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Transforming Food Production

Final Evaluation

Final Report

SQW

Contents

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Executive Summary

The programme and its context

1. In 2017, the Government's Industrial Strategy set out the long-term plan to "*boost productivity and earning power throughout the UK*". As part of this, the Transforming Food Production (TFP) programme was announced under the Industrial Strategy's Clean Growth Grand Challenge. TFP set an ambitious goal "*to accelerate the development and adoption of integrated precision approaches that will improve the productivity and resilience of primary food production systems and, at the same time, to set the sector on a trajectory to net zero emissions by 2040*".

2. The backdrop in 2017 was significant and longstanding productivity challenges for UK agriculture – with the UK not keeping pace with international competitors – and high greenhouse gas emissions – with the sector accounting for 10% of all UK emissions. More recently, structural challenges were compounded by external shocks (Covid, energy crisis and inflation) and the transition following the UK's exit from the EU. Together these factors have accelerated labour supply issues, squeezed already tight margins, and increased food security pressures.

3. Encouraging the adoption of new innovations in agriculture – both at pace and scale – was (and is) seen as essential to address these challenges. The UK is well positioned to respond, with its world-class research and innovation expertise in agri-food technologies and precision production processes. However, long-standing fragmentation and coordination failures in the innovation system, and underinvestment in R&D had limited the translation of R&D/innovation into improvements on the ground.

4. In response, and delivered by UKRI, in partnership with BBSRC, TFP had seven main "strands" of activity. Each strand targeted a different stage of the R&D process, and they varied in scale, duration and timing. However, they all sought to deliver against the goal to drive improved productivity and reduce emissions in the primary food production sector over the long-term.

5. Delivered over 2017-2024 (with programme close in March 2024), TFP had two phases.

   - Phase 1 (up to 2019) provided funding for small, academic led 'seeding' awards and 'traditional' collaborative R&D projects.

   - Phase 2 (from late 2019 onwards) saw a significant shift in approach to include more ambitious, innovative and systems focused R&D projects, which included large-scale projects designed to develop novel food production systems, international bilateral projects and investor partnerships. Phase 2 also placed a greater emphasis on programme-level and strategic activities, intended to ensure that TFP was 'more than the sum of its parts'.

6. The 2017-2024 period represented a challenging, constantly shifting and uncertain operational, economic and strategic context for the programme, and its key communities of interest.

The evaluation

7. SQW was commissioned by UKRI in Autumn 2020 to lead a consortium[1] to deliver a longitudinal evaluation of TFP. Interim outputs included an evaluation framework, baseline, process evaluation and progress evaluation. The purpose of this final evaluation was to assess whether TFP has delivered outcomes/impacts as intended, and its overall performance against objectives.

8. The evaluation adopted a theory based approach. The purpose was to gather evidence on *what has actually happened* as a result of TFP, compare this to *what was expected to happen*, and test *whether the programme was important in generating observed outcomes and impacts relative to other factors*. This reflected the complex nature of the intervention and its delivery landscape.

9. A range of qualitative and quantitative methods were used. This included surveys with beneficiaries, unsuccessful applicants and businesses in the agriculture sector (at baseline and final stages); in-depth project case studies; consultations with strategic stakeholders and TFP's management/governance; and a technology tracing exercise focused on TFP's role in developing several technology areas. Econometric analysis was used to test the performance of supported businesses with non-supported businesses. The evaluation was also informed by review of monitoring and contextual data, and international evidence on agri-tech innovation and support.

Key findings

Implementation

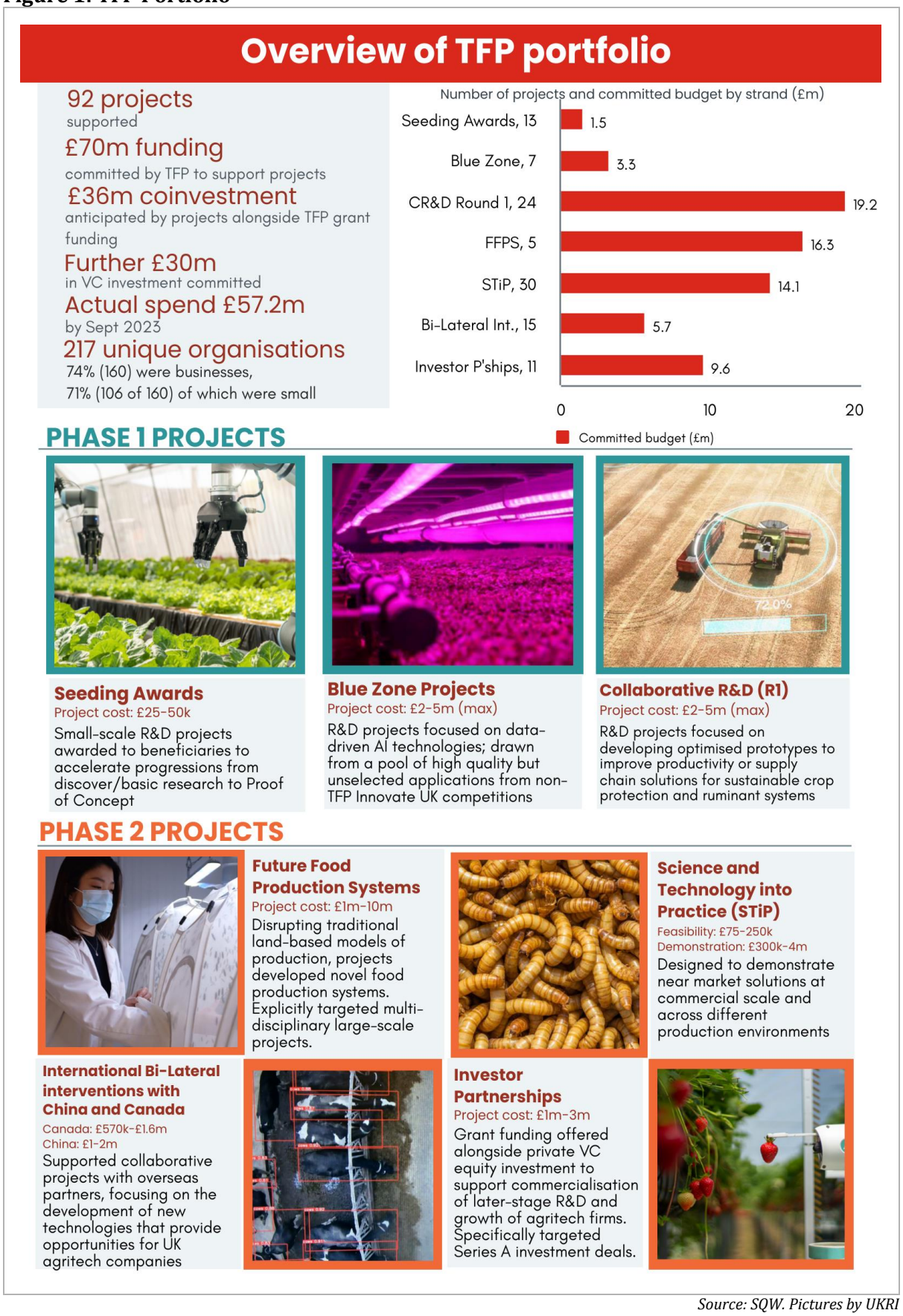
10. By September 2023, TFP had committed £70m of public money to 92 projects, of which 82% had been spent. One third of projects were at final claim stage or live, so the majority of the outstanding budget should be spent by March 2024. There is likely to be a small underspend overall. Given this challenging delivery context – both for UKRI, and at an individual project-delivery level – the level of spend achieved should be seen as a considerable achievement.

11. Activities have been delivered as anticipated, with the types of organisations, technologies and collaborations supported well-aligned to plans. The strands vary in size and stages of technology development, but most projects were early stage (TRL 1-4) at the outset. Projects have involved collaborative R&D (including new partnerships) and multidisciplinary inputs, and many focused on precision farming specifically. Most projects surveyed for the evaluation had adopted a systems approach and/or developed entirely new technologies or introduced existing technologies to the agricultural sector for the first time, and industry engagement was strong.

12. Monitoring data indicate that most projects were delivered effectively, although under-spend and delays were experienced. Notably, projects became increasingly outward-facing over the course of project delivery, regularly engaging in dissemination and knowledge exchange activities.

[1] With IfM, Collison and Associates, IFF Research, Cambridge Econometrics, know.space and Frazer-Nash

Figure 1: TFP Portfolio



Source: SQW. Pictures by UKRI

13. Several key elements of the design and delivery of TFP enabled effective implementation:

- the scale, length and level of ambition, whilst maintaining a strong focus on alignment with sector needs through the challenge led approach
- the balanced portfolio approach, with a mix of smaller, more accessible funding streams and larger-scale longer term projects; within this, the Investor Partnership and Science and Technology into Practice Demonstration strands have worked particularly well
- strong programme management and governance, characterised by a willingness to take risks and pilot new approaches, flexibility and agility where necessary, an openness to feedback and a strong emphasis on continuous improvement.

