed up to the translational programme as a whole the GVA estimates are £192 million over the lifetime of projects and £652 million over in the 10 year model delivering returns per £1 BBSRC translational support investment of £2.65 and £9.00 respectively.
- The regional distribution of translational projects has been estimated for Greater South East (GSE) and the rest of the UK (ex GSE) based on the location of the host RO. Total net GVA in GSE was estimated at £104 million compared to £88 million ex GSE for the lifetime model and £447 million GSE and £205 million ex GSE in the 10 year model.
- In addition to the GVA impacts, BBSRC translational projects also attracted significant private investment of £71 million or £2.49 per £1 of BBSRC translational support investment.
- PIs from both FoF and IAA programmes also report a range of health, environmental and policy impacts: 75% of FoF projects and 73% of IAA projects have realised of have potential for future 'public good' impacts.

4.1. Impact Assessment Methodology

4.1.1. The economic impact of the BBSRC translational support has been estimated based on the current and projected impacts of the 28 FoF and 11 IAA projects[24] that report an economic impact at the time of the survey (see Table 4.1). No projections have been made for the 18 FoF or 20 IAA projects which

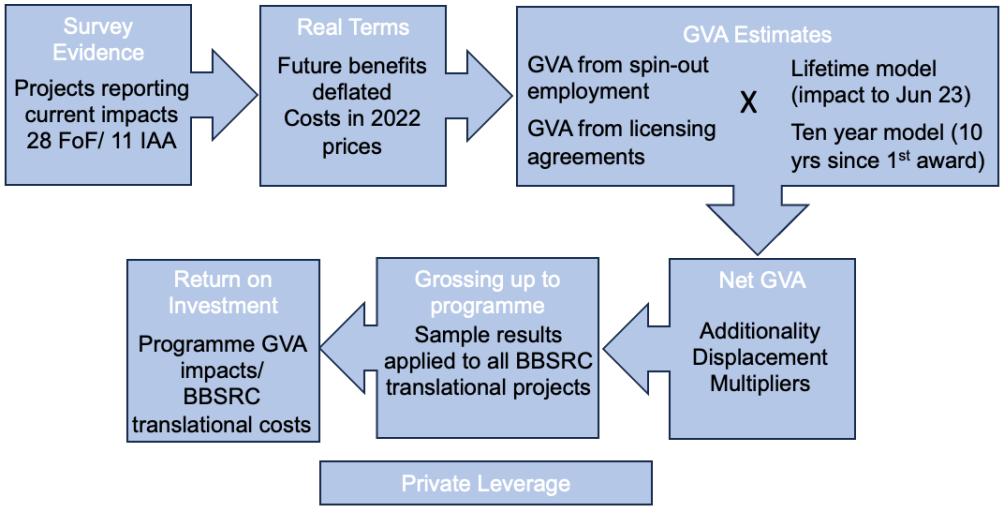
[24] Discussions with PIs benefitting from BBSRC translational support focused on the combination of FoF and IAA awards that led to the progression of the research idea towards commercial impacts. These combinations of awards are termed as translational projects and form the basis of the economic impact assessment.

have a potential impact in the future[25]. In addition, this economic impact assessment does not take into account the impact of the long term health, environmental and other impacts arising from the projects. These impacts are discussed further in section 4.7.

4.1.2. Estimates were made based on two scenarios:

- the lifetime model – estimating the economic impact of the support to the current date (June 2023) in GVA terms
- the ten year impact model – estimating the economic impact of the support over a ten year period[26] (calculated from when the first FoF or IAA award commenced).

Figure 4.1: GVA and return on BBSRC investment estimates



25 We have reviewed these projects and they are all at an earlier stage with plans for establishing a spin-out or expansion and while a number are on the cusp of commercialisation these is as yet no robust method by which to estimate expected impacts. Six FoF projects had a moderate likelihood of future commercial impacts and a further 12 are expected to take longer to achieve impacts. There is no information as yet on which to quantify the scale of these impacts. Thirteen IAA projects had a similar level of confidence in commercial impacts. Other cases are less certain and may be dependent upon further funding/research to progress to a stage where they will generate impact. IAA projects are also more recent and their translational process needs more time to mature.

26 This model was designed to capture the benefits that will arise from translational project that report an economic impact over their lifetime. HM Treasury Green Book Guidance suggests that benefits should accrue so long as the asset has an economic value in the market. In previous studies we have assumed this to refer to the maximum lifetime of the IP protection such as a patent (20 years from the point at which the Patent is registered). Given the greater uncertainty surrounding the expected commercial benefits, especially the scale and duration of licence deals it was agreed to assess the value added from translational projects up to a maximum of 10 years from the start of a translational project. This is likely to be a conservative assumption.

4.1.3. BBSRC translational support and research costs were adjusted to real terms (2022 prices) using a GDP deflator and future impact benefits were adjusted using HM Treasury Net Present Value calculation.

4.1.4. The methodology used to calculate impacts comprised the following stages:

Estimating the economic impacts from spin-out employment

- in cases where a spin-out had been incorporated and had employment, interview data was used to map the change in employment to date. Total employment costs over this period were calculated using data from the interview and deflated using GDP deflators for previous years. Real wage costs (in 2022 prices) were converted to aGVA using sectoral aGVA/employment cost ratios from the Annual Business Survey
- a deflator of 26%, based on the findings from our previous BBSRC spin-out research, was applied to the total aGVA to take displacement into account[27]. A type 1 multiplier was applied to account for supply chain impacts
- PIs' responses to the additionality of BBSRC translational support from the survey was used to calculate the net GVA impact attributable to BBSRC translational support
- the methodology for the 10 year projection mirrored that for the lifetime projection. Where a spin-out had been established and was employing people an estimate (based on interview data) was made of the growth in employment over any remaining years (10 years from the data of support). In keeping with HM Treasury Green Book guidance the projected impacts from 2024 onwards were discounted by 3.5%

Commercial impacts from licensing and service agreements

- in other cases data was collated on any license agreements or service agreements which had been generating revenue for the RO . License agreements are often subject to confidentiality clauses and so PIs were often unable to provide details and data were available for just three of the ten cases[28]
- while many of these projects have provided evidence of their current and future economic impact through their employment, evidence of the expected benefits from license agreements is limited by:
  - (i) license agreements in their early stages where payments relate to the right to develop the IP into products with (as yet) little or no information on how these might translate into (typically much larger) sales-based payments
  - (ii) some license agreements were still in negotiation and were often covered by non-disclosure agreements preventing the sharing of data

27 CPC (2024) Economic impact assessment of BBSRC supported spin-outs, BBSRC

28 It should be noted that the costs for those projects where no data was available have not been removed from the calculation of return for BBSRC investment in translational support so this represents a highly conservative estimate of impact.

  - (iii) there is a lack of benchmark data from other sources on the value of license agreements so it has not been possible to estimate likely impacts from other sources[29]
- where a licencing or service agreement was in place an estimate was made in terms of future impacts based on interview data. In both cases the agreement involved an initial one-off payment and subsequent regular ongoing payments and these were calculated over the 10 year timeframe[30]
- for these three cases gross total sales revenue to date was calculated. This figure was adjusted to take into account the high proportion of export sales (95%) and for additionality as for spin-outs. A type 1 multiplier was applied to account for supply chain impacts
- impact estimates were calculated for both the lifetime model (to June 2023) and the ten year model to reflect the fact that many impacts were expected to persist into the future. As with future employment impacts, the licensing projected impacts from 2024 onwards were discounted by 3.5%. However, because future license revenue was largely unknown, the 10 year modelling of future licensing income is likely to represent a significant underestimate of impact

Leverage impacts reported in the survey of translational PIs

- interviews with FoF and IAA PIs also identified the contribution from private and other non-public sources to the development of the translational project. This private leverage has been included in the benefits arising from the BBSRC translational programmes but not included directly in the calculation of GVA impacts

Estimation of impacts relative to BBSRC translational programme costs

- grossing up the impact estimate to BBSRC translational programme level uses the sample ratio of costs to impact and applies this to total programme spend over the same period
- finally, these real terms net impact estimates were compared with BBSRC investment in translational support to produce a return on this investment
- these results are also presented at regional level (Greater South East – GSE and all other areas) based on the location of the RO

29 UK Bioindustry Association reports on UK Biotech Financing provides evidence of the maximum value of license agreements struck by UK spin-outs with 'big pharma' companies 2021 to 2023. The maximum license payments (when all milestones etc are achieved) accruing to eight spin-outs supported by BBSRC research is £7.3 billion or an average of £992 million per license agreement. While these may represent 'gold standard' agreements in biotech sector, this does highlight the potential importance of license agreements to overall economic impact.

30 Unfortunately while we are aware of a number of licensing deals related to FoF projects most of the details on these are confidential so the impact estimates only include the known elements which for FoF are upfront payments (and so do not change over the future 10 year period) whereas there are two licensing deals with known contributions included in the IAA impact estimates.

4.2. Estimates of the economic impact of translational support

Total BBSRC translational project impacts

4.2.1. Table 4.1 summarises the translational impact estimates across all 105 FoF and IAA projects (in the survey sample) and grosses this up to the programme level (representing a total of 854 awards between 2004 to 2021). Total net GVA in the lifetime model amounts to £192 million and £652 million in the 10 year model. The return to each £1 BBSRC invested in the sample projects is £2.65 for the lifetime model[31] and £9.00 for the 10 year scenario.

4.2.2. As before, it is important to bear in mind that in both calculations, there are economic benefits arising from IP licencing agreements with commercial partners that remain confidential and so have not been included in these estimates. Neither has this analysis been able to estimate the potential substantial economic contribution from wider health and environmental benefits arising from BBSRC translational projects (these wider benefits are set out below) nor the future potential commercial impacts from translational projects that are yet to mature.

31 i.e. up to June 2023

Table 4.1: Total BBSRC translational programme impacts

All awards	Sample (105 projects)		Population (854 awards*)	
	Lifetime	**10 year**	**Lifetime**	**10 year**
Total funding	£23,840,571	£23,840,571	£61,426,460	£61,426,460
Funding in real terms	£28,632,215	£28,632,215	£72,479,741	£72,479,741
Gross aGVA from employment	£89,256,473	£288,608,062	£243,518,462	£1,003,812,305
Net (adjusted for displacement and additionality)	£48,760,313	£136,676,603	£126,737,747	£436,225,411
Net (incl multiplier)	£71,921,462	£201,597,989	£186,938,177	£643,432,482
Gross aGVA from licencing/contract research	£3,212,285	£3,914,681	£8,230,419	£11,645,434
Net (adjusted for displacement and additionality)	£1,324,090	£1,806,611	£3,474,106	£5,820,098
Net (incl multiplier)	£1,953,033	£2,664,751	£5,124,307	£8,584,644
Total net aGVA	**£73,874,495**	**£204,262,740**	**£192,062,484**	**£652,017,126**
Return to £1 BBSRC translational programme investment	**£2.58**	**£7.13**	**£2.65**	**£9.00**
Total net aGVA excluding multipliers	**£50,084,404**	**£138,483,214**	**£130,211,854**	**£442,045,509**
Return to £1 BBSRC translational programme investment	**£1.75**	**£4.84**	**£1.80**	**£6.10**

Source: CPC calculations based on survey of 44 IAA PIs and 61 FoF PIs covering 105 translational projects (180 awards). BBSRC translational support awards between 2004 and 2021 identified 490 FoF and 364 IAA awards totalling 854 awards in the population calculations (the number of translational projects is not known at programme level).

Regional distribution of BBSRC translational impacts

4.2.3. Table 4.2 presents the estimate of the impact of BBSRC translational support programme as a whole at the regional level. It should be noted that the data require careful interpretation. For example, the estimates are based on the location of the PI's RO and this may not necessarily be the location of any commercial activity that results from the translational project. In addition, the GSE and ex-GSE sample sizes are relatively small and it has not been possible to estimate fully the current and future economic impact arising (see paragraphs 4.1.4 and 4.2.2).

4.2.4. Total funding in the GSE sub region was £33.5 million (in real terms, 2022 prices) from BBSRC and over the lifetime the return for each BBSRC £1 spent is £3.11. Over the 10 year model the return per £1 BBSRC spent is £13.34. BBSRC translational support in the rest of the UK was £39 million and over the lifetime the return per BBSRC £1 is £2.25. Over the 10 year model the return is £5.25.

Table 4.2: BBSRC translational support regional impacts

	Lifetime	Future 10 year
GSE real terms funding	£33,529,959	£33,529,959
ex GSE real terms funding	£38,949,783	£38,949,783
GSE total net aGVA	£104,441,987	£447,349,670
ex GSE total net aGVA	£87,620,498	£204,677,456
Return on BBSRC investment GSE	£3.11	£13.34
Return on BBSRC investment ex GSE	£2.25	£5.25

Source: CPC calculations based BBSRC funding data for FoF (2004 to 2021) and IAA (2019 to 2022) awards & BBSRC data on programme spend by location of RO where the award made.

4.2.5. The return to BBSRC funding of translational projects in GSE is somewhat higher in both scenarios. This is due to proportionately more FoF projects to ROs in GSE area (that have a longer period over which to generate impacts) as well as more IAA projects that were able to quantify their impacts[32].

32 This result is driven by GSE translational projects having both a higher proportion of spin-outs with measurable impacts and more projects with licensing arrangements that could be quantified. Unfortunately, there are too few cases to establish whether the result is simply by chance or whether it reflects better prospects for commercialisation within GSE.

Private leverage for translational projects

4.2.6. In addition to this GVA estimate, the 105 FoF and IAA projects leveraged around £7.3 million in overseas funding, £17.4 million in private (industrial) funding and £47 million in Venture Capital funding in their further development. This represents a gross return of £2.49 on each £1 of BBSRC translational funding. This is an underestimate because in two cases the private funding amount could not be disclosed.

4.2.7. Applying the above additionality calculations to leverage funding provides an assessment of the total net additional funding which is attributable to the BBSRC translational support. Total net leverage funding is £54 million and represents a net return of £1.89 on each £1 of BBSRC translational funding.

Table 4.3: Gross and net leverage of translational support projects

	Gross Private leverage	Net Private leverage
Overseas funding (public, private or charity)	£7,255,308	£6,135,519
Private industry	£17,423,695	£12,807,015
Venture Capital	£46,543,905	£35,046,953
Total	**£71,222,909**	**£53,989,486**
Leverage per £1 BBSRC translational funding	**£2.49**	**£1.89**

Source: CPC face-to-face survey of 61 FoF and 44 IAA recipients

4.3. Wider impacts and public good benefits

4.3.1. Both FoF and IAA translational projects resulted in a range of public good impacts. For example, just under a quarter (24%) of projects were currently realising one or more health impacts and a further 35% had potential to realise these in the future (Table 4.4).

4.3.2. Nine percent of projects were currently realising one or more environmental impacts and a further 19% had potential to realise these in the future.

Table 4.4: Health and environmental benefits from translational projects

FoF projects	Environmental	Health	Total projects	Total %
No health or env. impact	-	-	15	25%
Potential for future impact	6	21	23	38%
Project realising impacts	6	19	23	38%
Total projects	**12 (20%)**	**40 (66%)**	**61**	
IAA projects	**Environmental**	**Health**	**Total projects**	**Total %**
No health or env. impact	-	-	12	27%
Potential for future impact	14	16	23	52%
Project realising impacts	3	6	9	20%
Total projects	**17 (39%)**	**22 (50%)**	**44**	
All projects	**Environmental**	**Health**	**Total projects**	**Total %**
No health or env. impact	-	-	27	26%
Potential for future impact	20 (19%)	37 (35%)	46	44%
Project realising impacts	9 (9%)	25 (24%)	32	30%
Total projects	29 (28%)	62 (59%)	105	

Source: CPC face-to-face surveys of 61 FoF and 44 IAA recipients

4.3.3. It is outside the scope of this research to try to quantify the economic impact of these health and environmental impacts however it is clear that a number of projects will generate a long term net health or environmental benefit.