14. The continuity and strong sector, innovation and technology knowledge across the TFP team was also important. However, the capacity of the team was a constraining factor, including in relation to the delivery of strategic and ecosystem development activities alongside 'core' delivery.

15. As noted, the programme was delivered in a rapidly evolving, challenging and complex landscape, linked to the process of transition to new arrangements in the lead up to and following the UK's withdrawal from the EU, Covid-19, the war in Ukraine and inflationary pressures. The pandemic particularly influenced implementation at both a project and programme level, by causing delays and hindering outreach activities. However, the programme managed the pandemic and this wider grouping of external shocks and uncertainties well.

Project level outcomes and impacts

16. There is strong evidence short-term outcomes have been realised, notably in terms of:

- Knowledge exchange and collaboration, including engagement with end-users and technologies that have been drawn in from other sectors. This has improved the quality and pace at which technologies have been developed, facilitated systems integration and helped to develop products that are better attuned to market needs. TFP is also having a legacy effect on collaboration.
- R&D capabilities, knowledge and skills, including enhanced technical and research skills, knowledge of the agricultural sector, understanding of commercialisation processes, and wider business development and management capabilities.
- Technological progression, including validating/proving concepts or progressing from "proof of concept" to "real world solutions", moving towards better systems integration, and making technologies more accessible/scalable in the marketplace. Crucially, there is strong evidence, including from econometric analysis, that the programme has accelerated the development of technologies at a pace that would not have been achieved without the support.

17. There is also encouraging evidence on commercialisation and the (initial) adoption of some of the technologies progressed, especially in precision agriculture. Many supported organisations are optimistic about taking TFP-funded technologies to market in the near future and are taking steps to commercialise. However, most of these will require further funding to realise this intent.

18. TFP is also contributing to the growth of UK agritech firms, via generating high quality employment and turnover via commercial sales in some organisations to date. The scale of this is modest at this stage in aggregate. However, econometric analysis indicates TFP has had a statistically significant positive impact on employment growth in beneficiary businesses compared to a wider, matched group of businesses. There also appears to have been a significant impact on the proportion of beneficiary businesses that are exporters after TFP, relative to similar unsuccessful applicants. These findings are encouraging, given the stage of many projects and the timing of the evaluation, and indicate the potential for TFP to lead to material economic impact over the longer-term.

19. TFP has also facilitated further investment in R&D, by helping to progress technologies to a stage that de-risks internal and external investment, providing credibility and more robust evidence to underpin investment business cases, and strengthening the investment readiness of organisations involved. The scale of follow-on investment secured, especially from the private sector, is a positive signal of the commercial potential of TFP-funded technologies in the future.

Strategic outcomes

20. The delivery of strategic outcomes increased as the programme matured and sought to impact more fully in this area. At a programme level, key achievements include supporting better co-ordination, aligned priorities and funding between UKRI and Defra in relation to agritech, notably in relation to the Farming Innovation Programme (FIP); providing thought leadership pieces and attending conferences; and playing a convening role on key thematic and priority areas, for example in relation to alternative proteins and VC investment.

21. The programme also helped to strengthen the agritech innovation ecosystem, by connecting some TFP projects, signposting to wider support (e.g. international trade), and centrally promoting projects at events and in showcase documentation. The evaluation also identified examples of projects delivering strategic impacts, e.g. by seeking to influence the wider system and create an enabling environment for their technology.

22. Strategic activities have not been without challenge in terms of capacity and the very complex/fragmented nature of this sector, but appear to have helped to raise the profile of agri-food innovation, encourage greater investment into agritech R&D and support the development of this ecosystem. However, strategic impacts could have been maximised further - especially in terms of raising awareness of TFP, and wider engagement with sector stakeholders/intermediaries, notably on adoption. This may have helped to facilitate and unlock longer-term impact.

Figure 2: Key quantitative outcomes and impacts

Source: SQW. Pictures by UKRI

Conclusions and looking forward

23. At this final evaluation stage, and as the programme comes to a close in March 2024, the evidence indicates that TFP has delivered strongly against its original vision and objectives. It has supported the development of the UK's agritech capabilities, enhanced the connections across and resilience of the innovation ecosystem, and enabled the acceleration and progression of technologies that are expected to impact on productivity *and* GHG emissions in the agricultural sector in the long-term. The programme was very well aligned to key sector trends and drivers, notably the collection and exploitation of data, systems integration and automation, which should aide longer-term adoption.

24. The Contribution Analyses undertaken for this evaluation, across both core outcomes and strategic impacts, suggests genuine 'additionality'. Whilst other factors have played a role, the evidence indicates a plausible 'contribution claim' that outcomes observed – for supported organisations and the wider landscape – can be associated with the programme. This is a positive overall finding given the complexity of the agri-food landscape, level of risk associated with the programmes activities, and the very challenging delivery context.

25. In looking forward, the final points are made based on the evidence from across the evaluation:

- First, the 'ISCF model' has worked well for TFP, with the ability and autonomy this enabled to evolve, adapt and test new/innovative approaches generating valuable lessons, which should inform on-going activity in this space. The pivot to a materially different approach in Phase 2 was risky but successful and should be seen as effective practice.

- Second, by its close strategic benefits were starting to emerge from TFP, and there was a greater emphasis on this activity by the team. However, in hindsight, more ringfenced resource and a clearer delivery plan from the outset for non-project, strategic activities seeking to influence the wider ecosystem and create the 'conditions' for longer-term success was needed. There is a wider lesson here about the scale of opex required to deliver a programme of this nature and drive through impact, including by influencing the wider system in which collaborative R&D projects operate. This experience and learning should inform successor interventions.

- Third, TFP has supported a very wide range of technologies/subsectors. It is important that resource is available to consolidate and build on this and develop critical mass. The continuity provided by Defra's FIP and other more recent UKRI schemes, and the 'follow-on fund' to support projects in their commercialisation journey are extremely valuable in this context. However, across the technologies funded by TFP and the remit of FIP, there may be some gaps in future funding. A 'mapping and gapping' exercise to help inform future investment (and identify where there is market failure) is recommended.

- Fourth, TFP has delivered strongly in the development of new and innovative technologies i.e. on the 'supply side'. However, to 'shift the dial' of agricultural productivity and emissions,

precision technologies will need to be adopted at scale and pace. The programme has achieved less in this area at this point, and major barriers remain on the 'demand side' including awareness, capability, finance and willingness to adopt by businesses, and a fragmented support landscape. Adoption is a major system-level challenge, that requires a system-wide and increasingly co-ordinated response.

- Fifth, and linked to the previous point, there is a major opportunity to leverage and carry forward the valuable learning and legacy from TFP. Visible dissemination and promotion of TFP benefits and its projects, maximising the potential from the continuity in the knowledgeable delivery team in the on-going implementation of FIP, and ensuring effective ongoing stakeholder engagement will be key to this. Many of the lessons learned through TFP are also relevant for FIP (including the forthcoming Fund 3, ADOPT), and the establishment of an Agri Tech Catapult.

1. Introduction

An introduction to the Transforming Food Production Industrial Strategy Challenge Fund

1.1 In 2017, the Government's Industrial Strategy set out the long-term plan to "boost productivity and earning power throughout the UK". Clean growth was one of four 'Grand Challenges' identified in the Industrial Strategy where the UK had the opportunity to play a leading global role in 'industries of the future'. This included the ambition to 'put the UK at the forefront of the global move to high-efficiency agriculture'. To deliver against the Grand Challenges and invest in strategic innovation, the Industrial Strategy introduced Industrial Strategy Challenge Funds (ISCFs). These were a core pillar in the Government's commitment to increase funding in research and development (R&D) by £4.7bn over four years, with a focus on investing in world-class research and highly innovative businesses to accelerate the application of industry-led solutions to address major economic and societal challenges. The emphasis was on developing technologies, products, processes and services where the global market is potentially large and the UK has the capabilities to become a world-leader.

1.2 The Transforming Food Production (TFP) ISCF programme was announced in 2017 under the Industrial Strategy's Clean Growth Grand Challenge. The TFP programme set an ambitious goal: *to accelerate the development and adoption of integrated precision approaches that will improve the productivity and resilience of primary food production systems and, at the same time, to set the sector on a trajectory to net zero emissions by 2040*. TFP was initiated in 2018 with an original budget of £90m. Since then, UKRI (in partnership with BBSRC) has delivered a range of activities that are designed to progress the use of data-driven precision agriculture approaches, to develop novel, non-conventional and disruptive food production systems, and to accelerate investment, growth and internationalisation of the UK's agritech firms. The programme is seeking to tackle system level challenges, focusing on technologies that have the potential to transform the primary food production sector. The TFP programme will draw to a close in March 2024.