4.3.4. Across all FoF and IAA projects, 24% were already producing a positive health impact:

> *'Applications are broad and include diagnostics, vaccines, etc. As well as commercialising the tech, there is an inequitable distribution of plant based system tech where it would be of most benefit - the poorest countries. We would like to allow for development of a business model to create non-profit aspect and licence for free, e.g. for use in vaccine production.'* [PI, Human health sector]

4.3.5. Another 35% of projects had the potential to produce health impacts in the future. In some cases this was through the continuation of the research and in others through the impact of the existing research coming to fruition:

> *'The research is still developing but has the potential to improve health outcomes (detecting the microbes that make people ill) and environmental outcomes (microbes everywhere, e.g. in soil).'* [PI, Biotechnology sector]
>
> *'There will be health and quality of life benefits, our technology will enable patients to monitor hormone levels at home which will empower patients and help patient/doctor relationships. Initially this will help niche areas - Addison's disease, Cushing's disease, hyper tension. In the future there are multiple areas in*

> *which dynamic changes over time will be important, e.g. oncology and inflammation.'* [PI, Human health sector]
>
> *'The potential of this research is very substantial because this molecule is key to the pain experience particularly by sufferers from arthritis. The potential managing this molecule is enormous and the ultimate market of any drug in this area would also be enormous.'* [PI, Human health sector]

4.3.6. Across all FoF and IAA projects, 9% had already resulted in a positive environmental impact and 19% had a potential to in the future. In the latter case, PIs often report that blockages will need to be overcome before any impact could be realised:

> *'The technology enables farmers to increase wheat yields without the harmful environmental effects of fertiliser. It contributes to net zero objectives and helps increase in food security (particularly in light of the Ukraine war). Going forward if we can increase yields by 10 to 20% it has potential to help solve the world food crisis.'* [PI, Agriculture sector]
>
> *'FoF showed the tech worked but we didn't get any further due to GM blockages. In retrospect we wouldn't have gone down the GM route and would've found an alternative way to switch on genes using natural microbes. If we can overcome this there would be impacts re food security and net zero/reducing carbon footprint.'* [PI, Biotechnology sector]
>
> *'The research has potential to improve rice yields by 10 to 20% in impoverished areas of the world and improve quality of life for subsistence farmers. It has now been taken up by rice institutes.'* [PI, Agriculture sector]

4.3.7. However, in some cases, where there is no evident future commercial value, these impacts will only be realised with further public funding:

> *'…The project ground to a halt due to (name of industrial partner) not interested in continuing. There is a big academic reason for continuing to understand blackgrass dynamics and monitoring pest and weed problems but this would be something for government to fund, the commercial market is limited and is not something farmers are going to pay for.'* [PI, Agriculture sector]

Policy impacts

4.3.8. In addition to health and environmental impacts, 12 of the 61 FoF projects (20%) showed evidence of having had some influence on the policy environment (Table 4.5). Policy impacts were most common in the Agricultural and Animal health sectors. In all the cases in agricultural sector this related to input in relation to Genetic Modification (GM) regulation:

> *'I have given evidence to the government committee for the Genetic Technology (Precision Breeding) Bill and also regularly host ministers. This research has had a huge impact on policy makers and had attached lots of media interest, TV, radio and newspaper.'* [PI, Agriculture sector]

Table 4.5: FoF projects that report some influence on policy

	Count	%
Agriculture	4	44%
Animal health	2	29%
Biotechnology	2	11%
Food and drink	1	14%
Human health	3	16%
IT	0	0%
Total	12	20%

Source: CPC face-to-face surveys of 61 FoF recipients

4.3.9. In other sectors much of the policy influence is linked to the PIs role on advisory boards:

> *'I sit on a number of industry advisory bodies for the control of animal parasites and have helped to increase the likelihood of increased use of pen-side tests through these bodies. Through my membership of a guideline committee which was set up to develop research needs roadmaps for global animal diseases I contributed to the overall roadmap.'* [PI, Animal health sector]

4.3.10. The online survey also asked whether FoF projects had made a contribution to wider impacts and public good benefits. Only 10% of award holders in the FoF online survey reported any wider benefit but this was due to a higher proportion in this sample being at an early stage of their translational pathway. These were:

- one citation in clinical guidelines and one in a clinical review both in the Animal health sector
- membership of a guidance/ advisory committee in human health
- two influenced training of practitioners or improved professional practice in Animal and human health

4.3.11. Amongst IAA recipients, 9 of the 44 projects (20%), showed evidence of activities being undertaken to influence the policy environment. In many cases this is an ongoing process with limited evidence of policy change to date[33]:

> *'It is work in progress, we are working with the FSA to change policy framework for the production of cultured meat with different source cells.'* [PI, Food and drink sector]

33 There are too few IAA responses to provide an equivalent sectoral analysis.

5. PI AND STAKEHOLDER VIEWS ON BBSRC TRANSLATIONAL SUPPORT

Section summary

- PIs overwhelmingly welcomed the support available from FoF, particularly the scale of support available from FoF and SuperFoF. The speed and flexibility of the BBSRC IAA award was highly regarded by PIs, although many were aware that it had a limited budget compared to other RC IAA funds.
- TTO support was widely praised by PIs especially in regard to signposting for translational funding and advice on the application process. However, some PIs reported that they were not given sufficient guidance on what to expect across the whole translational pathway.
- There is limited evidence that fail fast principles are routinely designed into the translational pathway for FoF and IAA projects.
- The harmonisation of IAAs has led to increased communication and learning at RO level but there appears to be limited networking on detailed issues facing translational projects such as 'going rates' for IP licencing agreements and other commercial market intelligence.
- Some PIs reported that commercial partners were now more demanding of translational projects – requiring more evidence and seeking progression to a higher TRL than might have been common in the past.
- PIs noted that they had to invest a lot of time chasing and being creative with small pots of money. PIs commented that they would have been further along the TRL had they had access to more consistent and accessible funding.
- A few ROs have instituted a more pro-active engagement of BBSRC-remit researchers to encourage more ideas with additional support at the very early stages.

5.1. Introduction

5.1.1. This section draws on the discussions with PIs benefitting from either FoF or IAA translational support and the wider group of stakeholders involved in translational support including representatives from ROs TTOs and TROs, BBSRC FoF Committee members and people with experience of investment into new commercial operations and venture capital. These stakeholder discussions were very helpful in providing further perspectives on the translational support process. Not all of the points made can be directly addressed by BBSRC but they reflect the views of the full range of stakeholders interviewed. To preserve the anonymity of respondents we have chosen to present the results on an issue basis.

5.2. Views of translational support PIs

The role of advice and guidance in translational projects

5.2.1. A number of PIs were very complementary about the support that they received from their TTOs, particularly during the application stage – discussing strategies to pursue the translational research, providing information on what funding to apply for/ recommending FoF, providing information on what needed to be included in the application, developing the business case for the project, providing information for the commercial impact section or advising what should be included, undertaking patent scanning and due diligence to ensure the project didn't infringe any existing patent rights.

5.2.2. PIs gave more mixed views on TTO support in other areas. Some noted that TTOs had been helpful in further supporting their projects by advising on market research, IP processes and filing patents, negotiating licencing deals with companies, looking for industrial collaborations, and providing advice on how to translate ideas into a spin-out company. However, other PIs commented they considered the research team were on the wrong side of information asymmetries:

> *'They [the TTO] were really helpful and always answered our questions very well but they did not tell us what questions we were not asking.' [PI Biotechnology]*

5.2.3. Some PIs noted significant issues with how TTOs handled their projects and commented that there was a general skills gap across academia when it comes to technology transfer/ commercialisation skills and understanding the IP landscape. There was a perception that some TTOs are staffed with people with limited range of business contacts and networks that might form the basis of a commercial market entry strategy and identification of potential commercial champions for the translational project.

5.2.4. More often PIs reported that TTOs were very busy and that this impacted on their ability to provide support. Some PIs perceived that this meant any potential translational project that was complex or was felt to have more doubtful outcomes was less of a priority.

5.2.5. A small number of PIs had engaged external consultants/professionals to put together business plans or had used patent attorneys for IP advice. One had had a positive experience with their TTOs but felt that staff were inexperienced in the researcher's subject area. This experience was echoed by another PI,

who noted that research ideas were a steep learning curve for TTOs who were dealing with new technologies that they had no prior experience of and had to grapple with new information, with all academics trying to convince them that their idea is the most valuable.

> *'We have a small TTO team and they are very busy. We decided to invest in an external specialist organisation and without them this project would not have succeeded. They had the specialist knowledge to prepare our team to work effectively with big pharma.' [PI Biotechnology]*

5.2.6. PIs who had received the Pathfinder FoF were extremely positive regarding the support received. In addition to the financial support PIs valued the recognition provided by the Pathfinder assessment panel and many highlighted how they found this useful to keep them 'on track', help open up new networks and advise them on next steps in terms of funding. It is worth noting that FoF Committee members had a different view and did not consider that Pathfinder support was delivering value for money (see para 5.2.10 below). Although the IAA does go some way in filling the gap from the withdrawal of the Pathfinder FoF there is a potential gap in support with regard to PIs based at institutions who do not receive IAA funding.

5.2.7. PIs experiencing gaps in advice and information from their institution provided a number of suggestions of ways in which BBSRC could help to plug this gap:

Additional support to help build partnerships:

- support for small universities with a lack of innovation services to generate industrial interest/help with taking an application forward with industry
- access to mentors with relevant experience of the translational support process was mentioned as being useful where ROs offered this service. These individuals were an important source of 'independent' advice but also often had extensive contact lists
- a database of companies that could be used to generate industrial contacts for PIs[34]. Likewise, industry partners would like to see better mechanisms in place to match/introduce companies to academic researchers so that they are able to find mutual interests and help to take academic research into the commercial space, e.g. through networking events. One noted the good practice of MediWales at bringing together life sciences companies, academia, and the clinical community
- a restart of the BRIC (Bioprocessing Research Industry Club) which was described by one PI as a 'superb scheme'

34 https://konfer.online/ offers this service already so this suggestion may point to a limited awareness among PIs

Entrepreneurial support:

- to develop BBSRC support within FoF that is similar to Innovate UK/ICURe support, e.g. developing entrepreneurial/ commercialisation skills of PIs through funded programmes/courses, support to develop marketing pitches, support with spin-out creation, opportunities for shadowing spin-out founders, etc
- advice from BBSRC on the different ways of progressing a project/moving to the next stage and the options for commercialisation, e.g. spin-out route, social enterprise models, licensing, etc
- support to understand the IP landscape, which is a big skills gap in academia, perhaps with a dedicated BBSRC office that has people with this expertise
- others suggested that wider training to help academics with a basic understanding of the IP landscape. Some ROs now offer such training to early career researchers and new PhD students as a grounding and raise awareness of any confidentiality issues in the research they may be involved with
- support for TTOs with the spin-out process, providing advice on issues such as reasonable equity shares
- providing a database of potential VC investors which offer suitable funding opportunities

De-risking translational projects

5.2.8. Some PIs reported that commercial partners were now more demanding of translational projects – requiring more evidence of the project's potential and seeking progression to a higher TRL than might have been common in the past. This leaves more of a gap for translational support to fill to de-risk the proposition. A number of PIs in the human health field stated that it was much more difficult to secure a 'champion' in big pharma and some felt that they were required to develop their project to pre-clinical level before securing commitment from their commercial partner.

> *'We appear to have to produce more and more evidence and take the translational process further than before to give the big multinationals the confidence to invest in our ideas. It's a buyers' market and they don't have sufficient resources for all, so we have to do more to keep their attention.'* [PI Human health]

5.2.9. More than one PI reported that changes in corporate strategy and/or changes in senior staff in the commercial partner had led to them dropping their interest:

> *'We had established good relations with [large corporate] and we expect to be able to commercialise our idea with their support but the head of research left and their replacement took a different view.'* [PI Human health]

> *'I think Research Councils are doing a lot. The challenge is perhaps more that obtaining business investment, e.g. from VCs, is much harder in the UK than in the US. This means that fewer ideas are taken forward. This seems to be a particular challenge for strong business ideas that are based on unique (or rare) know-how as opposed to specific IP'.* [PI Biotechnology]

5.2.10. A number of stakeholders (including BBSRC FoF Committee members also highlighted another challenge posed by these lengthy timescales. It was noted that 'set piece' evidence such as market assessments or proof of markets undertaken at the outset of the translational process were often many years out of date by the time the idea was ready for market. However, this was often cited by ROs TTOs as their recommended first step when engaging with academics who approached them.

5.2.11. Other stakeholders were more critical that market studies had often been formulaic and merely cited current and future market sizes that did nothing to help the translational project determine the most appropriate market entry strategy. This should include identification of which current commercial organisations would be most amenable to the new idea and why, key individuals in the organisation to approach and what commercial structure would best suit such a pathway. Relating to this, stakeholders stated that more could be learnt from leading practice among TTOs in engaging entrepreneurial networks and providing structures to call on a wider pool of experts.

5.2.12. Some PIs stated that the external (peer reviewed) support of translational projects through FoF provided them with greater credibility with their TTOs – in a sense de-risking the project for further support from the TTOs.

Securing sufficient translational support to reach a stage where commercialisation is a realistic prospect

5.2.13. Inevitably, securing sufficient translational support funding was to the forefront of many PIs' concerns. Many PIs stressed the length time required to get translational project to the point where there is sufficient evidence to support a convincing case with potential investors at the commercialisation stage. FoF and SuperFoF can provide significant resource but for some the limited timeframe (up to two years) for completion creates another potential barrier. One PI was planning to apply to Innovate UK Farming Futures KTN rather than SuperFoF as it recognises that plant breeding projects need longer timeframes. PIs and TTOs reported that BBSRC remit projects had

particularly long journeys – starting with lower TRLs and often having long translational process to a commercial pathway that may itself involve lengthy regulatory approval, in particular:

- agriculture and animal health translational research often requires two growing or breeding seasons (in order to demonstrate that any novel traits are carried through into the next generation)

  'We had a good project team in terms of researchers and commercial partners which facilitated the success of the project. Making plant crosses to develop the plant populations necessary for fine mapping of plant traits is time consuming (plants have to be grown, our plants needed vernalising for up to three months, the plants then have to flower and seed has to set etc.), consequently two years for a plant project is massively restricting in terms of what can be achieved. So in terms of what BBSRC could do, longer projects would be important for our sort of plant work.' [PI Agriculture]

- biotechnology and human health translational projects may require substantial evidence base to secure collaboration with large pharmaceutical or health companies to take forward these innovations

5.2.14. PI responses highlight that securing further funding was a key barrier to progressing a project at each stage. Some noted that they had to invest a lot of time chasing and being creative with small pots of money, which meant that progress had been slower than it could otherwise have been. PIs stated that they would have been further along the TRL had they had access to more consistent and accessible funding. There are examples across both FoF and IAA awards that relatively small awards are often add-ons to secure more evidence for a patent application or further data designed to de-risk commercial partner involvement in the next stage.

> *'The Follow-on Fund was useful, but only got us to the point where we had to apply for further funds to support proof-of-concept for the idea. There has been a lot of time spent trying to find appropriate support for the next (translational) step (often costly because it included large animal surgery). As a result, we have taken a long time to get this far in very incremental steps. It is a shame that there wasn't a process where, if the RCUK believed in the idea, they couldn't have reviewed/extended support beyond the FoF and through the translational process - potentially providing [technology transfer] support for novel technologies.' [PI Animal health]*

5.2.15. PIs commented that BBSRC should encourage those that were performing successfully to continue to apply for funding and described the MRC's DPFS as an example of good practice. The DPFS allows researchers to keep applying for funding if all milestones have been met, recognising that

translational research is a long journey and to enable projects to maintain their momentum. Additional elements can be accessed more quickly and still remain part of coherent translational programme.

5.2.16. For others, fragmented funding had created issues for staff retention – with difficulty keeping hold of good postdoctoral researchers. This was considered to be more challenging in relation to translational support where short project duration (and repeated applications for each stage) added to uncertainty. While this is also an issue in 'standard' research, at least these grants relate to a more substantive period. Other PIs also reported that in translational projects researchers were more exposed to working alongside industry and a number had left to work for commercial partners.

5.2.17. PI suggestions for changes to funding included the following (irrespective of whether this would sit within BBSRC's remit):

- more frequent funding rounds, with a streamlined applications process. For example, grants that allow buy postdoc time for short periods (3 to 6 months) to allow development of IP with clear ownership from existing unrelated commitments
- many noted that it would be useful to have a 'follow on' for the FoF or IAA – an opportunity for additional funding for projects that have demonstrated success to get the technology over the line and further towards commercialisation, or a light touch approach to getting an extension, rather than needing to submit a fresh application, with appropriate recognition of what is possible to achieve during a relatively short time period
- better signposting to schemes that can be accessed on completion of the FoF or the streamlining of different funding streams
- stronger working relationships between BBSRC and Innovate UK, like the Biomedical Catalyst programme

5.2.18. A number of PIs with projects further towards commercialisation requested more help from BBSRC to bridge innovation's 'valley of death' and support projects to reach full commercialisation. There is limited awareness among researchers of the boundary between BBSRC's remit for translational support and Innovate UK's role in the system. Increasing awareness of the limits to translational support and expectations of what public funding can invest in and where private sources need to be engaged would manage PI expectations on what is possible.

Overcoming impediments to knowledge transfer

5.2.19. Interviews with industry partners highlighted that they perceived one of the biggest barriers to knowledge transfer between academia and industry to be "unnecessary IP impediments". They commented that discoveries were often not worth as much as academia perceived and ROs often patented research outputs too early. As one explained, care was required in drafting a patent that would provide adequate IP protection for the specific application and context in which the innovation was being deployed. Generalised patents registered before the application had been determined often did not provide this level of protection. They noted that this stifled innovation, with industry often unsure whether or not they were encroaching on IP rights.

5.2.20. One industry partner had noticed a recent trend towards ROs becoming more interested in entering into licensing arrangements with the value of some of these agreements being "totally out of proportion", which had acted as a barrier to taking on the technology. Indeed, this reflected the disappointing experience of one of the FoF PIs, as described above, whereby the TTO had pitched the licensing deal too high, resulting in the industry partner walking away.

5.3. Perspectives from translational support staff (TTOs)

TTO translational support delivery arrangements

5.3.1. A number of interviewees reported that their RO had adopted an increased focus on research impacts leading to spin-outs and this in turn was a catalyst for a greater emphasis on supporting the translation of innovative research ideas into practical applications within their institution. In some cases the previous system was operated at faculty level but the introduction of the UKRI harmonised IAA provided the impetus to re-organise IAA delivery through a combined central team to enable cross-disciplinary translational support across BBSRC and other UKRI research council remits as appropriate[35]. This was not universal, with some institutions having long-standing translational support and a minority still having reportedly under-resourced TTO support.

5.3.2. The adoption of a single IAA team within a RO to deliver TTO translational support was felt to improve communication across the different elements of the wider TTO team (for example, commercialisation specialists are often in a

35 The individual IAA funds are still subject to competitive bids to the respective research councils so individual institutions offer only the IAAs where their applications were successful.

separate team in all but the smaller institutions). It was also suggested by interviewees that the single team were better able to support cross-disciplinary applications and improve their experience and learning from a wider group of IAA applications. In most cases BBSRC-related disciplines were supported by a specific TTO officer to build engagement with the research community.