Overview of the evaluation

1.3 SQW, together with the Institute for Manufacturing (IfM), Collison and Associates, IFF Research, Cambridge Econometrics (CE), know.space and Frazer-Nash, were commissioned by UKRI in Autumn 2020 to lead a longitudinal evaluation of the programme.

1.4 The overall purpose of the evaluation is to "gain insight into the outcomes and impacts of the programme" and "assess both the programme itself and the process through which it is delivered".[2] There have been five phases to the evaluation: the development of a peer reviewed evaluation framework in March 2021 (Phase 1), a baseline report in May 2021 (Phase 2), a

[2] Source: UKRI (2020) Transforming Food Production: Evaluation Brief

process evaluation in late 2021/early 2022 (Phase 3), a progress evaluation in Autumn 2022 (Phase 4), and a final evaluation in Summer/Autumn 2023 (Phase 5).

1.5 The overall approach to this evaluation has been theory based and employing mixed methods. This has involved analysis of programme monitoring and contextual data on the agri-food landscape, two waves of surveys with beneficiaries, unsuccessful applicants and businesses in the wider sector (at baseline and final impact stages), in-depth 'impact tracing' case studies of supported projects, in-depth consultations with stakeholders and project leads, a technology tracing exercise (including expert workshops), econometric analysis of impacts, contextual sector projections, and international reviews/learning. Further details on the methodology is presented in Section 2 and Annex B. Emerging findings have been shared with UKRI throughout and have been used to inform ongoing implementation.

Focus and structure of this report

1.6 As outlined above, the evaluation has encompassed both process and impact evaluation. A separate process evaluation report was produced for URKI in early 2022, the findings of which are not repeated here. This report focuses on impact evaluation, drawing primarily on evidence gathered in Phase 5 (and, where appropriate, evidence from the progress evaluation in Phase 4).

1.7 The report is structured as follows:

- Section 2 sets out the evaluation aims and approach
- Section 3 provides an overview of the TFP programme, including its vision and objectives, planned activities and intended outputs, outcomes and impacts
- Section 4 provides an assessment of TFP's inputs and activities
- Section 5 presents evidence on outcomes and impacts achieved at project level
- Section 6 presents evidence on TFP's strategic and wider impacts
- Section 7 summarises feedback on additionality and includes the econometric counterfactual analysis
- Section 8 discusses factors that have helped or hindered outcomes and impacts
- Section 9 presents analysis of quantitative and qualitative futures
- Section 10 presents the overall conclusions and final reflections on TFP's performance.

1.8 The report is supported by a series of annexes in a separate document. This includes more detail on the programme and evaluation methodology, stakeholders consulted for the evaluation, additional analysis of Beauhurst and survey data, and summary technology statements.

2. Evaluation aims and approach

Key messages

- This final phase of the evaluation has assessed whether TFP has delivered the outcomes and impacts intended (or will do so in future) and delivered against its vision and objectives. It has also considered the role of programme design/implementation and wider external influences.
- The evaluation has adopted a theory based approach with Contribution Analysis, based on mixed methods, including qualitative and quantitative research and analysis.

Research Questions

2.1 The TFP evaluation framework set out two overarching impact evaluation research questions:

1: Has TFP delivered / Will TFP deliver the attributable outcomes and impacts expected given its original rationale and objectives?

2: Has TFP successfully set food production systems on a trajectory to achieve productivity and sustainability goals, and net zero emissions by 2040?

2.2 A series of sub-questions were developed in discussion with UKRI. These are presented in Table 2-1. Four points are highlighted in relation to the evaluation sub-questions.

- First, there is an important relationship between process and impact, whereby the effectiveness and appropriateness of implementation – including whether activities are delivered as anticipated – may influence the ability of individual projects and the programme to realise its anticipated outcomes and impacts. Evidence on process is important in explaining how and why outcomes and impacts have been realised. This phase of the evaluation has therefore included process-related research questions that relate to '*mechanisms that explain impact/causality*'. This phase has not revisited research questions that relate to '*processes and implementation*', which were covered in Phase 3.

- Second, it is important to emphasise caution in the extent to which it is possible to evidence indirect/longer-term impacts at this stage, particularly as many TFP projects had only recently completed or were still live at the time research was undertaken for Phase 5. Furthermore, innovation processes are typically non-linear with a long lag time before new technologies are adopted (particularly at scale), and so the full impacts of the programme are likely to be realised after this impact evaluation (with associated uncertainty looking forward). The focus has therefore been on leading indicators and the potential future contribution of the programme to longer-term impacts (recognising the limitations of precisely quantified estimates in complex and evolving systems).

- Third, the programme comprises a variety of strands, with different project durations/timings, composition and distance from market. Nested logic models have been developed for each strand (see Annex A) to structure evidence gathering. However, the research questions (RQs) will be considered at the *level of the programme overall* (i.e. answers to each question have not been segmented by strand, as agreed in the evaluation framework).

- Fourth, the contribution of ISCF programmes to Equality, Diversity and Inclusion (EDI) outcomes will be assessed through the overarching ISCF evaluation[3], and not within scope of this evaluation of TFP.

Table 2-1: Evaluation Sub-Questions

Impact Evaluation	
Direct outcomes & impacts	To what extent and how has TFP: • strengthened effective connectivity & collaboration to increase knowledge exchange (KE) and engagement, especially business-academic, between small/large/value chain businesses, and encouraging new techs/players into agritech (AT)? • improved R&D capability and capacity in AT? • increased private R&D investment in the development of AT techs/production systems (in UK & overseas)? • stimulated the development of novel high value production systems to position UK AT technologies at the forefront? • contributed to the development of export opportunities for the UK's AT firms? • driven business growth & improved business performance in the UK's AT firms? • increased foreign direct investment (FDI) in the development of precision techs/production systems? • generated any unexpected or unintended outcomes? To what extent and how have various aspects of TFP generated intended outcomes?
Indirect/ longer-term impacts	To what extent and how has TFP: • led to sustained, ongoing industrial engagement in R&D • delivered "leading outcomes" on the pathway to intended adoption / productivity / low carbon outcomes in the agricultural sector? • increased or accelerated the implementation and adoption of precision technologies (through the development and commercialisation of integrated low emission data driven solutions) to increase UK agricultural productivity and reduce carbon impact?

[3] The overarching ISCF evaluation includes the following research questions: How has ISCF contributed to EDI? Specifically, how are the ways which ISCF embed EDI in its processes and delivery (from Challenge inception to close out)? How has ISCF contributed to thought leadership of EDI in ISCF, UKRI and its external participants? What is diversity in the membership of advisory and programme boards and Challenge teams? How effective and wide reaching is the ISCF communication and engagement to support EDI? What were the diversity characteristics of the applicants, lead investigators and project partners, and application assessors)?

	• led to wider spillover effects? What wider influence on actors in the agri-food landscape have TFP activities generated? Incl. individual flagship projects/groups of projects acting as "influencers" (e.g. FFPS & IP strands)
Strategic/ system level effects	To what extent and how has TFP as a Challenge: • influenced the UK's position as a location to undertake world-class research and innovation to transform/improve food production practices? • added value strategically to the agri-food innovation landscape? E.g. strengthening ecosystem, influencing behaviours/policy? To what extent has the challenge-led and systems-based approach of TFP been effective in delivering the intended scale/nature of impacts?
Related process evaluation questions (i.e. mechanisms that explain impact/causality)	
Project level	To what extent have projects adopted a systems level approach & engaged effectively with the wider innovation / agri-food system in order to realise intended outcomes and impacts? How effectively has the TFP team facilitated this, in working with projects?
Challenge level: Design & delivery	To what extent has the design and delivery of TFP (including the different strands) enabled TFP to achieve its objectives, and reflecting sector needs and wider existing support landscape? Are there any barriers or facilitators (between TFP, industry, end users) that contribute to realising change? To what extent and why has TFP hit (or not) its target audience, and what are the implications?
Challenge level: Governance, management & monitoring	To what extent and how do governance structures and processes add value and contribute to impacts? What's distinctive? To what extent and how has Covid-19 influenced implementation at a project and/or Challenge level? How effectively have projects and/or Challenge adapted in response?
Strategic/ system level	To what extent has TFP as a Challenge engaged effectively and aligned strategically/practically with the wider innovation system, actors and other interventions in order to realise intended impacts? What added value can TFP bring in supporting sustained/ongoing industrial engagement in R&D over the long term?