5.3.3. IAAs typically involve three to four internal calls per annum across the relevant academic departments and a single application form. In some institutions applicants are invited to choose which research council IAA that best fits the domain of their proposed project. In others, this selection is made by the central IAA team. Where projects span the research domains of different research councils it was not unusual for IAA teams to apportion funds from more than one Research Council in the project.

5.3.4. Some institutions offer informal advice to potential applicants on how to structure their bid for IAAs. A number looked to ensure that bidders address key elements that would help frame progression to the next stage and further translational support as appropriate. In one institution guidance was offered around five elements:

- relationship development – new opportunities for collaboration and knowledge exchange – this can include travel expenses and time to explore relationships with potential partners and support for workshops etc
- Proof of Concept (PoC) – with an emphasis on ensuring that this correctly framed so it is asking the right questions and able to deliver robust answers within the resource
- staff secondments to add specialist knowledge where appropriate etc
- Innovation Works – networking, regional engagement, thematic brokering and innovation labs with commercial organisations setting out their needs and priorities for researchers to discuss
- commercial development – initial market & competitive landscaping, technology evaluation to lead on to potential spin-out and licensing opportunities

IAA assessment procedures

5.3.5. It was noted in a number of interviews that the BBSRC IAA funding award was relatively small in comparison to EPSRC and MRC and so where appropriate ROs had adopted an approach of husbanding BBSRC resources and enabling larger IAA projects to go ahead by combining funds with other Research Councils' IAAs. Translational support staff stressed that the funds remain remit-led and in their view BBSRC-related researchers remained focused on securing BBSRC translational funds. However, the more significant budgets available in other Research Council IAAs means that researchers are

pragmatic when an opportunity to combine UKRI research council funds into their co-funded IAA project.

5.3.6. RO's internal IAA bids are most often assessed after an initial check by the IAA team:

- all applications are reviewed initially by team discipline leads (not formal but each member has a background in sciences) before going to panel (in order to check that bid is coherent and could be implemented)
- IAA panel includes external expert input from two to three people on each (RC) panel – including sector experts, technology experts and Technology commercialisation expert, and (in one case) included a senior Knowledge Transfer Partnership (KTP) adviser focusing on policy impacts
- the Panel Review is focused on the structure of project – its coherence and whether it is implementable (this would cover whether the project is ready to consider next steps, whether the PoC a real test and what happens next for the progression of the project). Ensuring these elements are in place usually leads to robust results from the IAA that can progress the project and build confidence that the idea 'has legs'

5.3.7. Some TTOs seek to encourage the involvement of commercial partners in their IAA projects. This is perhaps more deep-seated where TTO staff also have an involvement in partnership programmes such as KTPs and have built up extensive networks with commercial organisations and have used the opportunity to cross-sell involvement to better engage organisations.

5.3.8. For one RO the inclusion of external commercial partners was estimated to be around 90% of IAA projects[36]. This was considered to be an important element in project success as it brings a 'real world' assessment to the project proposal – a clear 'go' or 'no go' decision that is seen as valid for all parties. More generally, TTOs report that most commercial partners provide a direct financial contribution or contribution in kind, in itself a measure of partner commitment to the project idea. Access to costly equipment was cited as a frequently item covered by commercial partners as this was otherwise relatively uneconomic for short-term projects.

5.3.9. Similar observations were made by staff at research institutes who often work in specific niche market segments e.g. vaccines, where the major players are well-known and the economics of the commercialisation process make it essential to engage with a commercial champion.

36 The IAA was administered by staff with extensive experience of KTP projects and they were able to use their strong network of contacts to ensure a commercial partner. Ideally the commercial partner contributed some investment into the project but this was not a requirement in all projects.

5.3.10. The concentration of IAA support has meant that systems and procedures are more standardised and build on a wider range of translational support experience, such as a standard collaboration agreement with commercial partners (developed by one institution helping to regularise partnership working arrangements - this is not a licence but may be a lead in to one if things develop successfully)[37].

TTO support for FoF applications

5.3.11. All TTOs provided support to academics bidding for FoF funding – many raise the potential of the FoF funds in their initial discussions with academics considering developing their research ideas. All welcomed the requirement that TTOs formally support the FoF bid as it ensures that they are engaged by proposers on what is being proposed and provided substantial resources to progress projects and establish a clear progression plan.

FoF and IAA funding arrangements

5.3.12. TTOs welcomed the overall level of support provided through the FoF scheme. Exceptions to this were those institutions where food science or animal health were a key part of their research portfolio where the two-year time limit for completion of the project was criticised for not fitting with the timescales to secure results.

5.3.13. IAA block award holders felt that their budgets were being badly eroded by inflation. More than one TTO reported that whereas £100,000 per annum could fund four projects with a postdoctoral researcher for six months in the past, this was no longer the case. Employment costs and visa fees for highly skilled staff from outside the UK have risen considerably. Some suggested that the same budget would only support three to four months now. Others commented that this budget allocation offered too little scope for project progression (and was not attractive to highly qualified staff) and preferred to suggest that only two six-month projects were now credible with the same budget.

5.3.14. Two ROs had been successful in their bids for BBSRC IAA funding in the past but did not secure funds in the 2022 round. Both reported that this had left something of a gap in support – particularly for crop science and food science (where other funds – MRC or EPSRC – do not stretch across). Both institutions have responded by adapting Higher Education Innovation Funding

37 There are a number of toolkits on collaboration available see: University and business collaboration agreements: Lambert Toolkit - GOV.UK (www.gov.uk)

(HEIF) to plug the gap. However, both reported that their basic biology and biotech researchers were under-served by translational funds – particularly as IAA funding provides a crucial first step on the translational ladder.

5.3.15. Other institutions had BBSRC Pathfinder IAA where the funds were awarded for one year at a time. This meant that the ROs were uncertain about developing a pipeline of translational projects when confirmation of funds are not usually announced until mid-summer. As a result, a number of respondents commented that more could be done by BBSRC to help smooth out this uncertainty. One institution has taken the decision to underpin the awards with their own resources in the interim to avoid significant disruption to projects.

Demand for TTO support

5.3.16. TTOs from most institutions report that demand for their services from academics is high. One institution with almost seven FTE members reported that they would still be very busy with three times the staff complement. In part, the healthy demand reflects a range of ideas at very different stages of development. A primary driver for this demand is the desire of most academics to see their ideas put into practice where possible. Some may see a potential commercial pathway as part of ensuring this, but this is not the majority.

5.3.17. Managing the demand for innovation support is an issue even at the larger TTOs. Translational support plays an important role in resourcing additional support to help PIs shape their initial ideas. TTOs point to the availability and flexibility of small scale IAA awards as a vital first step in translational support. The projects can be defined quickly to provide an initial PoC and market assessment and (from their perspective) do not demand significant time input. In effect IAAs progress projects to a point where TTOs can further engage and discuss progression pathways with the academic team in greater depth. Award values vary in relation to the nature of each project but TTOs stress that it is possible to progress an idea significantly, especially if they have been able to engage with external (commercial) partners with up to £10k. One institution has recently introduced a scale of awards available to communicate to researchers based on the project's TRL:

- Stage 1: TRL1 to 2 up to £11k
- Stage 2: TRL3 to 4 up to £27k
- Stage 3: Spin-out/ commercial up to £50k

5.3.18. A number of translational support teams have established stage gate procedures to triage ideas at different stages of development so that the TTO staff can focus available time on those who are ready to progress:

- informal discussions or email exchanges with academics with an idea but limited detail on its potential application
- initial discussions to determine basic information around the ownership of the IP. This is often overlooked and may not have been considered by the academic. The Terms attached to research grants may have provisions over the exploitation of any research results and Joint research programmes often raise the question of shared ownership of IP and the formal basis for establishing a share. TTOs/ Commercial teams can advise academics on these issues but it is often something that they would prefer the lead academics to establish for themselves before any formal disclosure process to notify the institution of the idea and potential for the development
- PoC test that is well structured so that it is a true test of potential with recommendations for next steps and the resources required to put this in place. TTOs use a range of trusted associates and consultants but a number accept that some projects require very niche expertise and sourcing this can be challenging
- IP protection is an important consideration and draws on the expertise of internal commercial teams
- detailed evaluation of project progress and review of market potential and technical proof of concept, review of further work necessary to develop technology and de-risk the project in preparation for commercialisation and seeking investment opportunities

5.3.19. One TTO in a research institute has adopted an initial review of every potential project to jointly determine with the PI the likely translational pathway for their idea. Their research areas are well-defined and the RO has built up long-standing relationships with the small number of multinational commercial organisations in their sector. However, the discussion and mutual agreement with the PI on how their idea will be taken forward to an outcome does not appear to have been adopted elsewhere. Translational pathways are one of the following:

- adopted practice or dissemination of new techniques through to implementation but with a likelihood that this will be made available for free (as there is no effective market for the innovation) but it will be in effect a public good
- policy or regulatory change in science policy, government policy or regulations
- commercial pathway, typically licensing to a commercial organisation or a spin-out
- education and engagement of scientists, particular PhDs, early career researchers (ECRs) and postdoctoral researchers.
- research publication in the academic literature

5.3.20. The point is that the agreement with the PI considers all options and with the available evidence selects the most realistic. This is undoubtedly easier to do in single sector research but it has the attraction that it considers the full translational pathway in the round and not just the next step. Translational projects can evolve and this approach does not fix the destination of any idea but in practice the vast majority develop in the pathway they were expected to.

Timing of registering patents and other IP protection

5.3.21. TTOs stressed the importance of the smaller awards under IAAs (and Pathfinder FoF awards when they were available) in providing the initial steps to research management for ECRs and postdoctoral researchers. This did mean such awards outweigh their financial significance for many.

5.3.22. An unintended consequence of ECRs taking on this research management role, is that they are keen to publish the research findings as promptly as possible (to add to their CV and boost their application for the next research role). In circumstances where exploitable IP exists, this means that there is a pressure to protect that IP (typically through registering a patent) before publication of the research. A number TTOs felt that while this was understandable in the circumstances, it did mean that in a number of cases, the patent was filed too early when the scope of the IP and its application was not fully apparent (something that has been raised by a number of commercial partners).

Adoption of fail fast approaches

5.3.23. All TTOs were asked for their views on the potential to encourage '*fail fast' approaches.* While most recognised the importance of securing robust PoC to clearly establish a 'go/no-go' decision, many felt that obtaining such clarity at a very early stage was unlikely.

> *'We would prefer a clear black and white decision but many are a shade of grey. Sometimes the better looking prospects fail at the next stage and it is possible that the less promising do find a way forward.' [TTO staff]*

5.3.24. Many suggested that if the IAA is well-structured then they are happy to accept the outcomes whether positive or negative – this does not always mean that the academics do so too but the presence of external partners does tend to mean that researchers move on if there is insufficient interest in supporting the next step.

5.3.25. However, there is limited evidence that fail fast principles are routinely designed into the translational pathway for FoF and IAA projects. This would require a more active management of the translational pathway including consideration of the whole translational process at the outset in order to identify key technical stages that might be planned to occur earlier in the pathway (as far as possible) to ensure that any critical challenges are overcome early. Structured approaches to managing the translational pathway (e.g. stage gate processes etc) are more about triage and smoothing innovation demand in circumstances where most TTOs are overstretched.

5.3.26. For their part, PIs fully endorsed the importance of taking on board the consequences of failure of the technology to meet expectations. This is an essential part of the scientific process. However, many PIs felt that technical failure of one approach meant that alternative technical approaches may provide the solution (and so the translational pathway could continue albeit with an alternate pathway). Market or commercial failure was seen as a different matter and both PIs and TTOs report that a negative market report would lead to a more fundamental re-assessment of the translational pathway.

6. CONCLUSIONS AND REFLECTIONS

6.1. Conclusions

Estimates of economic impact of BBSRC translational support

6.1.1. The economic impact of the BBSRC translational support is significant and fully reflects the positive contribution of BBSRC support reported by PIs. BBSRC FoF and IAA translational support have been a success in delivering against the programme objectives. PIs rated the additionality of FoF and IAA highly. On average the additionality of FoF was 72% and IAA 61%. There is evidence that additionality of FoF funding has increased over time.

6.1.2. Translational support more than pays for itself despite this estimate being based only on those cases that could be quantified at the time of the survey[38]. These partial estimates of GVA outweigh the total costs of BBSRC translational support:

- the 105 FoF and IAA sample projects delivered £74 million GVA over their lifetime and £204 million in the 10 year model with a return to BBSRC investment of £2.58 and £7.13 respectively
- grossed up to the translational programme as a whole the GVA estimates are £192 million over the lifetime of projects and £652 million over in the 10 year model delivering a return to BBSRC investment of £2.65 and £9.00 respectively
- in addition to the GVA impacts BBSRC translational projects also attracted significant private investment of £71 million or £2.49 per £1 of BBSRC translational support investment
- the regional distribution of translational projects has been estimated for GSE and the rest of the UK based on the location of the host RO. Total net GVA in GSE was estimated at £104 million compared to £88 million ex GSE for the lifetime model and £447 million GSE and £205 million ex GSE for the 10 year model.

6.1.3. These impact estimates are unfortunately partial. Limited access to the terms of licensing deals which according to Higher Education Business and Community Interaction (HE-BCI) data are considerably larger than commercial outcomes from spin-outs, means that we cannot fully capture the benefits from translational support. The estimates also exclude the potential commercial outcomes in future from FoF and IAA awards that cannot be currently quantified. Furthermore, there has been no attempt to quantify the wider

38 Some 28 (46%) FoF and 11 (25%) IAA awards in our sample could be quantified at the time of the survey and a further 18 FoF projects and 20 IAA projects reported having prospective impacts in future.

benefits arising from the range of health, environmental and policy impacts due to BBSRC translational research support.

Wider non-commercial impacts from BBSRC translational support

6.1.4. PIs from both programmes report a range of health, environmental and policy impacts:

- three-quarters of FoF projects (75%) have realised or have potential for future 'public good' impacts
- almost three-quarters of the 44 IAA projects (73%) have realised or have potential for future 'public good' impacts
- a fifth of FoF and IAA projects have contributed to policy impacts. FoF PIs were more likely than IAA PIs to report policy impacts in the agriculture and animal health sectors through guidance on government committees and membership of industry advisory bodies

6.1.5. The fieldwork programme with PIs, TTOs and other stakeholders have highlighted the importance of BBSRC translational support funding to the innovation process:

Fit with BBSRC translational process

- PIs overwhelmingly welcomed the support available from FoF, particularly the scale of support available from FoF and SuperFoF. Most reported that their focus on FoF and BBSRC IAA funding is primarily due to their research remit
- TTO support was widely praised but some PIs did not feel that they were not given sufficient guidance, with a number feeling that support services were at times too busy to offer greater levels of support. Some felt that access to specific expertise (in specialised commercial knowledge) was lacking and TTOs did not have extensive networks to call on a wider pool of experts
- the harmonisation of IAAs has led to increased communication and learning at RO level but outside of the more formal regional collaboration agreements between ROs, there appears to be limited communications and mutual learning on translational projects. This is particularly apparent in sharing knowledge on 'going rates' for IP licencing agreements and other commercial market intelligence

6.2. Reflections on BBSRC translational funding

6.2.1. Our reflections are focused on the discussions with PIs and their views on where BBSRC translational support might be improved from their perspective:

- the economic impact estimates strongly suggest that BBSRC should continue to support translational research in future:
  - BBSRC translational support generates a range of impacts not all of which can be quantified either because they are confidential, will

occur sometime in the future or will arise through health or environmental benefits that are themselves challenging to quantify. Nevertheless, the estimates of GVA impact from FoF and IAA still generate a positive return over a 10 year period, even when the costs of the underpinning BBSRC research are included in the calculation

- pro-active support could encourage more researchers operating in BBSRC remit to translate the outputs of their research to practical application:
  - a number of ROs have started to introduce TRO teams or at least TTO staff with a TRO remit with a view to reaching out to BBSRC remit researchers to explore their research activities and outline the range of support available for potential research ideas. BBSRC should encourage more ROs to adopt such pro-active approaches and work with ROs to assess their effectiveness
- a continuum of support may help translational projects progress:
  - PIs report a number of interlinked issues that are combining to make the translational pathway more challenging and longer than in the past (i) commercial partners are demanding more evidence (and a higher TRL) to de-risk their investment, (ii) current funding arrangements can mean the process is somewhat episodic with translational research results leading to further funding applications to achieve the required results. Together these combine to limit the adoption of fail fast approaches
  - BBSRC could consider how best to support the translational pathway through a continuum of support, along the lines of MRC DPFS where translational projects are assumed to move to their next stage of funding subject to meeting clear milestone targets
- a fail fast approach may have greater impact on saving translational costs:
  - a greater emphasis on planning for critical "go/ no-go" stages would sit better within this broader funding envelope where the translational pathway can be assessed as a whole at the outset and key stages in the research process can be highlighted with potential options for alternative approaches/ or ceasing the project can be fully discussed
  - the projects with the longest average duration are those which reported potential commercial outcomes that may arise in future that run for almost twice the length of projects that reported commercial outcomes. It is these 'potential impact' projects where a fail fast approach could play a greater role and BBSRC might consider how these projects can be best supported in future
- BBSRC could have a role in disseminating good practice:
  - not all PIs have a full understanding of the respective roles of BBSRC and Innovate UK and how the support available to progress commercial ideas could draw on the latter. This has a very practical impact in translational research when commercial partners are keen to see the public sector de-risk their investment
  - while practice is developing at RO level it is not clear that this is being shared more widely. Key elements of the process including access to expert mentors etc, key contacts for commercial partner searches and licencing terms are areas that would strengthen the

negotiation strategies of individual TTOs in securing the best deal available for the IP generated by BBSRC research

ANNEX A TRANSLATIONAL SUPPORT THEORY OF CHANGE

Introduction

This section sets out the expected causal process by which the BBSRC's translational research portfolio will deliver its intended results. We have identified three primary benefit streams through which the impacts of the translational support from each programme may be traced:

- firstly, commercial pathways where translational support ultimately leads to one of a number of potential commercial outcomes – a spin-out, licencing or other commercial partnership arrangements
- secondly, strengthening partnership working with commercial and academic partners to improve the range and depth of collaboration around future research activities which may not necessarily lead to commercial outcomes in the short to medium term
- thirdly, increasing the profile and reputation of the ROs in the quality of their advice and support through formal and informal networking with the wider translational ecosystem – building relationships with venture capital organisations and others to better understand the scope and scale of market opportunities

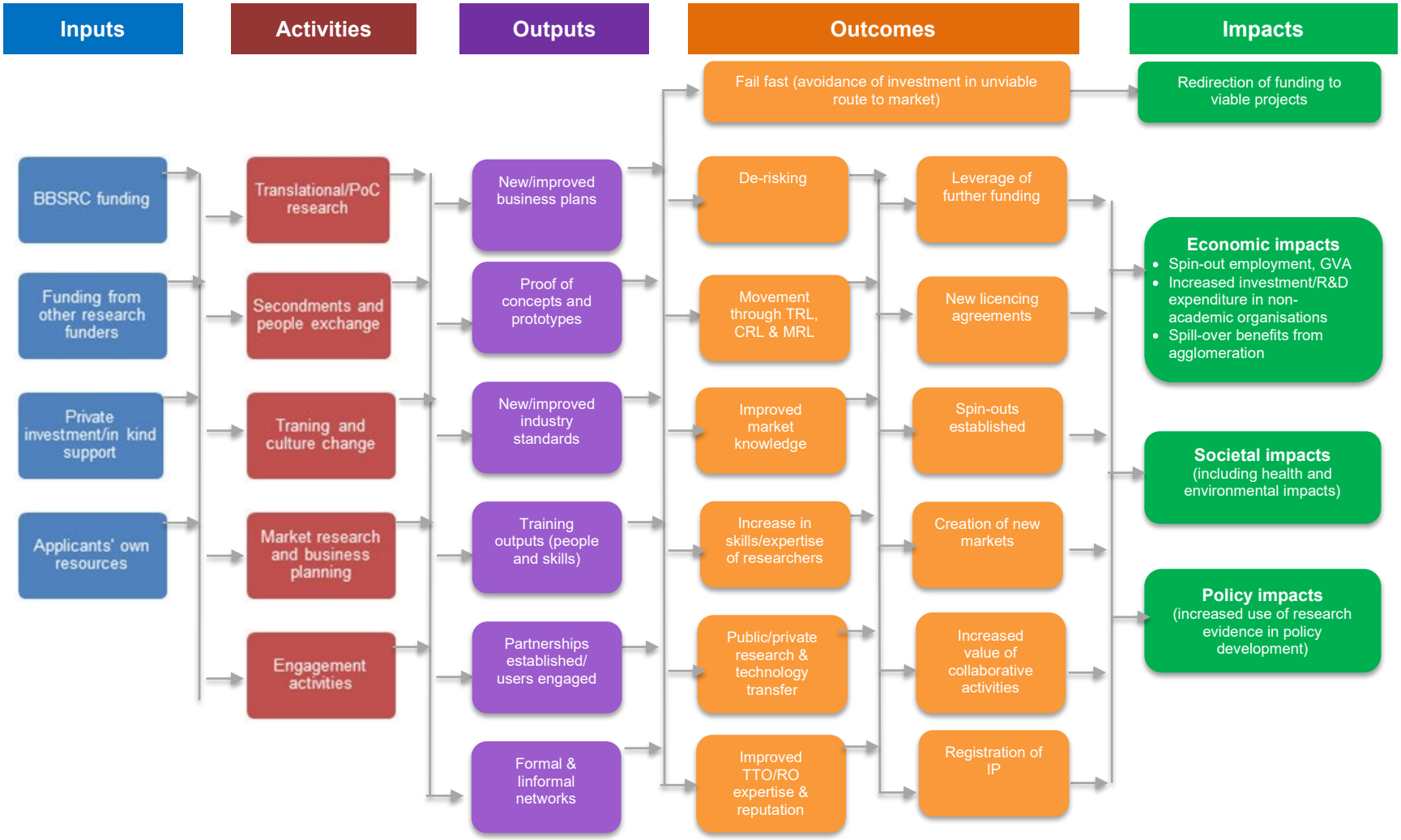
The overall evaluation logic model is set out in Figure A.1 and following sections set out the core inputs, activities, outputs, outcomes and impacts in more detail.

Inputs

Projects within the BBSRC's translational research portfolio may draw on a wide variety of inputs:

- *BBSRC funding*: Translational research projects will draw on BBSRC funds to progress the programme of activity
- *funding from other research funders*: In addition to BBSRC funding, projects may receive funding from other public or charitable research funding organisations (e.g. Other UKRI Councils, Wellcome Trust, Leverhulme Trust, European Research Council)
- *private investment and in-kind support*: Projects may receive funding from private investors to support the development of specific products, methodology, best practice or underlying infrastructure
- *applicants' own resources*: Researchers may also draw on resources from their own organisation to support the delivery of a project, including financial, technological, infrastructure and human resources, as well as knowledge. Academic research teams are likely to draw on the resources of their TTO, and where applicable, the TRO, to support project management, collaboration with industrial partners, understanding of regulatory pathways, or commercialisation

Figure A.1: Evaluation Logic Model



Activities

Activities which fall within the remit of FoF or IAA or both comprise:

Activities	
Translational/ Proof of Concept (PoC) Research	Investing in projects which would not be supported elsewhere, including higher-risk proposals; support knowledge exchange and commercialisation at early stages of progressing research outputs and outcomes to the point when they would be supported by other funding. Although this is core to FoF, IAAs can also support smaller scale translational/PoC research projects. For example, in the first cohort of IAAs, these represented a significant proportion of the spend.
Secondments and people exchange	Supporting activities that enable impact to be achieved in an effective and timely manner, including secondments and people exchange.
Training and culture change	Strengthening the exchange of knowledge through culture and capability development, including through the development of skills for knowledge exchange activity.
Market research and business planning	Conducting activities essential to preparing a robust business plan and to secure, where appropriate, further funding and support to progress the innovation; collaborative agreements put in place to enable all parties to better understand their roles on the grant and to clarify the IP rights (IPR) position. This is appropriate both to IAA and FoF (this activity was a particular focus for Pathfinder FoF awards). All FoF applicants are expected to have robust ideas of the market opportunity as part of their application. There is an expectation that they will continue to develop their understanding of the business opportunity as the technical development progresses.
Engagement activities	Supporting the uptake of research by users through translational, knowledge exchange and commercialisation activities is an important activity that is supported by the FoF. The nature and scale of the engagement will differ between FoF and IAA – with IAA likely to support earlier stage engagement.

Outputs

There are a range of output measures which will be derived from the activities. It is in the nature of the translational support that these will not be exclusive as different combinations of activities will potentially lead to a combination of outputs:

Outputs	
Translational/ PoC Research	New / improved business plans and improved understanding of market opportunities New / improved industry standards are shaped
Training outputs	People and skills
Partnerships established or extended	Research outputs involving non-academic partners Secondment and placement opportunities for research staff Collaborative projects with industry
Formal & informal networks established	Engagement with key stakeholders, customers, enablers and users Increased networking activities with VC and wider tech support ecosystem – strategic events, workshops, joint publicity and marketing activities

The interview programme and case studies are designed to draw out the relationships between these measures in the context of each support example and in this way the evaluation will build up a picture of how different activities, outputs combine with different outcomes.

Outcomes

Outcomes are important in describing the mechanism through which the evaluation will be able to assess the impact of translational support on GVA. Not all the benefit streams will lead to a GVA impact but help set out the wider benefits arising from translational support in terms of the impact on the quality and diversity of research partnerships and, formal and informal networking between stakeholders improving the flow of knowledge and the potential for spill-over benefits and the reputation of the ROs:

Outcomes	
De-risking of novel technologies	Innovation leads to new processes, products and services in bioscience, which are de-risked, and brought to market (domestic and global)
TRL progression	Movement through Technology Readiness Levels, Commercial Readiness Levels and Manufacturing Readiness Levels
Improved market knowledge	Providing evidence of a route to market and identifying clear actions to progress it
Increase in expertise	Upskilling of trained people leading to an increase in expertise in UK bioscience sector and more broadly
Academic & commercial further research & technology transfer	Increased public-private (non-academic) sector partnerships and an increase in knowledge and technology transfer Diffusion and adoption of R&D into other sectors and places, through collaboration and problem solving with industry, leading to spill overs
Improved knowledge on support and market issues	Increase in capacity to support the commercialisation of research through funding, brokering and knowledge sharing Lessons from the structure and management of TTOs in ensuring more research outputs are brought forward to explore potential commercial pathways Speed and flexibility of support including the capacity and support to acknowledge and learn from “fail fast” approaches
Leverage of further funding	Improved operational finance with increased access to private investment and leverage of overall R&D funding Increasing number of successful applications to funds supporting further collaborative activities (e.g. Innovate UK, KTP etc). Diversified range of research investors
Licensing	Licensing agreements with commercial partners
Spin-outs	Spin-out companies or social enterprises established
Creation of new markets	Improved technical standards leading to the creation of new markets
Collaboration	Increased value of collaborative activities Increase in collaborative R&D leads to new technologies
Intellectual Property (IP)/ Patents or other protection of intellectual assets	Role in ensuring more inventions can be patented or move forward in their commercial pathway through other IP protection routes. Patents are more focussed towards pharmaceuticals or some elements of engineering, with Copyright for Informatics and Plant Breeders Rights in the agricultural section. Several sectors do also not have formal IPR, e.g. animal vaccines or food innovation or processing.
Fail fast	Providing early evidence that there is not a viable product or a route to market based on the current project and thereby avoiding further investment.

Impacts

There are a narrower set of impacts with most of the commercial pathway benefit stream linking to GVA and wider economic impacts. However, there may be additional impacts arising from improved knowledge networks developed as part of the experience of delivering translational support and increased contact with wider stakeholders such as venture capital companies, other commercial partners and funders and market research organisations. Previous research on BBSRC spin-outs has highlighted the importance of both PIs and TTOs/ ROs to engage with wider formal and informal networks to increase access to knowledge and support:

Impacts	
Economic impacts	UK bioscience businesses achieve productivity improvements, increases in employment and increases in GVA through adoption of new knowledge, new tools, and new technology
	UK bioscience businesses achieve export growth and increased market share
	Increase in number and size of bioscience companies with high-value jobs across the UK regions
	Re-investment of translational funds "saved" when commercial pathways have ceased because of proof of concept failure or other evidence that pathways to market are not viable
	Increase in R&D expenditure of non-academic partners
	Spill-over benefits arising from agglomeration and improved local networks and knowledge
Societal impacts	Environmental, health and other societal benefits in agri-food, manufacturing, biotechnology, bioprocessing and environmental sectors.
Policy impacts	Findings and discoveries from clinical trials are incorporated into clinical guidelines, or otherwise accepted as good medical practice
	Research findings help to inform the decision-making process and policy development and implementation

Additionality assessment

FoF and IAA are likely to be an important source of translational support but there are a range of similar support schemes that are available to those considering exploitation of research results. The evaluation will need to set FoF/IAA investment in the context of these other schemes. The surveys have attempted to catalogue other support and determined whether this made a (further) material impact on the process and obtain PI/ stakeholder judgement of the scale and scope of change to the translational process brought about by FoF or IAA support in the following terms:

- full additionality where the commercial pathway would not have proceeded at all in the absence of FoF/IAA funding
- partial additionality where the FoF/IAA contribution led to an increase in the scale and quality of the commercial pathway
- partial additionality where the FoF/IAA contribution brought forward the commercial pathway in time leading to impacts occurring quicker than would have been the case otherwise
- our experience suggests that individual respondents find it challenging to specify a specific value to additionality, so we have successfully used additionality bands in the past to rate the scale of additionality – e.g. 0 to 25%/ 26 to 50%/ 51 to 75%/ 76 to 100% based on respondents' perceptions of what would have happened in the absence of BBSRC translational support
- finally, it has been important for the interviews to draw out the relationship of the additionality of FoF/IAA support to the scale and significance of the impact

ANNEX B SAMPLING STRATEGY

Introduction

The fieldwork plan was to undertake telephone/ video interviews with a structured sample of FoF and IAA beneficiaries selected according to a number of criteria:

- a range of project sizes, but with an oversample of larger awards with start dates between 2004 and 2021
- a range of translational support types (e.g. venture creation, employment, licensing, defining policy and practice) (IAA only as this cannot be identified in FoF)
- a range of locations to ensure a spread of geographic locations
- cover the distinct design models (Standard and SuperFoF awards) so we are able to assess any impact from different stages of their evolution. There will need to be a balance of activity across the period of the evaluation
- include researchers that may have benefited from both FoF and IAA support

FoF sampling framework

The research plan was to undertake a total of 60 interviews with FoF award holders, 30 from the FoF awards, 10 from the Pathfinder programme and 20 from the SuperFoF awards. Interviews with award holders have covered all awards associated with the commercial pathway for the particular research output. A total of 61 interviews were completed with FoF award holders and 44 with IAA award holders.

Je-S data (Table B.1) shows that since 2004, 322 awards have been made through FoF with a total value of £46.0 million. Of these 322 awards, 50 were for the SuperFoF, 153 for the FoF and 119 for the FoF Pathfinder.

Table B.1 FoF Sampling and Interviews

Start Dates	FoF-Path	FoF	SuperFoF	Total	Sample
Population	119	153	50	322	
Sample	10	30	20		60
Interviews	**21**	**43**	**19**		**61**

Source: BBSRC monitoring data. N.B this data was an early run of Je-S data and further investigation identified more recent FoF awards but this data was used to structure the survey sample.

Because the majority of FoF award holders secured multiple FoF awards, each PI was interviewed about the 'package' of awards that contributed to a single translational project pathway. A total of 21 interviews were completed with Pathfinder FoF award holders (compared to a target of 10); 43 interviews with FoF award holders (compared to a target of 30); and 19 interviews with SuperFoF award holders (compared to a target of 20).

Table B.2 details the region of the FoF award holder's institution at the time of award. We tried to obtain a coverage across institutions and regions. There was a slight over-sample of award holders in the Greater South East and an under-sample in the West Midlands. This was largely linked to difficulties engaging PIs in the latter as proportionately more had retired or moved on.

Table B.2 Region of FoF award holder

Region	Interviews	%	Population	%
East Midlands	5	8%	20	6%
East of England	11	18%	68	21%
London	6	10%	37	11%
North East	2	3%	15	5%
Northern Ireland	1	2%	1	0%
North West	3	5%	30	9%
Scotland	7	11%	43	13%
South East	16	26%	45	14%
South West	2	3%	14	4%
Wales	2	3%	10	3%
West Midlands	2	3%	43	13%
Yorkshire & Humberside	4	7%	22	7%
Total	61	100%	322	100%

Source: BBSRC Monitoring Data & CPC interviews

IAA Sampling framework

Full details on the earlier phases of the IAA awards were not available and so the sample frame was based on monitoring returns relating to the 2018/19 to 2021/22 IAA funding round. Table B.3 details the number of IAA awards and associated funding by institution for this funding round. The sample frame aims to ensure interviews were distributed across institutions in line with IAA funding and award numbers.

Table B.3: IAAs by institution

Institution	Interviews	%	N° of awards	%	IAA Funding	%
Imperial	1	2%	15	4%	£434,024	6%
Cambridge	2	5%	26	7%	£441,446	7%
Birmingham	1	2%	16	4%	£387,564	6%
Edinburgh	5	11%	42	11%	£803,118	12%
Glasgow	4	9%	24	6%	£523,783	8%
Liverpool	3	7%	28	7%	£392,540	6%
Manchester	1	2%	26	7%	£390,271	6%
Nottingham	5	11%	35	9%	£619,454	9%
Oxford	4	9%	21	6%	£461,273	7%
Pirbright	2	5%	32	9%	£468,369	7%
Quadram	5	11%	40	11%	£401,257	6%
Sheffield	2	5%	19	5%	£443,275	7%
Warwick	2	5%	19	5%	£469,716	7%
York	7	16%	31	8%	£495,882	7%
	44	**100%**	**374**	**100%**	**£6,731,972**	**100%**

Source: BBSRC Monitoring Data & CPC interviews N.B. A subsequent data cleaning exercise reduced the number of IAA awards to 364, but the above data were used to structure the sample.

Table B.4 details the distribution of IAA projects according to a sectoral classification of the commercial opportunity. This classification has been undertaken by BBSRC and it should be noted that some projects may fit into multiple categories. Where this was the

case, the primary sector was identified. Again, the fieldwork aimed to ensure coverage across these sectors.

Table B.4: Sector of IAA commercial opportunity

	Interviews	%	Population	%
Agriculture/aquaculture	9	20%	63	17%
Animal health	8	18%	46	12%
Biotechnology	14	32%	53	14%
Food and Drink	3	7%	16	4%
Health	10	23%	147	39%
Interdisciplinary	0	0%	31	8%
Waste	0	0%	7	2%
Other	0	0%	11	3%
Total	**44**	**100%**	**374**	**100%**

Source: BBSRC data from RO monitoring returns & CPC interviews. N.B. A subsequent data cleaning exercise reduced the number of IAA awards to 364, but the above data were used to structure the sample.