Source: TFP Evaluation Framework (2021)

Approach

Overall approach

2.3 The programme exhibits key features identified in the Magenta Book that characterise complex interventions, with a range of different types of beneficiaries and interventions (with projects

that range in terms of scale, timing and duration), and has operated in a rapidly evolving innovation landscape and diverse and fragmented sector. In this context, and in light of the research questions above, **the evaluation has adopted a theory based approach with Contribution Analysis**. This is also consistent with UKRI's ISCF Evaluation Guidance.[4]

2.4 Contribution Analysis is an approach that assesses and compares the evidence collected on *what has actually happened* as a result of an intervention, against the intervention's original theory of change of *what was expected to happen.* This draws on a logic model and underlying theory as to how intended outcomes and impacts were to be brought about.[5] Evidence is gathered on an intervention's contribution to the observed outcomes and impacts, which is then used to construct a "contribution story" on whether the intervention was important in generating observed outcomes and impacts relative to other factors[6], such as external market, policy or environmental conditions and wider trends. In this, a *plausible association* can be made (or attribution demonstrated beyond reasonable doubt) if: (i) a reasoned theory of change is set out; (ii) the activities have been implemented as set out in the theory of change; (iii) the chain of expected results has occurred; and (iv) other influencing factors have been shown not to have made a difference, or the decisive difference. The process is based on a six-step method to gather evidence and develop a 'contribution story', which is summarised in Annex B.

Methodology

2.5 The evaluation has adopted a mixed methods approach, gathering quantitative and qualitative evidence from multiple sources to increase confidence in the results. This has included: "bottom up" methods, which provide evidence on performance, both in terms of projects and the programme as a whole; and "top down" methods, which provide contextual evidence on change in the agricultural sector and innovation landscape, to inform an understanding of pre-intervention conditions, and how these have evolved during the delivery of TFP, and are expected to change in future.

2.6 This report draws primarily on the methods implemented for the final impact evaluation (Phase 5), which included: analysis of monitoring and contextual data; telephone surveys with beneficiaries, unsuccessful applicants and the wider sector (Wave 2); stakeholder consultations; in-depth case studies (project and strategic); econometric and quantitative futures analysis; an updated technology tracing exercise; and updated contextual sector projections. The fieldwork for Phase 5 took place in late Summer and Autumn 2023. Where appropriate, we have also drawn on fieldwork undertaken for the progress evaluation (Phase 4) and compared progress to the

[4] This stated the following: "*We expect evaluations to provide an overarching framework for understanding, systematically testing and refining the assumed connections (the theory of change and logic model) between ISCF funding and the anticipated impacts. Within this, a range of methods may be appropriate, such as contribution analysis, which seeks to validate the logic model with evidence gathered, taking account of other influencing factors which may have led to the reported outcomes and impacts.*"

[5] Mayne, J. (2001) *Addressing Attribution Through Contribution Analysis: Using Performance Measures Sensibly*, The Canadian Journal of Program Evaluation, Vol. 16 No. 1, pp. 1-24.

[6] White and Phillips (2012) *Addressing Attribution of Cause and Effect in Small n Impact Evaluations*, International Initiative for Impact Evaluation Working Paper 3.

baseline (Phase 2). An overview of the methodology and key workstreams that have informed the final impact evaluation are presented below. Further details are available in Annex B.

Figure 2-1: Methodology overview (Phases 5 and 4)

Source: SQW

3. Overview of the TFP programme

Key messages

- TFP sought to tackle significant and longstanding challenges in the agricultural sector relating to productivity and greenhouse gas emissions. The original rationale for intervention was strong, to tackle market and other failures that hindered investment in R&D to address these issues and an opportunity to deliver positive externalities from a policy perspective.
- TFP began implementation in mid-2018 and will end in March 2024. It was delivered across a diverse and fragmented sector, and a rapidly evolving, challenging and complex delivery landscape.
- The overarching goal was to "to set food production systems *on the trajectory to* net zero emissions by 2040", recognising the long-term nature of challenge, and time-paths to impact. TFP sought to both accelerate the development *and* embed the adoption of integrated precision approaches, and in doing so, increase investment in R&D, drive growth in UK agritech firms (including via exports) and stimulate the establishment of novel high value production systems to position UK agritech at the forefront globally.
- TFP was delivered in two phases: Phase 1 (up to 2019) provided funding for small, academic led 'seeding' awards and 'traditional' R&D projects. Phase 2 (from late 2019 onwards) saw a significant shift in approach to include more ambitious, innovative and systems focused R&D projects. Given the intention to drive forward adoption (and develop precision technologies), effective engagement with wider actors in the innovation/agricultural landscape was necessary to realise long-term impacts. Phase 2 also included a greater emphasis on programme-level and strategic activities, which were intended to ensure that TFP was '*more than the sum of its parts*'.

Implications for the contribution story

- The programme had a well-reasoned theory of change (ToC), with anticipated outcomes and impacts – and the routes to these outcomes and impacts – clearly identified. A wide range of potential factors were anticipated to influence programme delivery and success, internal to the programme and in the wider research and innovation and agriculture landscape.
- The detail of the ToC and routes to outcomes and impacts varied in emphasis and scope across TFP's strands. However, each strand had clear alignment to the overarching ToC, and there was strong overall coherence across the programme.

3.1 In this section, we present an overview of the TFP programme, including the original rationale and context, objectives, inputs and activity strands, and intended outcomes and impacts. This section also includes an overarching logic model for TFP, which provides the framework against which the performance of the programme has been assessed.

Context and rationale for intervention

3.2 The agriculture sector is facing unprecedented challenges in terms of a growing global population and food demand, with associated pressure to increase yields/productivity, and the drive towards net zero and wider environmental imperatives. In this context, **UK agriculture has seen**

a long-term trend of "slow but steady overall improvement"[7] in productivity. This varies substantially across sub-sectors, but in aggregate **the UK had failed to keep pace with progress in competitor countries** (e.g. Germany, Holland, France, US).

3.3 **Agriculture also accounted for 10% of all UK greenhouse gas (GHG) emissions in 2017**.[8] The environmental challenge for agriculture is multidimensional, spanning multiple aspects of farming (e.g. input efficiency, land use, water and air pollution, biodiversity, plastics, renewable energy, animal health, genetics etc) and types of GHG emissions (particularly methane and nitrous oxide, plus carbon dioxide), as well as presenting opportunities associated with carbon capture. The level of GHG emissions from UK agriculture has been relatively static over the last decade.

3.4 Contextual evidence gathered for the baseline phase of this evaluation reinforced the original rationale for TFP, particularly in terms of the need to address substantive and long-term productivity and GHG emission challenges in the agricultural sector, as illustrated in Figure 3-1.

3.5 The sector was also adjusting to the effects and implications of Brexit, including impacts on labour supply and trade flows, during the programme period. More recently, Covid-19 has compounded and accelerated labour supply issues, increased demand for food in retail, raised questions around agri-food supply chain management/shortening, reinforced links between diet and health, and created opportunities for agri-food technologies in enabling a "green recovery" and strengthening the UK's resilience to future shocks.

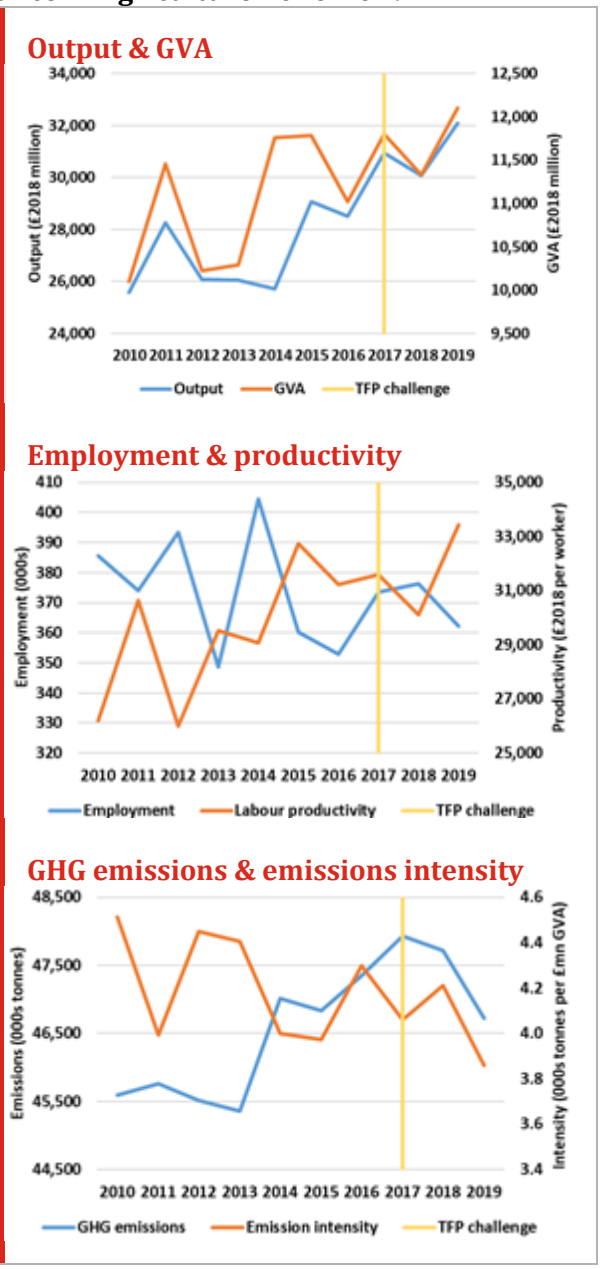
[7] Source: Defra (2020) Total factor productivity of the UK agriculture industry
[8] Source: Defra (2019) Agricultural Statistics and Climate Change

Figure 3-1: Economic and emissions performance in Agriculture 2010-2019

Since 2010, the UK's agricultural sector has seen an improvement in productivity and GVA performance. GVA growth in agriculture was broadly in line with the UK economy as a whole, but productivity growth out-paced the UK average, in part driven by falling employment in the sector. However, this was not sufficient to close the productivity gap with the UK average, and a substantial productivity deficit was evident when TFP was launched in 2017. The gap remained in the most recent data for 2019, with agricultural productivity around one-third lower than the UK average.