Online surveys of FoF and IAA award holders

The original plan was to undertake two online surveys of FoF award holders and IAA projects who are *not* included in the in-depth survey focusing on:

- rationale for applying for translational support and options available at the time for other forms of support
- time and resources required to secure funding
- how successful the support was for their commercialisation process and their views on the relative contribution from BBSRC translation support
- what, if any, other support was involved in this process are the changes above solely due to BBSRC translational support?
- what gaps exist in translational support and where should BBSRC consider are investment priorities in future?
- evidence of improvement in BBSRC translational support capacity

Discussions with BBSRC revealed that it would not be feasible to survey IAA projects without a considerable administrative effort because award holder details are held by the institution rather than centrally. It was therefore decided to focus these resources on the telephone/video surveys and the FoF online survey.

The FoF online survey was circulated to 140 FoF award holders who had not participated in the online survey.

The FoF online survey was circulated to 140 FoF award holders who had not participated in the online survey. A total of 56 responses were collected online but five of these were very partial and have been excluded from the analysis. This gives an effective response rate of 37%. This is around average for a group of more 'engaged' target sample.

The selection of face-to-face interview sample was biased to older and larger awards (SuperFoF and FoF) with Pathfinders more often one of a series of awards (i.e. in combination with FoF/ SuperFoF sequence). In contrast, the online survey has proportionately more Pathfinder projects, a similar proportion of FoF standard awards but fewer SuperFoF awards.

Table B.5: FoF online survey responses

	Response	%	Online Population	Face-to-face survey
Pathfinder FoF	33	65%	44%	26%
FoF	22	43%	47%	53%
SuperFoF	8	16%	10%	21%
	63			

Source: CPC online survey of FoF recipients

There are fewer multiple FoF awards among the online responses with 79% with just one award. Only eleven researchers had more than one FoF award – just two have been awarded a Pathfinder, FoF and SuperFoF. Six researchers were awarded a Pathfinder and FoF award, one Pathfinder and SuperFoF and two FoF and SuperFoF combinations (a total of 18%). Just two have three awards (4%).

This is similar to the proportions for the online sample population with 84% with a single award, 13% with two and 3% with three or more.

ANNEX C BBSRC TRANSLATIONAL PROJECT CASE STUDIES

Rothamsted Research: Solving the world food crisis by developing technology to significantly increase wheat yields

BB/R019606/1 SUPER Follow on Fund, Spraying for Yield

Project Background

Crop yields must double in the next 35 years to meet projected global food demand. However, annual yield improvements of major crops are increasing below the rate required. To address this issue, Dr Matthew Paul from Rothamsted Research – in collaboration with Oxford University – received BBSRC funding in 2006, followed by smaller grants from industry and Rothamsted, to explore how wheat yields could be increased under controlled conditions. The research developed synthetic precursors of the sugar trehalose 6-phosphate (T6P) to modify how sucrose is used by plants and demonstrated that the more T6P that was available to wheat grains as they grow, the greater the yield. The T6P 'precursor' was added to a solution and then sprayed onto the plants, which resulted in more sucrose being drawn into the grain to make starch. In laboratory conditions, this approach resulted in an increase in wheat grain size and yield of up to 20%. This work resulted in three patents, was published in December 2016, and attracted significant attention from the agricultural and biotech communities.

The SUPER Follow on Fund

In May 2018, Dr Paul received a SUPER Follow on Fund grant of £367,885 to support translation of this fundamental research into commercialisation. Building on the previous research, which demonstrated the efficacy of the technology in glasshouse conditions, the FoF-funded project, 'Spraying for Yield', aimed to further demonstrate its effectiveness in field environments and develop the methodology for scale up synthesis of T6P precursor suitable for large-scale application. Field trials took place in Australia (working with a university to test the technology in dry conditions) and Argentina (working with a research institute to test the technology in conditions that were representative of global agricultural environments). The results exceeded expectations showing that, even in field, the T6P spray increased wheat yields by up to 20%, establishing 'without doubt' the value of the technology for addressing increasing food insecurity across the globe as well as contributing to net zero objectives through reduced fertiliser use.

Translational Impact

In 2018, Rothamsted Research and the University of Oxford worked closely together to create the spinout company, SugaROx. Headquartered in Hertfordshire and currently employing five full-time members of staff, SugaROx was formed to take forward the T6P biostimulant technology and investigate its application in other cereal and horticultural crops, helping farmers to 'optimise productivity from every unit of agricultural land and improve the resilience of crop systems amidst adverse weather conditions such as drought.' The company has an exclusive worldwide licence to the technology. In February 2023, SugaROx raised £1.4 million in Seed Round funding, including £850,000 from Regenerate Ventures and the UK Innovation & Science Seed Fund (UKI2S). The investment will enable the company to accelerate field testing, prepare to launch registration in major markets and obtain proof-of-concept on additional crops. Dr Paul attributes the creation of SugaROx to a series of grants, mainly from BBSRC and particularly the FoF project which enabled yield improvement in field conditions to be demonstrated. The data generated from the project also strengthened the company's negotiating position when seeking investor funding.

University of Portsmouth: Developing new RNA technology to 'drug the undruggable' and find solutions for unmet medical needs

BB/I532988/1, Follow on Fund, RNA array technology

BB/S004947/1, Follow on Fund, Unlocking high-throughput analysis within the RNA epigenetics domain

Project Background

Analysing the manner in which ribonucleic acids (RNAs) interact with other molecules is fundamental to novel drug discovery. Over 100,000 RNAs have now been identified in the body and it is recognised that targeting RNAs with drugs has the potential to treat both viral and bacterial infections, as well as offering new hope across a rapidly increasing range of diseases, including cancer, cardiac dysfunction, diabetes and neurodegenerative disorders.

While RNA-targeting drugs are at the leading edge of pharmaceutical innovation, the extent to which they can play a key role in reducing disease is dependent on increasing RNA-interaction knowledge at pace. In 2008, Professor Callaghan received a BBSRC New Investigator grant, working with PhD student, Charlotte Henderson, to look at new ways to study RNA-interactions. Importantly, they developed an innovative technology for studying these in high-throughput, thereby providing a capability to accelerate collection of RNA-interaction information.

The Follow-on Fund

To test if the technology would be applicable in a commercial setting, market research was undertaken as part of a BBSRC Pathfinder FoF grant (£10,000; 2011). The positive feedback led to Professor Callaghan securing her first BBSRC Follow-on Fund grant (£153,000; 2011). This enabled proof of concept demonstration of the technology, and resulted in a patent application, which has now been granted in Europe and the US.

Following further research funding through BBSRC's Tools and Resources Development Fund scheme (£150,602; 2014), and a responsive mode award (£335,977; 2016), additional developments and demonstrations of the technology were made. These ultimately led to a second Follow-on Fund award (£202,000; 2019), enabling collaboration with RNA drug discovery experts, Storm Therapeutics, to provide exemplification of the technology for applications in the RNA epigenetics domain.

With Dr Henderson (who worked as the postdoctoral researcher on the Pathfinder, FoF and responsive mode funded projects), towards the end of the second Follow-on Fund project, she embarked on the Innovate UK 'Innovation-to-Commercialisation of University Research' (ICURe) programme (£35,000; 2020). This enabled refinement and validation of the commercial potential of the technology. In scoping commercial opportunities, conversations, presentations and pitches were made to around 80 pharma and biotech industry companies. This provided insights and guidance as to the most appropriate route for commercialisation of the technology and its applications, and provided evidence that the spinout route had the potential to leverage the most impact.

Taking the next step to commercialise the technology, Dr Henderson secured a BBSRC-funded Royal Society of Edinburgh Enterprise Fellowship (£100,000; 2021), enabling her to build her entrepreneurial skills and scope a solid and robust business plan for forming the spinout company, RevoNA Bio Ltd.

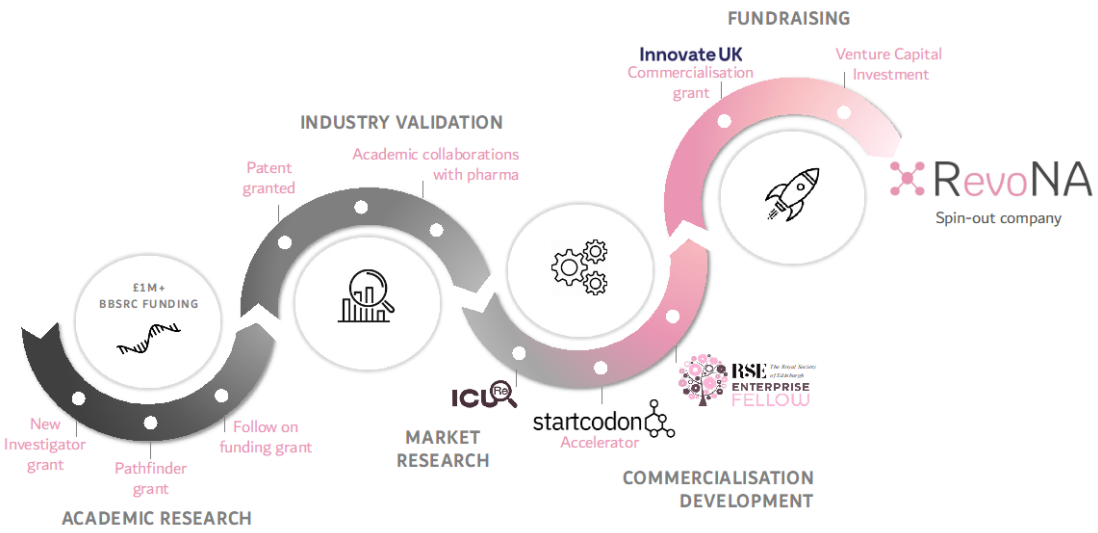
Translational Impact

RevoNA Bio was incorporated in 2022 and is the University of Portsmouth's first spinout. The company has to-date leveraged pre-seed funding from VC investors including

Cambridge-based venture builder and investor fund Start Codon, UKI2S, Possible Ventures and Discovery Park, as well as two Innovate UK grants. The success of RevoNA Bio's commercialisation journey was recognised in BBSRC's Impact Showcase 2022 (https://www.discover.ukri.org/bbsrc-impact-showcase-2022/).

Today, RevoNA Bio has a handful of key employees, with Dr Henderson as its full-time CEO. Through internal projects and strategic partnerships, RevoNA Bio is amassing proprietary, high-quality, RNA-interaction datasets to create a best-in-class prediction engine that will enable in silico RNA drug discovery affordably at scale.

BBSRC support was vital to the establishment of RevoNA Bio. Dr Henderson claims that it was "the breadth of BBSRC funding, spanning discovery research through to translational development and commercial activities, aligned with UKRI's Innovate UK ICURe grant that allowed [her] to be responsive to today's faced-paced global business environment and respond to the commercial opportunities in the growing nucleic acid biotech space." Prof. Callaghan similarly reflects that "if we hadn't had BBSRC Follow-on Funding, which enabled us to explore research translation, then we wouldn't be where we are today!"



University of Aberdeen: Developing humanised shark proteins as oncology and autoimmune therapeutics

BB/K010905/1 SUPER Follow on Fund, To benchmark the utility of E06: A half-life extension, single-domain, shark antibody bio-tool, and progress it to a Phase 1 ready candidate clone

Project Background

Professor Andrew Porter is a professor of Medical Biotechnology and Director of the Scottish Biologics Facility (SBF) at the University of Aberdeen. The SBF works with academics and companies across the world to develop antibodies and other binding proteins specific for a range of diagnostic and therapeutic targets.

In 2000, a BBSRC PhD studentship led to the discovery of antibody-like molecules called 'variable new antigen receptors' (VNARs). VNARs make up the binding sites of antibody-like molecules found in sharks and form an integral part of their immune system. Whilst evolutionarily derived from a different cell type, they play a similar role to antibodies found in humans, protecting sharks against infection and disease. However, these VNAR binding sites are much smaller than those found on mammalian antibodies, making them ideal for targeting hard-to-reach and treat areas in the body, such as solid tumours.

The University patented the VNAR technology and, in 2002, created the spinout company, Haptogen, which was granted a licence in 2006. Haptogen was bought by US pharmaceutical company, Wyeth, in 2007, which was then acquired by Pfizer in 2009. But when Pfizer exited much of its early-stage R&D effort from the UK in 2011, the 'shark' intellectual property was returned to the University of Aberdeen. In 2013, Professor Porter, together with Dr Caroline Barelle (now CEO of Elasmogen), was awarded a Super Follow-on Fund grant to further develop and commercialise this shark domain platform technology, which led to the creation of spinout company, Elasmogen Ltd in 2016.

The Follow-on Fund

When the IP was returned to the University, further development was needed to take VNARs from the laboratory towards clinic-ready assets. Specifically, the next step in their development, and the subject of the Super Follow-on Fund project ('To benchmark the utility of E06: A half-life extension, single-domain, shark antibody bio-tool, and progress it to a Phase 1 ready candidate clone', £435,000), was to take a shark protein and humanise it so that it would not be immunogenic if used as a protein drug in humans. The project focused on validating the most advanced of the shark domain products, 'E06'. The E06 bio-tool could be fused to a range of different therapeutic proteins/peptides to extend their serum half-life from hours to weeks, with the potential of greatly increasing their therapeutic potency. Through immunogenicity tests, the project provided proof of concept that E06 could be humanised and would not be 'seen' by the immune system. The humanised versions of these VNARs were termed 'soloMER®s' and the soloMER® version of E06 was termed 'NDure®'. When humanisation outcomes were compared with other highly efficacious and commercially valuable protein drugs, the team found that they had achieved a level that was the same or better than these comparator molecules. The NDure® patent was filed in 2014 and now includes the original filing plus three additional divisionals, all granted in the US. This comprehensive patent position means that others are unable to use the NDure® sequence, humanise this protein class, and use various antibody like formats and/or conjugate warheads to VNAR or soloMER targeted modalities without a licence.

During the project, Professor Porter and Dr Barelle also made contact with 20 top pharmaceutical companies to gauge their level of interest along with venture capitalists to confirm what would be required for the technology to become a viable investment proposition.

Translational Impact

A key medium-term goal of the SuperFoF project was to create a drug discovery company, based on the VNAR platform, which would develop therapeutic agents in-house or in partnership with larger companies. Following the success of the project, Dr Barelle received a Royal Society of Edinburgh/BBSRC Enterprise Fellowship along with a BBSRC Sparking Impact award to aid the creation of the spinout company, Elasmogen. The spinout was launched in 2016, with a £650,000 convertible loan from Scottish Enterprise and with Dr Barelle as CEO. The NDure® IP was licenced to the company and protected its position in the US – the company's most important market. Additional patents were also filed and exclusively licenced to the new company.

Elasmogen is now a therapeutic biologics company that is rapidly progressing a pipeline of next-generation, differentiated soloMER® products for the treatment of solid tumour cancers and auto-immune inflammatory diseases. Elasmogen has established several collaborations with major pharmaceutical companies, where soloMER®s are being used to target potent drug warheads for the treatment of aggressive and life-shortening diseases. Elasmogen's lead programme, partnered with Almac Discovery, is using the NDure® domain and other IgG based formats to develop a novel anti-cancer medicine targeting ROR1 in solid tumour cancers.

Since its launch, the company has received over £13 million of private equity investment (through pre-seed, seed and Series A funding rounds) along with several million pounds in grant funding (predominantly from Innovate UK) and currently employs 13 people in the UK. While primarily an R&D drug discovery company, Elasmogen has also generated revenue, including through a licence agreement to its proprietary NDure® technology and research agreements with US and Japanese bio-pharma companies.

Professor Porter commented: "There is absolutely no doubt in my mind that without the Super-Follow-On funding, Elasmogen Ltd would not have been spun-out successfully. This grant allowed us to de-risk the opportunity by providing an answer to a key question we were constantly being asked: 'How can you use a fish protein as a therapeutic in man?'. We were able to show that humanisation without loss of function was possible, including retaining all the funky things VNARs/soloMER®s could do, that antibodies could not. The IP from this research still underpins much of our efforts today. The SuperFoF funding and the BBSRC Enterprise Fellowship funding also allowed us the time required to get Elasmogen properly investor ready and therefore maximise our chance of securing the equity investment we needed."

University of Liverpool: Revolutionary liver fluke testing and treatment for sheep and cattle

BB/R013349/1 Follow on Fund Pathfinder & BB/T016981/1 Follow on Fund - Development of a pen-side diagnostic test for Fasciola hepatica

Impact Acceleration Account - International guidelines for evaluating efficacy of flukicidal medicines') to undertake meta-analysis of flukicidal drug use in the field to inform best-practice in detecting drug failure.

Project Background

Professor Diana Williams is a veterinary parasitologist with interest in controlling parasitic diseases in sheep and cattle. Her major research area is on improving the control of Fasciola hepatica (liver fluke) in sheep and cattle through improved diagnostics, reducing transmission and more targeted use of flukicide drugs. Liver fluke is a common parasite that affects sheep and cattle. Fluke-infected animals lose weight, become anaemic, lethargic and stop being productive. This has a serious effect on the welfare of the animal and substantial economic consequences for the farmer. It is estimated that fluke costs UK agriculture at least £300 million pounds a year through direct losses, although real costs may be much higher. In recent years, fluke has become much more common in the UK, due in part to changing weather patterns, wet summers and mild winters, which favour the development of the parasite and its vector (a mud snail, found commonly throughout Britain). Climate change is predicted to have a significant impact on prevalence of infection. A limited range of drugs is available to control fasciolosis with just one drug, triclabendazole (TCBZ), effective against early and late stages of the parasite. However, because of the lack of cost-effective diagnostic tests, groups of animals are blanket treated, which puts selection pressure on parasite populations to develop resistance. Resistance to drugs effective against liver fluke is becoming widespread, and there is a need for more targeted use of drugs to slow the development of resistance. To do this, better understanding of the epidemiology and transmission of disease is vital to develop control programmes that rely on improved on farm management practises.