Agricultural GHG emissions increased between 2010 and 2017, but declined in 2018 and 2019. Although fluctuating annually, overall emissions intensity has improved over the 2010-2019 period. However, agriculture still accounted for a significant share of UK emissions in 2019 (~12% emissions compared to 0.7% of GVA) with an emissions intensity ~17 times higher than the UK economy average.

Over this period, energy consumption in the agricultural sector also rose and accounted for an increasing share of the UK total. However, the increase in use of non-fossil fuel sources in agriculture has out-paced the UK average.



Source: TFP Evaluation (2021) Baseline Overview Report. Data sources: Cambridge Econometrics and Defra. Note: Economic activity in Agriculture is dominated by Crop and Animal Production, which accounted for almost 100% of output, GVA, employment, investment exports and GHG emissions in 2019

3.6 The UK is well positioned to respond to these challenges and opportunities with its world-class research and innovation expertise in agri-food technologies and precision production processes, supporting both domestic agriculture, and export opportunities. There is also a strong and growing base of technology entrepreneurs, including start-ups in areas such as agricultural software, non-software agricultural technology, satellite imaging, and urban farming, complemented by strong talent in hybrid tech sectors. However, funding gaps (particularly for mid-stage R&D) have hampered the commercialisation of new innovations in agritech, like many other sectors. Also, despite a growing Venture Capital (VC) interest in agritech and the global potential for growth in this sector, securing private investment remained a challenge for UK

agritech firms. According to research commissioned to inform the programme's Investor Partnership strand of TFP, the early stage companies in the agritech sector struggle to move on to later stage investment.[9]

3.7 Encouraging the adoption of new innovations – both at pace and scale – in the agricultural sector was seen as essential to address the challenges outlined above. However, long-standing "*fragmentation and coordination failures in the current UK innovation system*" has limited the translation of R&D/innovation into productivity improvements on the ground.[10] Whilst the UK is home to world-leading agri-food technology expertise and R&D, translating new innovative products and processes into changed behaviours and practices on farms has been a significant challenge in the UK, reflecting both supply-side and demand-side factors (see Annex A for further details).

3.8 The competitiveness of the UK's agriculture sector is important both economically and environmentally, and transformational and widespread innovation is critical to achieve the necessary step change in performance. These issues are at the forefront of the programme and wider Government policy. In 2013, the Government's Strategy for Agricultural Technologies set the ambition for the UK to become a world leader in agricultural technology innovation to increase productivity and sustainability. Government placed productivity and clean growth at the centre of the 2017 Industrial Strategy, which underpinned the creation of the TFP ISCF Challenge. More recently, the Agriculture Bill (ratified in mid-November 2020) sets out how farmers will be rewarded for "public goods" that contribute towards net zero emissions, increased productivity and food security in the transition away from farm subsidies. Innovation to "sustainably boost production and profitability" is also central in the National Food Strategy.

3.9 This high-level summary of the context illustrates how the programme was developed, and has subsequently been delivered, in a complex landscape – with a sector that is large, diverse and fragmented, with a myriad of actors, and influencing factors both domestic and global. Furthermore, there are long-standing issues that prevent the sector from addressing many of these challenges without intervention. The original TFP Business Case[11], identified a number of market and other barriers to justify intervention including:

- **Positive 'spill over' benefits that arise from investment in agricultural R&D**[12], meaning that private firms are often unable to capture the full returns on their investment because of the complexity of the agriculture value chain.

- **Underinvestment in R&D due to long lead times and low margins**. In addition, information failures mean farmers are not always equipped to make informed commercial decisions.

[9] Farm491 (2019) Agri-Tech Investment Ecosystem: Analysis, Findings and Recommendations (a Report to UKRI)
[10] Source: Defra (2019) The Future Farming and Environment Evidence Compendium
[11] Note, the business case and the underpinning evidence base were not formally updated between Stages 1 and 2
[12] Such as food security and sustainability/environmental benefits

- **Complex, diverse and fragmented supply chains** that make addressing cross-cutting sectoral issues, or large-scale innovation challenges, problematic. Collaboration is inherently difficult, and cost can prevent individual businesses leading engagement.

Vision and objectives

3.10 The TFP programme was introduced in 2017 to accelerate the shift to clean growth through the development of low carbon technologies, systems and services. ISCF programmes were challenge-led and highly ambitious, as illustrated by the Challenge Vision for the TFP programme:

"To set food production systems on the trajectory to net zero emissions by 2040. Accelerating the development and adoption of integrated precision approaches to improve productivity in agricultural systems and enable food to be produced in ways that are more efficient, resilient and sustainable. Driving economic growth across the country"

3.11 This Vision for TFP was underpinned by five objectives:

- create integrated data-driven solutions to drive primary agricultural productivity whilst driving towards net zero emissions
- embed adoption of precision approaches to bridge the productivity gap, strengthening connections between researchers, businesses and practitioners
- stimulate the establishment of novel high value production systems to position UK technologies at the forefront of new industries
- drive growth in UK precision technology companies, creating high value jobs and adding value in the UK agricultural value chain
- develop export opportunities for UK businesses and increase investment into UK research and innovation.

Design and implementation

3.12 A total of £90m was originally allocated to TFP, with additional match funding from private and public sources anticipated. There have been two distinct stages of the programme: 'Phase 1' from the launch in 2017 and delivery through to mid-2019; and 'Phase 2' from September 2019 onwards (the programme was awarded a one year uncosted extension to March 2024 in the process). The programme was structured around seven main "strands", each targeting a different stage of the R&D process and different in scale, duration and timing, but all ultimately aiming to improve productivity and reduce emissions in the primary food production sector. The strands are outlined below.

Table 3-1: Programme strands

Name	Description	Total project size	Anticipated Duration
Phase 1			
Seeding Awards	Small-scale R&D projects awarded via the Biotechnology and Biological Sciences Research Council (BBSRC) to academic institutions and research organisations to accelerate progression from discovery/basic research to Proof of Concept, enabling follow-on funding to then be secured to progress towards commercialisation.	£25k - £50k	6 months
Blue Zone Projects[13]	R&D projects focused on data-driven, Artificial Intelligence (AI) technologies. The projects were drawn from a pool of high quality but unselected applications from other non-TFP Innovate UK competitions.	£2m - £5m (max)	Up to 36 months
Collaborative R&D Round 1 (CR&D1)	R&D projects focused on developing optimised prototypes to improve productivity or supply chain solutions for sustainable crop protection and ruminant systems.	£2m - £5m (max)	Up to 36 months
Phase 2			
Future Food Production Systems (FFPS)	Sought to disrupt traditional land-based models of production by developing novel resource efficient and low emission food production systems, contributing to thought leadership on the transformation of current food production systems. It explicitly targeted multi-disciplinary, large scale and ambitious projects.	£1m - £10m	24 – 33 months
Science and Technology into Practice (STiP)	Designed to demonstrate near market solutions at commercial scale and across different production environments, providing end-users with evidence of technical feasibility and economic viability of combinations of precision solutions across one or more applications.[14] Included feasibility and demonstration projects.	**Feasibility studies:** £75k - £250k[15] **Demonstration:** £400k - £4m[16]	**Feasibility studies:** 6 – 18 months **Demonstration:** Up to 30 months
International Bi-Lateral interventions with China and Canada	Supported collaborative projects with overseas partners, focusing on the development of new technologies that provide opportunities for UK agritech companies to gain traction in rapidly expanding	**Canada:** £570k - £1.6m	**Canada:** 24 - 29 months **China:** Up to 36 months

[13] TFP has also issued Covid-19 continuity grant funding to existing Blue Zone projects in the portfolio

[14] The strand has two elements: (i) feasibility projects designed to accelerate the development of early stage precision solutions in a commercial environment (also considering the feasibility of business model, and routes to adoption); (ii) large-scale demonstration projects focused on the technical feasibility and economic viability of integrated precision solutions across different commercial environments to encourage their widespread use (projects must embed effective knowledge exchange during/after delivery).