In 2014, Professor Williams led a project, specifically requested by the farming industry and funded by a £436,000 BBSRC Industrial Partnership Award, to produce new, sustainable, bespoke control programmes for beef and dairy farms to reduce losses associated with fluke infection, including developing diagnostic tests to identify infected herds. Alongside this, the Agriculture and Horticulture Development Board (AHDB) funded a PhD project to develop a pen-side diagnostic test for fluke infection in sheep and cattle. The work found that it was possible to adapt lab-based diagnostic methods for disease to one based on a lateral flow test (LFT).

Follow on Fund

In 2018, Professor Williams was awarded a £19,000 Pathfinder FoF grant ('Development of a pen-side diagnostic test for Fasciola hepatica') to develop preliminary prototype pen-side Fasciola hepatica LF kits. This involved working with rapid diagnostics company, Mologic Ltd, the creator of the Clearblue pregnancy test, to establish that this test would work with whole blood. The University of Liverpool made the LF antigen and sent this to Mologic to create the LF kits. The University also conducted some online market research, in the form of an online questionnaire, to determine interest in the tests from farmers and veterinarians. The results of the project were presented to a range of farmer organisations, including Beef Expo June 2018, AHDB Beef and Lamb webinar and to farmers' groups, and industry expressed significant interest in the test.

In 2020, Professor Williams was awarded a £202,000 Follow on Fund grant ('Development of a penside diagnostic test for Fasciola hepatica') to produce an on-farm validated pen-side LF test for liver fluke – again working with Mologic to carry out further

design and construction. The ultimate aim would be for the LF test to be taken up by a company for commercial development and production. The University approached a small number of veterinary pharmaceutical companies and provided a solid contact to pitch the idea.

Impact Acceleration Account

Related to this project, Professor Williams received a £14,000 BBSRC IAA award in 2020 ('International guidelines for evaluating efficacy of flukicidal medicines') to undertake meta-analysis of flukicidal drug use in the field to inform best-practice in detecting drug failure. This led to updated guidelines on therapeutic control of liver fluke being published and reviewed by the World Association for the Advancement of Veterinary Parasitology for use as the industry standard, and helped to inform the need for a diagnostic test.

Translational Impact

In February 2022, Professor Williams received a £35,000 three-month AHDB Catalyst Award to work in-field and provide farmers with an opportunity to try the LFT. Follow-up meetings were undertaken with farmers to obtain feedback and provide information on necessary modifications. Professor Williams then secured a collaboration with a veterinary pharmaceutical company, with a grant of £100,000, to incorporate the modifications and develop the LFT to design freeze/full prototype stage. Following further on-farm validation, the University hopes to move to commercial manufacture and to licence the product to the company by the end of this year. The LFT will have a significant impact on the ability to diagnose and treat sheep and cattle for liver fluke infection by targeting treatment specifically at infected animals, with significant economic benefits for farmers and processors as well as improved animal health and welfare. Reduced use of anthelmintic medicines will also positively impact on development of resistance along with environmental consequences of anthelmintic use.

Professor Williams claims that being involved in FoF projects has enabled her to expand her skillset, from academic research to areas such as design, tooling and instructions for use as well as learn about ways of working with business and their requirements for investment. Following the success of the liver fluke LFT, Professor Williams was encouraged to expand her translational skills to other areas and was awarded a further £600,000 from the BBSRC Emerging Livestock Diseases call in June 2023, with a 10% contribution from the same veterinary pharmaceutical company, to develop similar tests for the sustainable control of other parasitic diseases in sheep and cattle, such as bovine lungworm.

University of Bristol: Pioneering portable biosampling

BB/M005089/1 Follow on Fund & BB/M019268/1 Follow on Fund Pathfinder Ambulatory microdialysis sampling system

BB/T004177/1 SUPER Follow on Fund Development and integration of a cortisol sensor with real-time read-out to an ambulatory microdialysis sampling system

Project Background

Monitoring fluctuating levels of body-chemistry is crucial for the assessment of biological rhythms. Rhythms are intrinsic to endocrine and metabolic systems, and disruption of these hormone oscillations occurs at very early stages of endocrine disorders, such as Addison's disease and Cushing's disease. Traditionally performed in a clinical setting, where multiple samples are collected throughout the day, this type of monitoring takes individuals away from their day-to-day activities, and does not represent their real-life data. If blood sampling is attempted overnight, this also necessitates admission to a clinical research unit, which can be stressful and disturbs sleep. Through BBSRC-funded research, Professor Stafford Lightman has developed automated sampling systems for monitoring hormone levels in the blood of both rodents and humans, and has been able to build a novel wearable device for human use. The device, which is worn around the waist and collects samples through microdialysis (a tiny catheter inserted under the abdominal skin) enables the minimally invasive automated collection of regular samples from a subject 24 hours a day, as they go about their everyday life and during undisturbed sleep. For the first time, the device enables the detailed study of clinical and biological analytes known to vary over the day, offers great sensitivity, reliable diagnosis and therapy monitoring, and removes the need for costly clinical investigation unit testing. The device, known as 'U-RHYTHM' is protected by a UK patent ('Fluid Sampling Apparatus and Method'), which was filed in September 2012 and has since been granted in the UK, Europe and US.

Follow on Fund

In 2014, Professor Lightman was awarded an £11,000 Pathfinder FoF grant ('Ambulatory microdialysis sampling system), which enabled him and an electronics engineer to make the first proof of principle device, confirming the feasibility of collecting individual samples at multiple times over 24 hours. However, work to manufacture the device was time consuming and there was a need to enable production at scale to move towards commercialisation.

In 2015, Professor Lightman received Follow-on Funding ('Ambulatory microdialysis sampling system', £179,000) to provide commercial proof of principle for the 'U-RHYTHM' device, by developing a pre-production prototype of the device that was more user-friendly, flexible enough to be used in a range of research scenarios, and robust enough to be used on large animals as well as humans. Professor Lightman worked with creative product design consultancy, Designworks Windsor, who redesigned and developed the device to make it scalable (advancing the device from its early proof of concept to its current third-generation prototype) while Professor Lightman's team performed the verification testing.

Professor Lightman subsequently received SuperFoF support in 2020 ('Development and integration of a cortisol sensor with real-time read-out to an ambulatory microdialysis sampling system', £641,000) to develop a sensor for cortisol to fit in the device. Professor Lightman had identified a molecule that detected cortisol, but needed to turn this into a working sensor and integrate this with the collection device. This would enable results to be immediately available, rather than having to analyse samples in a laboratory.

Translational Impact

Following development activity undertaken through the Follow-on Fund, the University of Bristol and Designworks formed a consortium with several other notable academic and commercial partners including University of Bergen, Karolinska Institutet, Olink Proteomics and Evangelismos Hospital, and secured over €6 million of Horizon 2020 funding. This work resulted in multiple improvements to the device, including significant reduction in size, installation of a rechargeable lithium polymer battery and wireless recharging dock, new manifold and pumps, volume and pressure monitoring, and pre-wound spools for sample collection. As part of the project, the device has been tested on 242 healthy participants (see doi:10.1126/scitranslmed.adg8464) and market evaluation has revealed a huge interest from researchers, clinicians, and stakeholders in the medical technology industry.

To commercialise the device, the University of Bristol formed spinout company, Dynamic Therapeutics, in June 2023, and transferred the IP to the company. Dynamic Therapeutics will embark on further development of U-RHYTHM and hopes to custom-build components in-house. Its main market is expected to be clinical researcher and health services (to date, Designworks has manufactured 75 devices for clinical investigation, with 35 being actively used globally) as well as the pharmaceuticals industry, to develop and verify the performance of drugs.

Professor Lightman has welcomed the support provided from BBSRC's Follow-on Fund programme:

"The support from the BBSRC Translational Funding scheme was absolutely critical for our ability to develop the pre-production prototypes of our device which we could test in man, and thus provide the data necessary both for funding from the EU Horizon scheme and the spinout of Dynamic Therapeutics."

The project has also resulted in a significant degree of knowledge and technology transfer between academia and industry. As well as bringing their valuable R&D, manufacturing and commercial expertise to the project, Designworks has noted that designing and developing U-RHYTHM has strengthened the company's portfolio, through learning about new manufacturing methods and techniques (specifically fluid dynamics) and investing in new equipment, which has opened up opportunities for new commercial ventures. The company has also stated that university collaboration has helped to raise the profile of the business and demonstrate that it is at the forefront of innovation. The company will continue its involvement in the project by supporting the spinout company, particularly through further development and manufacture of U-RHYTHM into a commercial product.

University of Nottingham, Development and Commercial Exploitation of Novel Fungal Strains for use in the Food Industry

FoF BB/L024470/1 Jun 14-Jan 16 - Development and Commercial Exploitation of Novel Fungal Strains for use in the Food Industry

FoF BB/N012631/1 May 16- Nov 17 - Development and Screening of Novel Fungal Strains for Exploitation in the Food Industry

Project Background

Fungi are used in the production of a number of foodstuffs. Prior to the award of the FoF grant in June 2014, Professor Dyer, had developed a novel sexual crossing technology to generate new fungal strains that might have enhanced properties for use in the production of certain food products. This included the production of strains with novel flavours, strains with lowered content of potentially harmful 'mycotoxins' and requiring less salt use, and strains with faster growth rates that would be of benefit to the food producers due to reduced manufacturing costs.

The Follow on Fund

Professor Dyer received an initial FoF Pathfinder grant in July 2013 for £8,000. This was used to fund external consultants to undertake research to identify if the overall project had commercial viability. He describes this research as very useful in identifying to market demand for new strains by producers and what attributes they were looking for. This was very useful for informing the next stage of research, for example by highlighting the demand for milder, less bitter, mould-ripened cheeses.

Professor Dyer was awarded £125k through his initial FoF project which ran from 2014 to 2016 with the aim of using the novel technology to produce a range of new fungal strains for blue-cheese production and screen them for desirable combinations of flavour, health and growth characteristics.

The FoF involved a range of industry partners. These included Highland Fine Cheese who produced 19 trial cheeses using either the novel strains or control commercial strains, at no cost. West Highland Dairy provided expertise in taste trials of the cheese produced by Highland Fine Cheese, Cropwell Bishop Creamery made some trial cheeses and New Food Innovation opened talks with Supermarket representatives about possible commercial sales of the final cheese products.

He felt that the FoF addressed a key gap in funding ‘the funding really was critical and not available elsewhere, we contacted the companies which sold the cheese strains and asked whether our new method for making the strains could be of use. Although they really liked the idea they did not have the R&D budget to support its development’.

In May 2016 Professor Dyer was awarded a second FoF of £211,000 which enabled him to complete key aspects of work associated with the development and screening of the new fungal strains. This included making more crosses to generate offspring with other favourable features, such as higher enzyme activity and growth rate to reduce manufacturing costs, and generation of fungal strains with novel colours. Around £100,000 of this funding was used to purchase analytical equipment for flavour analysis and to check for the production of toxins which Professor Dyer describes as critical to the success of the research: ‘without that analytical equipment we really could not have progressed and because of the cost of it we would have struggled to get support for this elsewhere. The University committed 50% of the equipment cost and it has been made accessible as communal kit’

The results of this work led to the best new strains being used in cheese production trials and were subject to blind taste trials. These revealed at least 6 new strains that scored very favourably and have been taken forward for commercial exploitation.

Translational Impact

Strain development began in the initial FoF project, and was continued under the subsequent Follow on Fund project. This ultimately led to the development of a series of four novel fungal strains for blue-cheese production. These were patented in 2019. A start-up company (Myconeos Ltd) was then launched in summer 2018, to commercially produce and market the novel strains, under licence from the University of Nottingham. To allow a round of £200,000 angel investment It was then necessary that the company owned the strains and the University passed on ownership of the strains to Myconeos in return for revenue income once sales targets had been met. Myconeos moved into labs at BioCity, Nottingham in February 2020.

The company has subsequently received two Innovate UK grants of £200,000 and £280,000 to develop strains for Brie/Camembert style mould-ripened cheeses and to create higher quality mould-ripened vegan cheeses, respectively. In November 2022 the company raised a further £436,000 in an VC round. Professor Dyer considers that the two FoF projects were critical to the development of the spin-out stating that 'without the FoF data we obtained and showing the proof of principle none of this would have taken place'.

Commercial sales of the strains are in early stages and are currently generating around £2000 to £4,000 per month. Currently an Italian distributor, Sacco is trialling the strains and they are seeking a second European distributor to cover additional countries. Following European expansion, sales are forecast to increase to around £1 million to £1.5 million per year. The company is expected to maintain production of lower volume more specialist strains at BioCity in Nottingham.

The company is still continuing to look at new areas for development. For example one of the novel strains produces an umami flavour and there is potential for its development to produce a healthy low salt cheese which retains a salty flavour. The company is also exploring the use of novel coloured strains as an alternative to traditional blue cheeses.

Queen's University Belfast: Manufacture and applicator technologies for commercialisation of polymeric microneedle arrays

BB/K020234/1 SuperFoF Award Aug 13 - Aug 15 £709,445 Manufacture and applicator technologies for commercialisation of polymeric microneedle arrays

Project Background

Professor Donnelly's support from BBSRC dates back to 2007, when he received a BBSRC grant which was cofounded by EPSRC, to explore the delivery of peptides and proteins using microneedles.

The research involved the development of a transdermal patch with tiny needles on its surface that painlessly and without causing bleeding by-pass the skin's outermost layer. These needles either dissolve quickly, leaving tiny holes in the skin, which will let proteins and peptides enter the body, or swell, turning into a jelly-like material that keeps the holes open and allows continuous delivery.

There was however, a lack translational information on the patch, for example what happens if you use it every day, how could a foolproof applicator be designed, and how could the manufacture of microneedles be scaled up. In 2009 Professor Donnelly received BBSRC Follow-on-Funding for £95,000 for a one-year project to give more information on the impacts of applying the patch to skin and any adverse effects and also to try to identify other translational challenges.

Whilst the one year FoF project was running Professor Donnelly considered applying for the BBSRC SuperFoF to explore these issues in more detail. He first requested a Pathfinder FoF Award of around £10,000 to undertake market research on the market potential for microneedles. This involved the assembly of a panel of experts in the field and a lay member representing the patient community who assessed what they were proposing to do for the SuperFoF and provided useful feedback in a written report.

The Super Follow on Fund

In 2013, Professor Donnelly was awarded £709,445 from the BBSRC SuperFoF. This project largely focussed on scaling up microneedle technology, so instead of making microneedles using a centrifuge by hand in the lab, it was possible to scale up manufacture. The project also addressed applicator techniques, how people could apply microneedles to their own skin and get feedback to know that they had been applied correctly.

The SuperFoF grant ran for two years until 2015 and, as a result of the work undertaken through this grant, they were able to award a tender for the scale up of manufacture to a German company. At the time, this was the only company in the world with the capability to scale up this product.

Professor Donnelly considers that the SuperFoF was fundamental in enabling his work with the German company on development, validation and scale-up of microneedle manufacture, which was previously a major roadblock to commercialisation, and that this work would have struggled to progress without BBSRC support. In addition to the financial support, he considers that the soft BBSRC support was also useful:

> *'Our BBSRC case officer used to come with the advisory panel and they would give us objective and serious advice in terms of what we were doing. This was really useful in shaping how we would progress the research and we were being pushed by them pretty hard, which was great in keeping us really tightly on track.'*

In 2013 Professor Donnelly was named BBSRC Innovator of the Year. He transferred his methods of manufacture to the company and, since then, he has been engaged as a

consultant, supporting transition of manufacture from laboratory to industrial scale and to ultimate approval by the German authorities. The main output of the SuperFoF was refining the method of manufacturing and the manufacturer now has Europe's only Good Manufacturing Practice microneedle manufacturing facility. Professor Donnelly is still working closely with the company to advise them on microneedle development:

> *'The crucial thing is that we are now in a position where if a company comes to us and says we are really interested in your microneedle technologies and taking them right through to clinic but are reluctant to commit to a product in your lab because we don't know how the final product would be able to be made and we have no capability of making it ourselves, we can now refer them to this manufacturer. We have handed a number of companies on to them, we do all the fundamental science and animal studies here and then refer them on for GMP manufacturing and clinical studies, which enables our technology to have an outlet with market potential'.*

Translational Impact

Since the SuperFoF Professor Donnelly has been collaborating with a large number of multinational pharmaceutical and cosmetics companies. He is also collaborating with a number of smaller UK health companies, for example, to use to patch to administer psychiatric drugs for depression that is resistant to conventional treatment.

There is a current economic benefit for the UK from this project. Queen's University receive income from multiple research collaboration grants which bring in between £500,000 and £1 million to the university per year. There is also potential for a significant economic benefit in the future when the technology is commercialised as Queen's University also holds royalty agreements varying between 1% and 10% of net sales.

Commercialisation is currently at TRL6 as further clinical trials are required to take the technology forward. The German manufacturer is now capable of manufacturing microneedle patches up to batch sizes suitable for Phase 2 clinical trials and have successfully completed Phase 1 clinical trials on the hepatitis B vaccine and are now working with several major pharma partners on development of microneedle delivery systems for their molecules.