[15] Exceptional projects over £250k would be considered

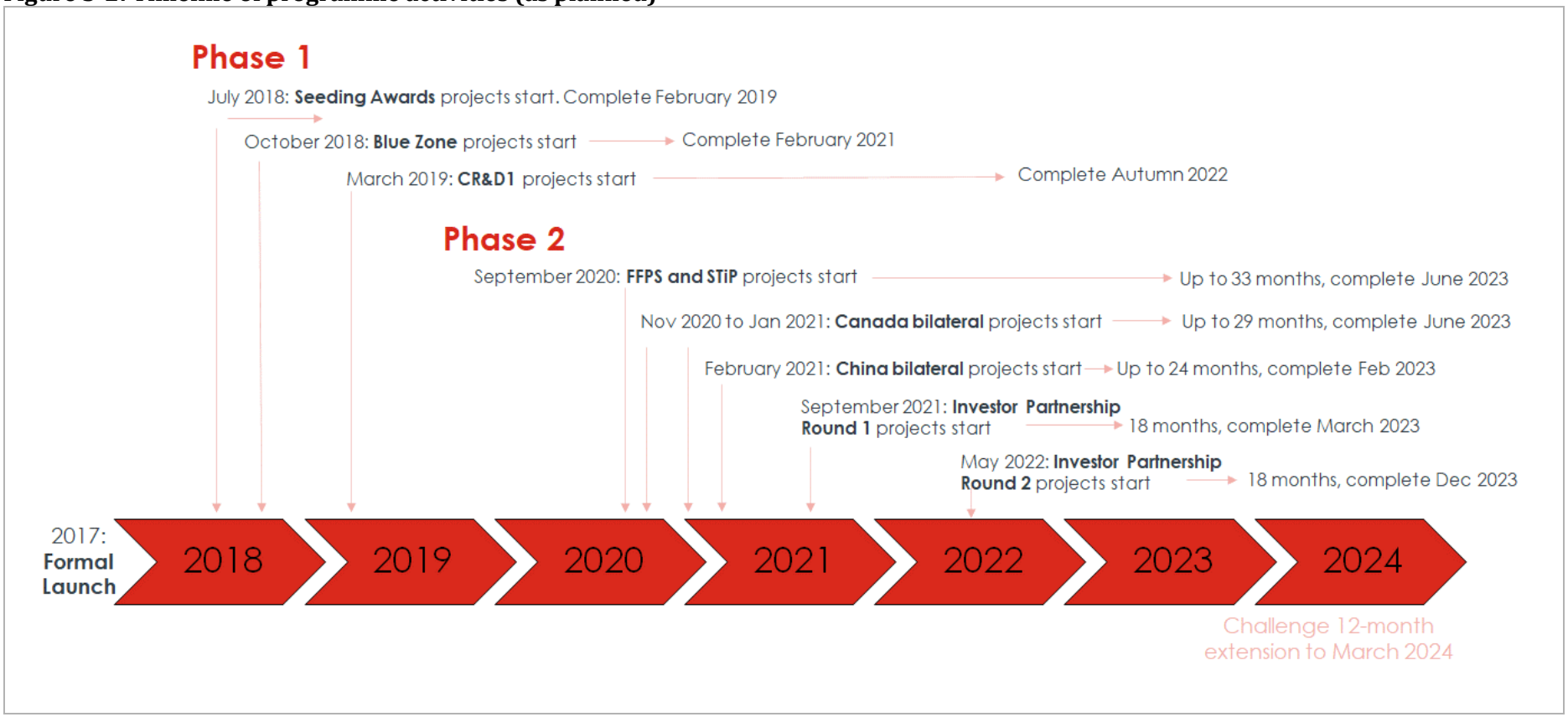
[16] Exceptional projects over £4m would be considered

Name	Description	Total project size	Anticipated Duration
Phase 1			
	precision agriculture markets in Asia and North America.	**China:** £1m - £2m[17]	
Investor Partnerships	Grant funding offered alongside private VC equity investment to support the commercialisation of later-stage R&D and growth of agritech firms (as well as encouraging new VCs into the agritech space). Specifically targeted Series A investment deals into UK firms, representing the first meaningful investment (c.£1m - £4m) that typically supports the company transitioning from a pre-revenue business to generating commercial revenue. Again, the focus was on data-driven solutions for the sector.	£1m - £4+m	18 months

Source: TFP Evaluation Framework, 2021

[17] For both Canada and China, total project cost is based on grant available and variable intervention rates (based on applicant size and type of project)

Figure 3-2: Timeline of programme activities (as planned)



Source: TFP programme documentation

3.13 The programme sought to engage a wide range of businesses (including micro firms and small and medium-sized enterprises, SMEs), academics and research organisations across these strands, including both those already working in the agriculture sector and new entrants.

3.14 There are three important distinctions between TFP and previous interventions in this space:

- First, TFP was not intended to be a continuation of "business as usual" R&D funding; rather, the focus was on supporting ambitious projects that will make a "significant step towards" net zero targets and improving productivity, with scope for transformational impact.
- Second, TFP and the projects within it, were expected to adopt a "systems approach"[18], in recognition that collaboration across the food system (including supply chains) and integrated approaches were expected to generate greater and more prolonged impacts.
- Third, in line with HM Government's Industrial Strategy in 2017, TFP encompassed both the need to accelerate the development and commercialisation of new technologies / products / processes *and* help to drive forward their adoption in the wider sector. This means that effective engagement with wider actors in the innovation/agricultural landscape, be it through partnership working, knowledge exchange or dissemination activities, was expected to be critical if long-term impacts are to be realised.

3.15 Reflecting the programme's aims and design, there are multiple and interrelated outcomes and impacts. These are expected to be realised both for those engaged in agritech activity (i.e. agritech firms and research institutes developing new technologies), *and* the wider agriculture sector (i.e. farms/other producers that will adopt the new technologies). They also span both economic (i.e. business performance, productivity) *and* environmental (i.e. reduced emissions) impacts.

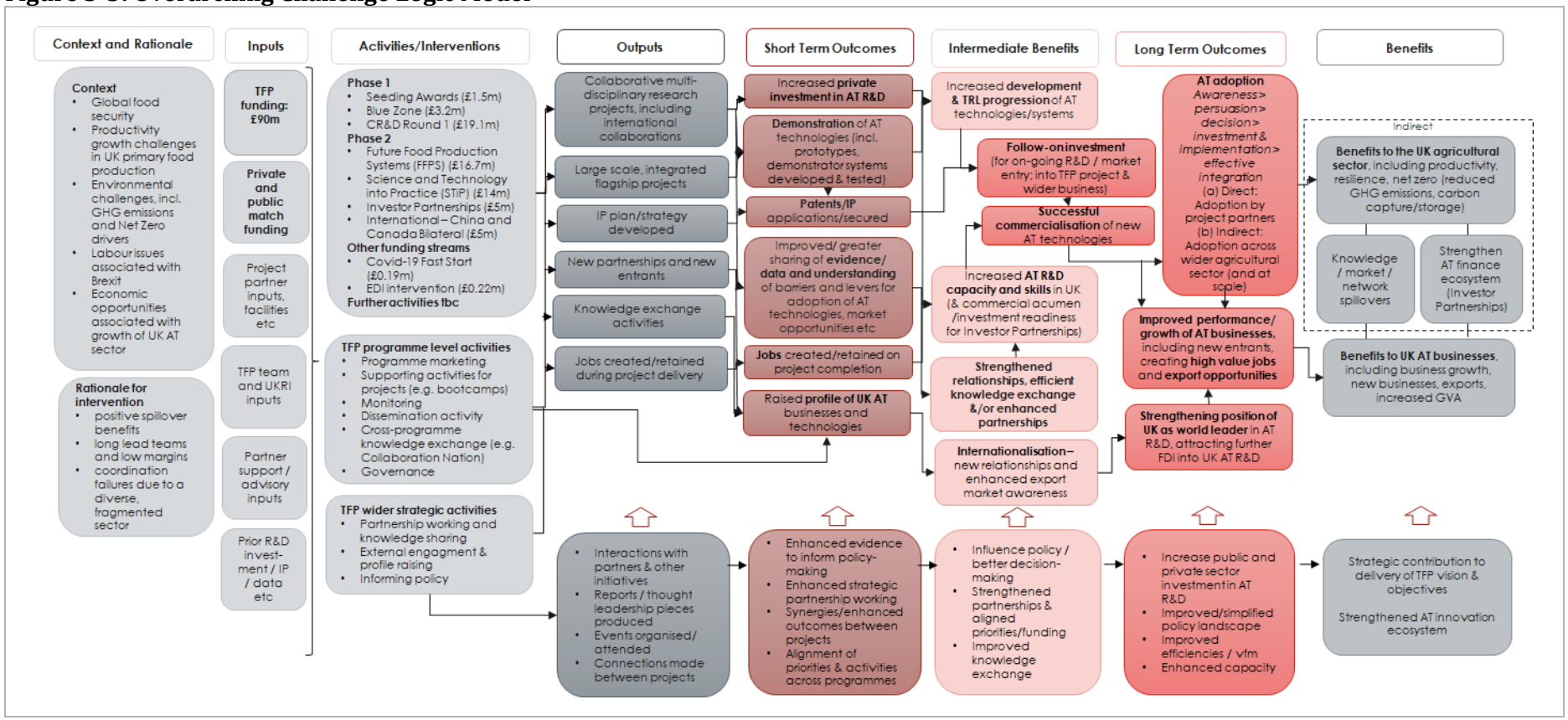
Logic Model and Theory of Change

3.16 In line with good practice and Government evaluation guidance[19], a logic model and theory of change has been developed for the programme. This shows how the inputs and activities of an intervention are expected to contribute to intended outputs (i.e. a measure of activities) and relevant outcomes and impacts (which relate back to the programme's aims and objectives). Figure 3-3 presents the overarching logic model for the TFP programme. It is supported by a review of factors that might enable or cause the theory of change to break down, and wider external drivers that may influence the progress and performance of the programme, which is presented in Annex A.

3.17 The logic model and theory of change provide a robust framework for the evaluation and structured approach to evidence gathering.

[18] In this context, the TFP team's definition of "systems approach" relates to activity being designed and delivered with a recognition of the role of, and an aim to engage with, other actors across the food production value chain, and with actors/initiatives across the agri-food innovation landscape.
[19] HM Treasury (2020) *Magenta Book: Central Government guidance on evaluation*. Available here.

Figure 3-3: Overarching Challenge Logic Model



Source: SQW. Note: the adoption process outlined above draws on BEIS framework to describe technology adoption process. Acronyms: AT – Agritech; IP – Intellectual Property; EDI – Equalities, Diversity and Inclusion; vfm – value for money

4. Inputs and activities

Key messages

- The large majority of programme budget has been committed, with c.£70m allocated to projects and c.£5m allocated to operational costs. In addition, TFP was expected to secure £36m in co-investment (i.e. match funding), plus £30m from VC investors in the Investor Partnership strand. The budget for TFP was reduced by approximately £13m in early 2022 following a decision by central UKRI/BEIS, which meant that existing investments could not be built upon as planned.
- Expenditure on projects was 82% (£57.4m) of the £70m allocation by September 2023, leaving 18% (£12.6m) to be spent over the final six months. At the time of the evaluation, one third of projects were at final claim stage or live, so the majority of the outstanding budget should be spent by the end of the programme. There is likely to be a small underspend overall. Given the very challenging delivery context and the scale of activity supported, this is not unreasonable.
- The programme funded projects under several strands as anticipated. The strands vary in size and stages of technology development (although the majority focused on the TRL 1-4 stage). Projects relating to precision farming specifically (rather than wider agritech areas), account for a substantial share of the programme. This is closely aligned with the programme objectives and national/global priorities in agritech.
- Projects involved 217 organisations. Three quarters were businesses, and over two thirds of these were small businesses, including end-users of agritech. Most beneficiaries had prior R&D experience. Projects have involved collaborative R&D (including new partnerships) and multidisciplinary inputs. Most projects surveyed had adopted a systems approach and/or developed entirely new technologies or introduced existing technologies to the agricultural sector for the first time.
- Projects became increasingly outward-facing over the course of project delivery, engaging in a variety of dissemination and knowledge exchange activities.
- In assessing TFP's performance, it is important to recognise the substantial and significant external changes that occurred during the programme's lifetime – and therefore the context in which the programme was delivered, notably in terms of Covid-19 (see Section 8 for further discussion).

Implications for the contribution story

- Activities were delivered and targeted as anticipated, with the types of organisations, technologies and collaborations supported closely aligned to expectations set out in Section 3. However, challenges have been faced in delivery leading to delays and underspend. Given the context for delivery (notably Covid-19) and the nature of the funded projects (explicitly high risk and associated uncertainty), overall progress has been strong.
- These findings are important context for the remainder of the report and frame the extent to which we may realistically expect to observe outcomes/impacts at this stage given the nature of projects funded. Importantly, many projects have only recently completed and some are still underway, including some of the largest projects (e.g. FFPS projects).

4.1 In this section, we present an overview of progress to Autumn 2023 at both a programme and project level, and characterise the supported projects and organisations; this represents the position on inputs and activities approximately six months before the end of the programme. It is

also important to recognise the challenging context in which the programme was delivered, with the majority of Phase 2 being implemented during Covid-19. More detailed analysis is provided in Annex A. The TFP team has also engaged in wider programme level, strategic activities; these are discussed in Section 6.

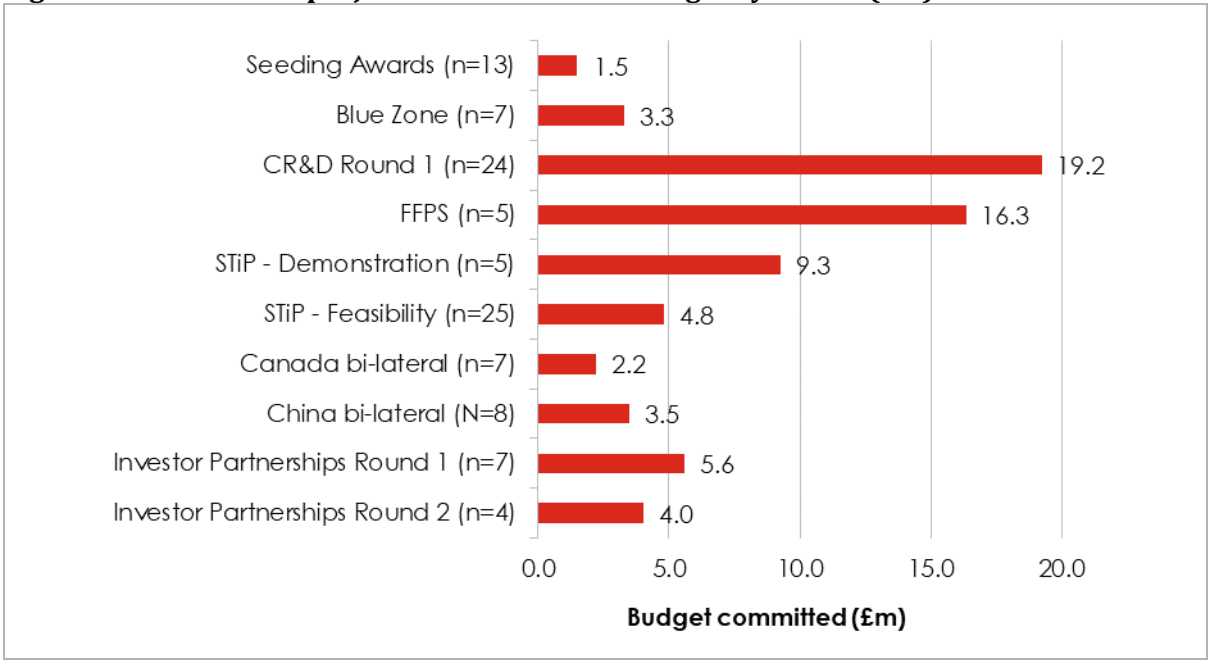
Programme portfolio and expenditure

Overall TFP commitment and expenditure

4.2 By September 2023, the programme had **committed nearly £70m of funding to 92 projects** (excluding Seeding Awards). By value, the CR&D1 and FFPS are the largest strands (£19.2m and £16.3m respectively), collectively accounting for 51% of aggregate committed budget (see Figure 4-1 below).

4.3 **Just over £5m was allocated to operating expenditure over the lifetime of the programme**, which covered the costs of the TFP team at UKRI (i.e. programme leadership, management and monitoring). A further £0.3m was allocated to Covid-19 Fast Start (Blue Zone) and KTN (Investor Partnerships business support). This leaves only £0.2m of uncommitted budget by September 2023.[20]

Figure 4-1: Number of projects and committed budget by strand (£m)[21]



Source: SQW analysis of TFP financial summary data to 30th September 2023

4.4 It is important to note that **the original programme budget was £90m, but this was cut by approximately £13m** in early 2022 following an external decision by UKRI/BEIS (not one taken

[20] Originally ringfenced for Equality, Diversity and Inclusion (EDI) activities
[21] The number of Seeding Awards refers to the number of ROs who were awarded funding. The number of projects per RO varied, as some ROs chose to spend the entire Seeding Award on one project, whereas others, chose to split the award into several smaller projects.

by the TFP team). This meant that a planned second round of the FFPS strand was not progressed, and the budget for the second round of the Investor Partnership strand was smaller than anticipated.