Professor Donnelly considers that the timescale to full commercialisation is around 5 years, with one of the first products likely to be a vaccine for children in developing countries. The microneedle application offers a number of benefits for this environment, with no healthcare worker required for administration of the vaccine and no requirement for needles and syringes.

There has also been a significant impact on skills and employment in Professor Donnelly's research group:

> *'When we started out, I only had 10 people in my research group, I have 50 now from 20 different countries, and the translational support has given me the opportunity to work with a big manufacturer and understand how you go from a prototype made by hand in a lab to an automated manufacturing process'*

Since SuperFoF, Professor Donnelly has raised around £12 million, of which around £4 million has been from private sources. Other funding sources have included EPSRC and the Wellcome Trust. EPSRC funding is currently being used to look at different types and shapes of microneedles. This technology is unique and could potentially revolutionise delivery of medicines. For example, novel sensor-functionalised hollow microneedles can extract fluid from the skin allowing monitoring of the levels of drugs in a person's blood without actually taking blood samples, meaning that adverse events and complications arising from blood sampling could be prevented.

Pirbright Institute: Influencing government policy on the control of foot and mouth disease outbreaks in Mongolia to improve farmers' livelihoods

Impact Acceleration Account - Guaranteeing impact: influencing livestock disease control policies in Mongolia by promoting stakeholder awareness of the socio-economic burden of control measures

Project Background

Dr Georgina Limon-Vega is an epidemiologist at the Pirbright Institute. Her work has contributed to projects assessing the socio-economic impact of animal diseases and control measures in Low-Middle Income Countries (LMIC).

Following the 2017 FMD outbreaks in Mongolia, Dr Limon-Vega and her colleagues – in collaboration with the Mongolian State Central Veterinary Laboratories (SCVL) and the General Agency for Veterinary Services (GAVS) – undertook BBSRC-funded research[39] into the economic and socio-economic impact of foot-and-mouth disease (FMD) in Mongolia and to assess the impact of FMD control methods employed on herders. As in many LMICs, rural farmers and herders in Mongolia – which has one of the highest per capita livestock ratios in the world – are heavily reliant on animal protein and fat in their diets. The lack of alternative food sources can leave them vulnerable to diseases of livestock such as FMD, which results in a reduction in livestock weight gain and milk production, and control methods such as movement control and stamping out are put in place. Countries with endemic FMD are also denied access to potentially lucrative export markets for livestock and animal products, giving governments a clear incentive to direct resources towards control the disease. It is often assumed that controlling the disease will benefit all animal holders by increasing their income or by increasing the availability of animal-source food. However, the benefits of controlling the disease in LMICs are complex and not well quantified.

In 2017, up to nine FMD outbreaks were reported each month across Mongolia. The national FMD control strategy consisted of vaccination twice a year in high-risk areas, modified stamping out (destroying animals with clinical signs) and movement controls. Following a report of an animal with clinical signs suspected as FMD, a 10km quarantine zone was introduced. Animals with clinical signs were destroyed and farmers affected were eligible to receive compensation worth 90% of the commercial value of the animals culled.

The research quantified the impact of outbreaks and control measures on subsistence farmers' livelihoods and food security and estimated the national-level gross losses due to reaction and expenditure during 2017. The team used the survey results to identify recommendations to ameliorate the unintended negative effects of the control policies in place at the time, for example, enhanced food support such as food banks for those in quarantined areas and providing compensation in a timely manner.

Impact Acceleration Account

In 2019, Dr Limon-Vega, Dr Nick Lyons and Professor Pip Beard received a £12,000 BBSRC IAA award ('Guaranteeing impact: influencing livestock disease control policies in Mongolia by promoting stakeholder awareness of the socio-economic burden of control measures'). The funding enabled the team to travel to Mongolia and host workshops to

[39] Limon et al (2020) 'Socio-economic impact of Foot-and-Mouth Disease outbreaks and control measures: An analysis of Mongolian outbreaks in 2017', *Transboundary and Emerging Diseases, 67(5), pp 2034-2049, doi: https://doi.org/10.1111/tbed.13547*

present their research findings and discuss potential policy responses with farmers and policy makers.

An initial workshop was held in the rural city of Chinggis, Kenthii province, focusing on knowledge exchange with 17 herders and nine private vets from the eight provinces affected by FMD. A second workshop was held in the capital city Ulaanbaatar, focusing on knowledge exchange with 20 government ministries and veterinarians, including representatives from the SCVL, GAVS, National Emergency Management Agency, government vets from provinces affected by the FMD epidemic, and representatives from Food and Agriculture Organization of the United Nations (FAO) in Mongolia. The second workshop also included a presentation from Pirbright's Dr Nick Lyons, on the suitability for Mongolia to enter the 'Progressive Control Pathway for Foot-and-Mouth Disease' (PCP-FMD)40, a risk and evidence-based framework to guide endemic countries to progressively improve the management of FMD risks and reduce disease impacts and viral circulation. Following the second workshop, training on vaccine evaluation was also provided to these stakeholders. Presentations for and documents distributed within these workshops were translated into Mongolian and a translator was present to facilitate the discussions. Discussions during the high-level workshop and following the training session led to a long debate on the potential way forward to control FMD in the country.

Translational Impact

A key outcome from the research and workshops has been updated FMD control policy in Mongolia. Modified stamping out is no longer conducted as part of the disease control strategy and this modification on the control strategy was implemented during numerous FMD outbreaks in 2021. Herders also subsequently received compensation that was pending, which was likely influenced by the research and engagement workshops. The work resulting from this grant also supported their resilience to subsequent outbreaks.

Following the workshops, the Pirbright Institute received £25,000 of funding from the FAO in Mongolia to conduct follow-on research in collaboration with the University of Liverpool, entitled 'Cost-benefit analysis for establishing a foot-and-mouth disease free zone in Mongolia'. Conducted in close collaboration with the General Agency for Veterinary Services (GAVS) in Mongolia, the objectives of this project were to perform a cost-benefit analysis of establishing an FMD-free zone in Western Mongolia, to formulate recommendations for policy makers based on the outcomes and to train a small group of people working in relevant departments at GAVS. The research found that the costs of an FMD free zone exceeded the benefits over time. This led to the development of a control plan based on the Mongolian situation developed by a team form GAVS and FAO-Mongolia.

Dr Limon-Vega states that *"The IAA funding gave us the opportunity to go back to Mongolia to present and discuss the results of our BBSRC-funded research with herders, field vets and policymakers. The collaboration and support of our Mongolian colleagues was crucial in allowing our research to have a direct and positive impact on end-users – in this case the Mongolian herders and their families".*

40 The PCP-FMD was developed by the Food and Agriculture Organization (FAO) and endorsed by the World Organization of Animal Health (WOAH)

Quadram Institute, Using metagenomics technology to improve food safety

Impact Acceleration Account - Demonstration of Metagenomics with a Food Factory

Project Background

Dr Matthew Gilmour leads QIB's Listeria research group and is a Group Leader of QIB's 'Microbes and Food Safety' strategic programme. His work specialises in improving the understanding of the microbial traits of Listeria that contribute to its significant risk as a foodborne contaminant and invasive human pathogen, as well as using metagenomic platforms to better detect other invasive pathogens in both food safety and health settings. The group uses microbiology and genomic approaches to provide actionable data to partners, ranging from food producers, government departments and clinicians. Dr Gilmour is also Director of the Food Safety Research Network (FSRN), hosted by the QIB and funded by BBSRC and the Food Standards Agency, the FSRN connects food industry, food and health policymakers and academia to collaboratively pursue shared research priorities that will protect the UK from foodborne hazards.

Listeria monocytogenes is one of the most concerning causes of food poisoning, as it is associated with common chilled foods such as cheeses and salads, and also other food types that often require no further cooking prior to consumption such as deli meats and smoked fish. L. monocytogenes most often affects those over 60 years of age, the immunocompromised, and pregnant women along with their unborn or newborn infants. While the incidence of listeriosis is relatively low in comparison to other food-borne diseases, the disease is associated with significant public health and economic burdens because of its high mortality rate of up to 30% and associations with outbreaks when contaminated foods enter the food chain.

Since 2017, the UK Health Security Agency (formerly known as Public Health England) had been actively collaborating with a major producer of ready-to-eat foods ('known as Company X'). This collaboration followed a case of listeriosis which had occurred in a hospitalised patient in July 2017, caused by consumption of food supplied by Company X. In conjunction with the Company, UKHSA had conducted enhanced sampling and investigation of Listeria in their principal factory and the foods produced therein. Despite robust methods to clean and disinfect the facility by the company, a persisting Listeria strain was observed on some of the surfaces within the manufacturing premises that also cross-contaminated some of the food products. This signifies the challenges to remove Listeria using disinfectants, as this microbe is known to be able to adapt to such environments and survive through control measures that otherwise work on other microbes.

To better understand the nature of this Listeria contamination, Dr Matthew Gilmour was awarded £8,000 of IAA funding ('Demonstration of Metagenomics with a Food Factory') in 2022 to collaborate with UKHSA and Company X and exploit the metagenomics technology utilised at Quadram Institute Bioscience (QIB).

Impact Acceleration Account

The IAA project enabled QIB to gain access to 40 environmental samples collected by UKHSA that were representative of 'high care' zones within the food production environment of Company X that had previously been associated with *Listeria* contamination. From these samples, QIB was able to exercise its culture/microbiology and metagenome sequencing pipelines to survey the composition of the entire microbial populations present within Company X's premises and to monitor the impact of cleaning and disinfection routines on these populations. This would help to understand the relationship between these factors and what may help support persistence of the *Listeria*

strain. QIB also tested the Listeria strain's survival characteristics in the presence of the sanitisers used to determine why these were proving ineffective.

This study revealed that the microbial populations in the factory were adapted to the different areas of the facility and maintained a stable composition over time, even in the face of routine cleaning procedures. These findings were shared with representatives of Company X during a half-day virtual session. Participants in this session included technical and management personnel from Company X, UKHSA senior leadership and Environmental Health Officers, the local authority from which Company X is based, and scientists and students from QIB. In addition to metagenome sequencing results, QIB presented the results of its phenotypic characterisation of the persisting strain of Listeria that had been present at the facility. These results provided evidence on the nature of the persisting strain and why it had survived through the application of commonly-used disinfectants.

Translational Impact

The collaboration provided QIB with an opportunity to obtain direct access to samples to demonstrate and refine its metagenomic platforms. The data obtained in this study will also help to model food processing environments, creating opportunities to explore novel methods for eliminating Listeria from food production facilities in the context of the total microbiota that are present. By working directly with UKHSA and Company X, there was also knowledge exchange on topics such as environmental sampling protocols and disinfection regimes in food processing.

Following the IAA project, QIB hopes to test further disinfectants used by Company X to expand their evidence base so that they can tailor their biocontrol regime to eradicate this persistent Listeria strain. This strain is also now serving as a major point of study for a PhD student, who is comparing the Company X strain to a strain that is entirely susceptible to disinfectants, with the goal of understanding of how biofilms of Listeria can adapt in the presence disinfectants.

The results of the project have also sparked further interest in the food sector. Dr Gilmour has been invited to a large number of events and conferences to discuss the outputs of the research and the potential of QIB's metagenomic technology and has commenced work with other companies to provide further information and advice on their issues with persistence of different but undesired microbes.

University of Sheffield, Development of a novel data analysis product for the biological research market

Impact Acceleration Account - Development of a novel data analysis product for the biological research market

Project Background

The major component of the bacterial cell envelope is called peptidoglycan. This bag-shaped molecule is essential and confers bacterial cell shape and resistance to osmotic stress. During bacterial growth, peptidoglycan structure is constantly modified. It undergoes partial cleavage, to allow cell surface expansion or separation of newly formed cells at the end of division. It can also be modified to protect the cell against enzymes produced by other microorganisms that could destroy them. This process, called "peptidoglycan remodelling" allows bacteria to adapt to changing environmental conditions and is important for bacterial population dynamics.

Despite the pivotal role of peptidoglycan for bacterial physiology and ecology, studying the structure of this molecule using mass spectrometry is extremely challenging. The limiting step resides in the analysis of large datasets generated by mass spectrometry because no software tool can handle the unusual properties of peptidoglycan.

Since 2016 Dr Mesnage has been interacting with a US based company providing tailored software solutions to try to ascertain if they could provide a software solution to analyse the molecules of interest. The company funded a four year ICASE BBSRC Studentship 2017 resulting in two publications, and provided in kind support of around £200,000. However at the end of ICASE the software was still not sufficiently functional for Dr Mesnage's peptidoglycan research.

Impact Acceleration Account

At the end of ICASE Dr Mesnage was awarded the £22,000 IAA project 'Development of a novel data analysis product for the biological research market' that the company match funded. This project specifically focussed on creating an open-source software toolbox called PG Xplorer to carry out a consistent and automated analysis of peptidoglycan structure and composition.

Following this the company agreed to fund a second ICASE NERC Studentship and is still working with Dr Mesnage to develop this software. Alongside this work Dr Mesnage has developed an open source tool to allow other members of the research community to benefit from this research.

Translational Impact

To date there has not been any commercial impact however the scientific impact of this partnership has been immense and the project has resulted in an extremely valuable open source tool for the research community which allow a wide range of users to address questions across disciplines that could not have been addressed in the past.

New "peptidoglycomics" analyses can now enable the identification of novel properties of peptidoglycan to study how this essential molecule changes in the context of complex microbial communities like in the mouth, the gut, or in the soil.

For example the tool and expertise developed through the IAA led to Dr Mesnage receiving a MRC grant to look at the structure of this molecule to study antibiotic resistance, because the peptidoglycan is the target of the most widely used antibiotics.

He has also received a BBSRC grant to look at symbiosis, when microbes interact with legumes to fix atmospheric nitrogen their cell envelope is changes, this grant focusses on how the changes in this cell envelope affect the resilience of bacteria in the soil.

Other applications include developing a better understanding of behaviour disorders linked to the gut brain axis because peptidoglycan fragments, released during remodelling, play an important role during microbe-host interactions. Some fragments have been shown to contribute to diseases caused by pathogens whilst other fragments released by probiotics have a beneficial role and enhance antitumor cancer immunotherapy. Recent studies in mice also indicate that peptidoglycan fragments produced by gut bacteria can circulate in the organism and can be sensed by the brain to modulate behaviour, sleep and appetite.

Dr Mesnage is also exploring the use of this tool to detect colorectal cancer as there is a relationship between the circulating molecules of these fragments and cancer and inflammation. As Dr Mesnage states:

'The tool developed through the IAA in collaboration with this company has become the cornerstone of various aspects of my research and has led to successful MRC, BBSRC and NERC grants and a recently submitted BBSRC grant. I believe this tool is so transformative as it is allowing you to ask questions in different remits and addressing questions which relate to different Research Councils'

University of Warwick: Improving oilseed rape yields with new turnip yellows virus resistances

Impact Acceleration Account - Exploiting virus resistance in arable and vegetable brassicas

Project Background

Professor Walsh is an expert in plant-virus interactions, with particular interests in viruses infecting brassicas and identifying, characterising, discovering the mechanisms and mapping the plant resistance genes with a view to developing durable plant resistances. Professor Walsh's team are working to identify and deploy new sources of resistance that, when commercialised, will reduce the selection pressure for TuYV strains to overcome the extant resistance and the new ones they have identified.

Turnip yellows virus (TuYV) is a very damaging pathogen of brassicas, particularly vegetable brassicas and oilseed rape (OSR) in the UK and mainland Europe. Unlike many viruses, TuYV does not cause very obvious symptoms in most brassicas, meaning that many growers are unaware of the infestations. However, infected OSR plants produce fewer side branches, pods, and seeds per pod, significantly reducing seed and oil yields by up to 30%. The Agriculture and Horticulture Development Board (AHDB) levy board estimated losses to cost UK growers £69 million per annum. TuYV also reduces the yields and quality of vegetable brassicas, for example, by up to 65% in Brussels sprouts and by up to 36% in cabbage.

The virus is transmitted by a common greenfly (peach-potato aphid). Around 70% of these aphids carry the virus and will transmit for life once they acquire the virus. Insecticide control of the aphid vector is limited due to insecticide resistance in aphids and the banning of the most effective active ingredients (neonicotinoids) in the UK and EU. Neonicotinoid seed dressings had been effective at keeping aphids out of arable crops but, since their ban, the proportion of infected OSR crops has increased from just a few hotspots a decade ago to endemic across much of the UK today.

Natural plant resistance is the ideal approach to control plant viruses for a number of reasons, particularly as it can be very effective, environmentally friendly and negates the use of insecticides to control the virus vectors. One source of resistance to TuYV is already being utilised in at least 24 different OSR varieties in Europe. However this has created a strong selection pressure for resistance-breaking strains of TuYV to arise.

Impact Acceleration Account

In October 2015, Professor Walsh and Limagrain UK Ltd commenced collaboration, through a BBSRC-funded CASE studentship, undertaken by Shannon Greer ('Broadening and improving the Turnip yellow virus resistance base in oilseed rape (BITYR)'). The aims of this project were to identify brassica plant lines with extreme resistance to TuYV, examine these traits to determine the position of the gene(s) responsible for the extreme resistances in the genomes of the plants and use these plants to resynthesise TuYV-resistant OSR. It was agreed that Limagrain would have the option to be granted a licence for the commercialisation of products developed from the use of Intellectual Property arising from the studentship. However, upon completion of the studentship, further funding was required to continue the work, particularly due to one plant population being very slow at flowering and producing seed. IAA funding was therefore sought to complete the project.

In 2020, Professor Walsh received a £15,000 BBSRC IAA award ('Exploiting virus resistance in arable and vegetable brassicas') to narrow down the number of candidate genes through further genotyping of TuYV-resistant and TuYV-susceptible brassica plants and to identify improved molecular markers for the resistances. The genotyping was outsourced to an Australian company, who were able to conduct this more efficiently.

The project successfully led to the identification of the locations of resistances in the plant genomes and the identification of a number of candidate genes.

To exploit further sources of TuYV resistance to further reduce selection pressure for resistance-breaking virus variants, Professor Walsh received a £213,000 Follow-on Fund grant ('Delivering important virus resistance (DIVR)') in March 2020, in collaboration with Limagrain and other major plant breeding companies (Syngenta, L S Plant Breeding and Elsoms). Boosted by cash and in-kind contributions from the commercial plant breeders, Professor Walsh developed TuYV-resistant plant lines for the seed companies to incorporate resistance into vegetable brassica types. Resynthesised OSR plant lines with TuYV resistances were also developed. The molecular markers that have been identified will accelerate the introgression of the resistances into commercial OSR and vegetable brassica crop varieties. Broadening the sources of resistance to TuYV in these commercial crops will reduce the selection pressure for resistance-breaking viral variants and enhance the durability of all the resistances, thereby providing farmers with an alternative to using pesticides to control the virus.

Translational Impact

As a result of the outcomes from the BBSRC-funded IAA research, Limagrain are negotiating a licence agreement with the University of Warwick concerning the TuYV-resistant material. A Material Transfer Agreement has been signed and Limagrain received germplasm and genetic marker information in July 2022, with the aim of introducing the trait into commercial lines. Both parties are formalising a licence for the use of the material and know-how through an exclusive evaluation licence.

Limagrain, which was founded as a farmer-owned cooperative in France 50 years ago, is the UK's largest producer of OSR varieties and the fourth largest global seed company. The company – which was the first to introduce a TuYV-resistant commercial OSR variety to the UK in 2014 – spends a significant proportion of its turnover on R&D, by developing varieties with higher yields, improved resource efficiency and reduced environmental impact. While all of their OSR varieties have TuYV resistance, there is only one source of TuYV resistance in current commercial OSR varieties, which, as above, creates heavy selection pressure for the virus to overcome genetic resistance. Providing more than one source of genetic resistance to TuYV would therefore help to protect the crop. Limagrain will therefore use the materials from the BBSRC IAA-funded project at Warwick within an OSR breeding programme, with the aim of incorporating the natural plant resistance to TuYV into Limagrain's varieties and making these available for farmers to grow. The outcomes would be longer-term resistance of OSR to TuYV, improved yields, reduced reliance on insecticides, reduced insecticide residue in food, and improved food security.

Following the Follow-on Fund project, Warwick has also granted, Syngenta, Elsoms, L S plant Breeding, Limagrain and their affiliates a royalty-free commercial licence to the TuYV-resistant OSR material derived from the project. The TuYV-resistant vegetable brassica lines from this project are being made available to the seed companies via a non-exclusive licence. Syngenta is a major science-based agtech company with 30,000 employees in more than 90 countries and is the third largest global seed company. Elsoms is the UK's leading independent seed specialist and plant breeder and an independent family-owned business. L S plant Breeding is a medium-sized, privately-owned plant breeding company specialising in OSR breeding.

Professor Walsh states that "Without the BBSRC translational funding, it would not have been possible to take our scientific discoveries forward to a point where we could provide commercial seed companies with material (plant seeds) and scientific information (molecular marker data*) that will allow them to exploit the discoveries in commercial plant varieties for vegetable and arable farmers."*

University of Oxford: Automated 24/7 assessment of chicken welfare

Impact Acceleration Account - OpticFlock: Preparation for commercial licensing

Project Background

Across the world, demand for chicken meat is steadily increasing, with over 70 billion chickens reared each year. Broilers are kept in large sheds in flocks of often 30,000+ birds. They have been bred to grow fast and reach final weight of 1.5kg in less than 35 days. There is increasing public concern over the welfare of these birds, with farmers under pressure of use less medication and to reduce the impact on the environment by becoming more efficient. Since both profitability and welfare depend on the health and survival of the birds, both chickens and producers would benefit from improved chicken health. However, there is currently no easy way of measuring the welfare of chicken flocks on commercial farms while they are alive. Welfare assessment is either done post-mortem or by human auditors visiting a farm. This gives only a snapshot on that particular day, is labour-intensive and poses a security risk.

Professor Marian Dawkins is a professor of animal behaviour at the University of Oxford's Department of Zoology. Her research interests include animal welfare, with a particular focus on putting welfare research into practice and examining the relationship between good welfare and the immune system. With funding from BBSRC (including two FoF awards), Professor Dawkins and colleagues, including Professor Stephen Roberts (Department of Engineering Science) and Professor Christl Donnelly (Department of Statistics) have been working towards realising the potential of her research correlating flock movement and chickens' underlying health conditions, by developing a flock management tool, 'OpticFlock™'.

OpticFlock™ is part of the rapidly developing field of SMART or 'precision' livestock farming in which technology is being increasingly used to monitor and control the lives of animals. OpticFlock™ examines chicken behaviour with an automated sensor giving continuous 24/7 welfare information throughout the whole life of the flock to assess their welfare. It uses CCTV cameras coupled with a small on-farm computer to analyse camera images in real time and deliver daily information on key welfare indicators, such as mortality, walking ability and leg health. The tool shows the overall level of flock activity and measures the extent to which there is unusual or anomalous movement within a flock. Using this information, the technology aims to provide farmers with early warnings of potential problems, enabling them to intervene and achieve higher standards of flock health and welfare. It uses inexpensive and commercially available components so that it has the potential to be widely used as a routine flock management tool.

Impact Acceleration Account

While there had been a great deal of interest from producers, retailers and manufacturers of equipment, with several asking to evaluate OpticFlock™ with a view to a possible licence arrangement, further software development was needed. Professor Dawkins' ambition is to create a plug-and-play inexpensive, easy-to-install, self-monitoring system that could be either stand-alone or run on farmers' existing dashboards.

In 2020, Professor Dawkins received a £25,000 BBSRC IAA grant ('OpticFlock: Preparation for commercial licensing') to develop OpticFlock™'s software. The funding was used to employ software development company, Oxford Computer Consultants (OCC), to develop software and hardware that would be more suitable for the commercial market and could cope with power outages, electrical interference, network loss, high temperatures and other hazards of working in a computer-hostile farm environment. The team worked with various European poultry companies to test and validate the system and OCC added the facility to enable the University to 'remote in' to farms over the internet so that the team could see the data being collected on-farm and sort out any problems.

Translational Impact

Since the technical development activity undertaken through the IAA, OpticFlock™ has been successfully trialled on over 200 commercial flocks. It has been demonstrated to predict future risk of high levels of hock burn when a flock is only three days old and before any external signs of leg or foot damage appear, and can pick out flocks at greatest risk of testing positive for Campylobacter when birds are less than a week old and before any signs of infection are detectable.

The outputs of the IAA meant they could partner with Tyson Foods' Research Farm in Arkansas and Master Good in Kisvárda, Hungary to test the technology and demonstrate achievement of improved flock welfare. Both FFAR and McDonald's have been extremely positive about the trials. These partnerships helped the University to leverage $750,000 of further funding from an international SMART Broiler programme jointly sponsored by the US charity, Foundation for Food and Agricultural Research (FFAR), and McDonalds to continue and expand commercial application.

Professor Dawkins has also received interest in OpticFlock™ from a variety of other sources. OpticFlock was used in a joint study with the Universities of Aarhus (Denmark) and Newcastle to predict tail-biting in pigs, a collaboration has been formed with a cooling equipment manufacturer to use the tool to test for Campylobacter and heat stress in birds, offers have been made from an Australian company (Inghams) and US producers to host further trials, two non-disclosure agreements (NDAs) have recently been signed with two international companies, and $119,000 of funding has been secured from Cobb to work on one of their farms in the UK from January 2024 to help them evaluate how new breeds perform in a commercial farm environment. However, further development work is needed to produce an easy-to-use app that is ready for licencing to industry and to provide positive evidence that using OpticFlock™ really does 'work' in the sense of improving chicken welfare. Professor Dawkins is therefore seeking further BBSRC support, through the Follow-on Fund, to complete this work.

Professor Dawkins states that the BBSRC IAA award has been essential to OpticFlock™'s progress "because it has helped us along the rocky road of turning OpticFlock from a research tool into a commercial product that is easy to use, reliable and provides information in a convenient form. It is still not the plug-and play piece of kit we would like it to be but IAA funding has helped us to get further funding, put us in touch with key people *and led to contact with many potential customers."*

Quadram Institute: Developing commercial applications using transposon mutagenesis technology

Impact Acceleration Account – 'Massive transposon mutagenesis to determine biological responses to stress'

Project Background

If a bacterial species is to be successful, it needs to survive, thrive and grow under diverse environmental conditions, as well as resist the action of antibiotics and antimicrobials. Understanding the genetic basis of how bacteria survive and grow in diverse environments provides opportunities to control them, remove them or make better use of them.

The Quadram Institute Bioscience (QIB) has developed technology to better understand which of the many bacterial genes are involved in survival and growth in a range of environmental conditions. Transposon mutagenesis is a well-established genetic tool for creating pools of mutations in genes and observing the resulting impact on behaviour of the organism, by competing them to show which ones survive and grow under a range of conditions. QIB has developed a powerful version of transposon mutagenesis – based on transposon directed insertion site sequencing (TraDIS) and termed TraDIS-Xpress – which provides a much better understanding of bacterial cell biology by including the ability to over- and under-express genes as well as inactivating them. This technology can help researchers to identify new ways to combat pathogenic bacteria, encourage beneficial commensal bacteria, or optimise bacteria used in medical or industrial processes.

Professor Mark Webber, a Group Leader at QIB and whose early career was funded by a BBSRC David Phillips fellowship – is developing new technologies to understand the biology of key bacteria and applying this to different areas, including antimicrobial resistance, biofilms and microbiome research. Professor Webber has aspired to create a spinout company to exploit QIB's transposon mutagenesis technology, which has many applications in the commercial space. To explore the potential market for the company, Professor Webber needed to conduct some market research and user engagement. Additionally, as the underlying software had been written by another institution, QIB did not have complete freedom to operate nor full entitlement to any IP generated by new discoveries made using the software. Professor Webber therefore aimed to create new software, which could be licenced to the spinout company.

Impact Acceleration Account

In 2019, Professor Webber was awarded a £10,000 IAA award ('Massive transposon mutagenesis to determine biological responses to stress') to commission a market research report. Undertaken by Ithaka Life Sciences, the market research looked to determine the interest, key requirements, market size and acceptable price points for a planned spinout company to exploit QIB's transposon mutagenesis technology. Based on interviews from 40 potential customers spanning different sectors, the report identified strong interest and potential collaboration requests from the academic community, along with interest – but a need for greater clarity and simplification of the technology – from industry. To explain and promote the technology, Professor Webber was awarded a second IAA in 2020 ('Promotional video to explain QIB TraDIS functional genomics capacities', £11,000). The funding was used to commission and produce a promotional video to explain the new 'TraDIS-Xpress' technology and to use this as an engagement tool with industry, for teaching and for other academics.

In 2022, Professor Webber received a further £10,000 of IAA funding ('Re-development of bespoke software for analysis of transposon mutant libraries'), to employ an

experienced software developer to redevelop a bespoke software package, which would provide initial analysis of TraDIS data and allow outputs to be integrated with a package for downstream analysis that was previously produced by QIB (AlbaTraDIS). The software – which has already been used on several datasets and shows a superior performance in accuracy and speed – makes data analysis simpler and faster, while providing a more user-friendly installation experience.

Translational Impact

Following positive results from the market research and comms work, Professor Webber is in the process of creating the spinout company, which will aim to further develop and licence the technology to those with bespoke applications. The research helped to identify where industry felt the technology – which has broad application – could best be utilised as well as a preferred business model for the spinout – likely to comprise a two-tier 'service' offering along with a 'platform development' arm. In 2022, Professor Webber received £35,000 of Innovate UK ICURe funding to develop a business plan and pitch for the company and is currently applying for Follow-on Funding to develop concrete examples of products using the technology. The IAA-funded work has also led to new collaborations with industry. QIB is currently undertaking contract research for companies, including a £400,000 two-year project with a multinational, looking at how bacteria could best be used to improve their product.

Professor Webber said 'The availability and flexibility of the IAA scheme has provided essential support of the right scale and scope at key stages. This funding has allowed us to undertake work needed to validate concepts and provide key tools for generating a spin out.' Without the IAA, Professor Webber claims that he would likely have focused on developing academic collaborations, rather than moving into the commercial space.

University of Glasgow: Supporting researchers to achieve translational impact

Impact Acceleration Account - MVLS Opportunity Audits

Project Background

Through its Innovation, Engagement and Enterprise strategy, the University of Glasgow's College of Medical, Veterinary and Life Sciences (MVLS) aims to develop real world impact through identifying, championing and facilitating the translation of innovative research. The MVLS has formed a Translational Research Initiative (TRI) to deliver this vision. Aligned with substantial University funding to support dedicated staff, infrastructure and project costs, the TRI coordinates access to translational funding and provides project management support and training for staff through an integrated hub.

As part of the TRI, the MVLS has committed to a systematic assessment of its translational pipeline via a series of 'Opportunity Audits'. Conducted by a panel of experts, including members of the University's IP and Commercialisation team and external, sector-specific consultants, the audits comprise an informal one-hour discussion with researchers, during which the translational potential of their research is explored. A short report is subsequently provided to the researchers, containing recommendations and follow-up actions identified by the panel. By engaging with the Opportunity Audit process, it is hoped that academic researchers will develop a better understanding of the translational potential of their research, identify next steps for attracting translational funding (where applicable), and increase levels of industry engagement. The systematic mapping of the MVLS translational pipeline is intended maximise the likelihood of successful translation of fundamental science to healthcare impact.

Impact Acceleration Account

In 2019, the MVLS allocated a proportion of the University's BBSRC IAA funding – matched by funding from the MRC IAA – to deliver Opportunity Audits (OAs). To date, just over £7,000 of BBSRC IAA funding has been used to conduct OAs, with a further £22,000 ringfenced for future OA delivery. The IAA funding has been used to employ expert external consultants to audit the activities of 141 PIs and Research Fellows within six Schools within MVLS – including a new cohort of academics who might not have otherwise considered their projects to have translational potential.

Translational Impact

Through the OA exercise, a wide variety of new opportunities for IP assessment, invention disclosures, licencing, translational funding, external collaborations and entrepreneurial training have been identified, along with spinout propositions at various stages of development, including SalmoSim and SOLASTA Bio Ltd. By providing project-specific advice and guidance and helping to identify the most appropriate funding for each project, the OAs have also helped a number of researchers to secure BBSRC IAA funding themselves. Since the OAs have taken place, the TRI has awarded £234,278 of BBSRC IAA funding to help researchers progress their translational research projects, which in turn has generated £545,000 of further funding. Highlights include the following individual IAA projects supported through the University's IAA block award:

- A BBSRC IAA award (£66,927) to Dr Joel Milner to develop a novel, bacteriocin-based method to treat bacterial infection in plants. Previous market research identified a market for non-GM approaches to combat bacterial infections, which are responsible for annual worldwide loss of $50 billion. The goal is to commercialise the product to reduce the threat of pest populations in agriculture. This project resulted in over £257,000 in further funding and a patent being filed.
- A BBSRC IAA award (£53,919) to Dr Rucha Karnik to develop 'Sci-Seedlets', a novel plant science teaching platform and potential social enterprise with the

overarching aim of inspiring the next generation of plant scientists. In partnership with local schools and academic partners at Glasgow and Lancaster universities, Sci-Seedlets has evolved over almost a decade, with evaluated practices to improve the impact on learning outcomes in children and develop a self-sustaining initiative building a legacy for plant science.

- A BBSRC IAA award (£38,383) to Professor Shireen Davies who has championed a revolution in next-generation green insecticides. In 2020, Professor Davies and partners formed the spinout, SOLASTA Bio Ltd, a specialist green insecticides company which is amongst the first of its kind globally. The formation of the company represents the culmination of a four-year translational research journey, taking fundamental research directly into the applied and commercial sphere, driven by world-class science, realising opportunities and with support from MVLS and the School of Molecular Biosciences. Professor Davies stated that her IAA-funded project provided a convincing data package to validate the efficacy of her bee-safe bioinsecticide technology, which underpinned the creation of the company. To date, SOLASTA Bio – which employs 21 staff – has filed three patents, published three academic papers and secured £3.8 million of equity investment.
- A BBSRC IAA (£25,502) award to Professor Kostas Tokatlidis to develop 'Mitotargin,' an innovative therapeutic and diagnostic agent targeting the mitochondria. The team behind Mitotargin has shown that targeting the mitochondria in a way that can modulate function and cell metabolism offers a promising therapeutic approach with potential to address unmet clinical needs including the treatment of therapy-resistant cancer, neurodegeneration and genetic mitochondrial diseases. The Mitotargin project has received over £162,000 in follow-on funding, including Wellcome Translational Partnership Funding, 'Industry Champion' mentorship (via Wellcome funding) and MRC Confidence in Concept and IAA Awards. The project has yielded seven academic publications and generated two patents thus far.

The MVLS plan to continue the roll out of the OA across the remaining MVLS Schools to identify further new translational opportunities, potential projects for BBSRC IAA funding and unmet staff training needs. The translational research projects identified through the opportunity audits have also led to 55 new opportunities for IP assessment, 7 spin-out propositions, 5 licence deals and 13 patent filings. Following the success of the Opportunity Audit programme within MVLS, the University of Glasgow's College of Science and Engineering has also committed to adopting the audit model.