4.5 **The programme had spent 82% of committed budget (£57.2m) on projects by September 2023.** This meant that 18% of the programme budget (£12.6m) would need to be spent over the remaining six months of delivery to realise anticipated total expenditure by programme close. At the time of the evaluation, UKRI anticipated remaining spend on projects would be £8.6m, and so a small shortfall of £4m was likely. This is discussed further below. In addition, 94% of the opex budget had been spent by September 2023. The large majority of opex budget is expected to be spent by the end of the programme; there may be a marginal overspend. However, this will be balanced by the anticipated underspend on projects.

Co-investment

4.6 In aggregate, £36m in co-investment was anticipated by projects alongside the TFP grant funding at the time of application (excluding Seeding Awards). Co-investment, also known as match funding, refers to other funding provided/secured by project partners that contributes to the project cost alongside TFP grant funding, i.e. total project cost minus TFP grant funding. The leverage ratio is therefore 1:0.53, i.e. for every £1 of TFP grant, planned co-investment was £0.53.

4.7 Actual co-investment is not monitored by URKI. Therefore it is not possible to comment on whether this anticipated level was delivered against in practice.

4.8 **A further £30m in VC investment has been committed** to the 11 projects under the Investor Partnership strand of TFP. This is discussed further in Section 6.

Characteristics of projects

4.9 **The average TFP grant offer varies significantly across the strands of activity,** with FFPS projects receiving the largest grant offers, at an average of £3.3m, compared with £0.19m for STiP feasibility projects. **Average co-investment committed per project also varies by strand.** Similar to grant offer, average co-investment is greatest for FFPS projects at £1.5m which reflects the significantly higher project costs compared to other strands. In terms of leverage ratio, Investor Partnerships strand performs well (note, these figures exclude VC funding).

Table 4-1: Average grant size and anticipated co-investment by strand

Strand	Average TFP grant offer (£m)	Total anticipated co-investment (£m)	Ratio (TFP grant vs. co-investment)
Blue Zone (n=7)	0.47	1.21	1:0.37
CR&D Round 1 (n=24)	0.80	7.88	1:0.41
FFPS (n=5)	3.27	7.67	1:0.47
STiP – Demonstration (n=5)	1.85	2.86	1:0.31
STiP – Feasibility (n=25)	0.19	1.31	1:0.27
Canada bi-lateral (n=7)	0.32	1.21	1:0.54
China bi-lateral (n=8)	0.43	2.23	1:0.64
Investor Partnerships Round 1 (n=7)	0.80	6.84	1:1.22
Investor Partnerships Round 2 (n=4)	1.01	4.92	1:1.22

Source: SQW analysis of TFP monitoring data to October 2023.

Technology focus

4.10 **Projects relating to precision farming account for a substantial share of the programme**, both in terms of the number of projects and the level of resources involved, which is closely aligned with the intended purpose and objectives of TFP. The technologies funded align with programme objectives and national/global priorities in agritech. More granular analysis of the primary technology focus shows:

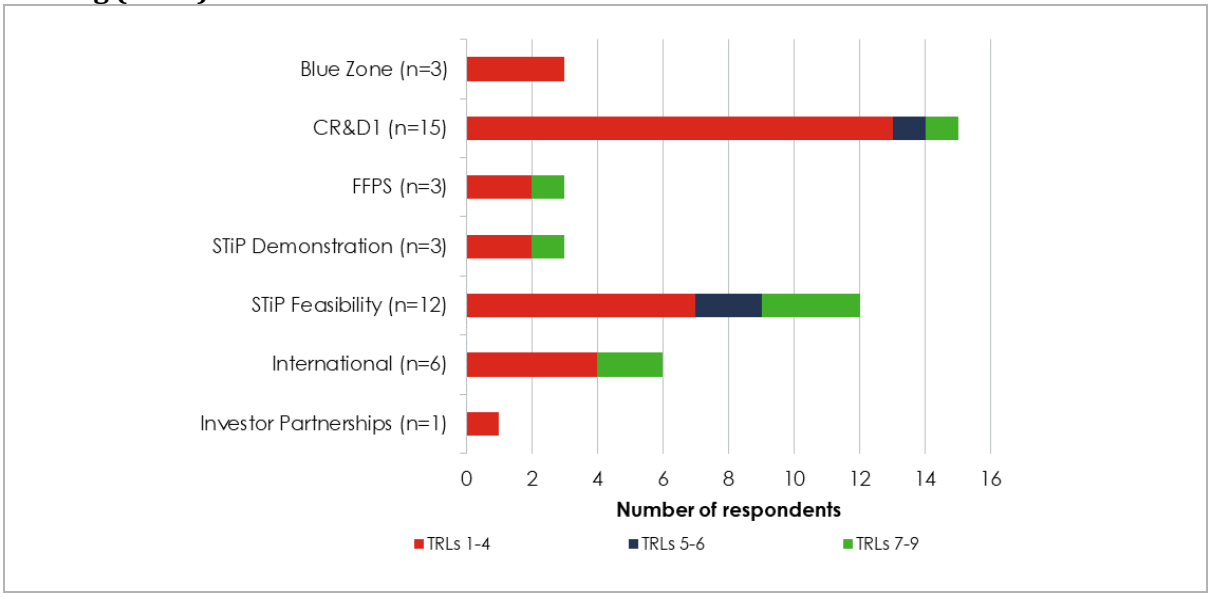
- a strong focus on **Data, AI and Machine Learning, Diagnostics and Sensors, Enhanced Management/Decision Support, and Robotics**: together these technology categories account for nearly three-quarters of projects and over two-thirds of resource allocated
- the technological focus **shifted between the two phases of TFP**, with a greater emphasis on some technologies (e.g. data/AI/Machine Learning) and a broader spread of technologies covered by the programme (e.g. to include Nutrition/Feed Formulation, Algal Biotech/Fermentation, and Cell Culture) in Phase 2.

4.11 At the time of applying for TFP funding, our survey of project leads (n=43)[22] suggests that most **projects were at Technology Readiness Levels (TRLs) 1-4 across all strands (74%).** Most later stage projects (TRL 7-9) were STiP and International as shown below. This demonstrates how the programme spanned across TRLs providing support for projects at different stages of

[22] Note, this data combines responses from the baseline and new respondents in the Wave 2 survey (i.e. those who did not complete the baseline). N=2 who answered Don't Know / Refused excluded.

their development. This is also important context when interpreting the findings on outcomes/impacts below, and the need to be realistic about what can plausibly be expected at this stage.

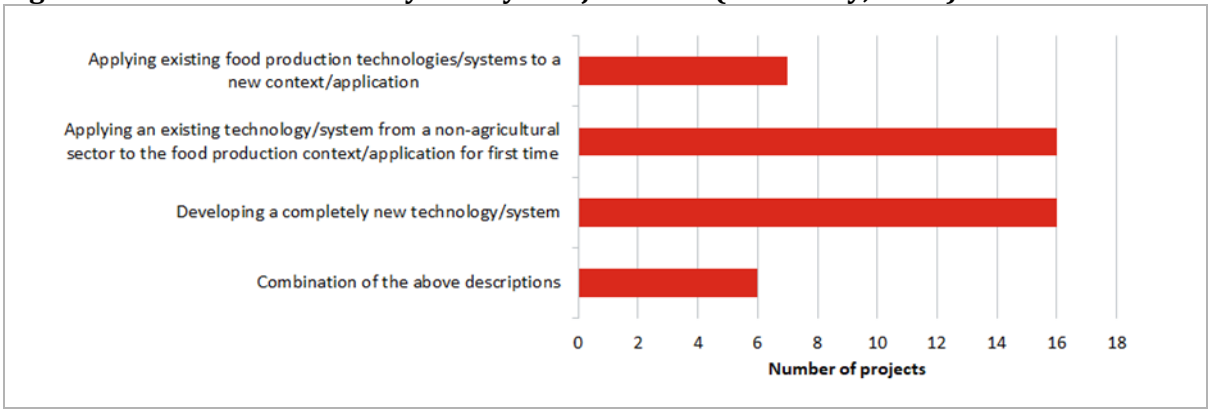
Figure 4-2: Phase 2 and 5 beneficiary surveys: TRL stage at the time of applying for TFP funding (n=43)



Source: SQW analysis of beneficiary surveys. Note, this data combines responses from the baseline and new respondents in the Wave 2 survey (i.e. those who did not complete the baseline). N=2 who answered Don't Know / Refused excluded.

4.12 The majority of projects surveyed were focused on developing a completely new technology/system or applying technologies from non-agricultural contexts to the sector for the first time (see Figure 4-3). It is encouraging to see that the programme has attracted 'spill-ins' and new technologies into the sector. Moreover, most leads said their project focused on an integrated solution (78%, 35/45), rather than a single technology (18%, 8/45), which aligns closely with the intended 'systems approach' of TFP.

Figure 4-3: Phase 5 beneficiary survey: Project focus (leads only, n=45)

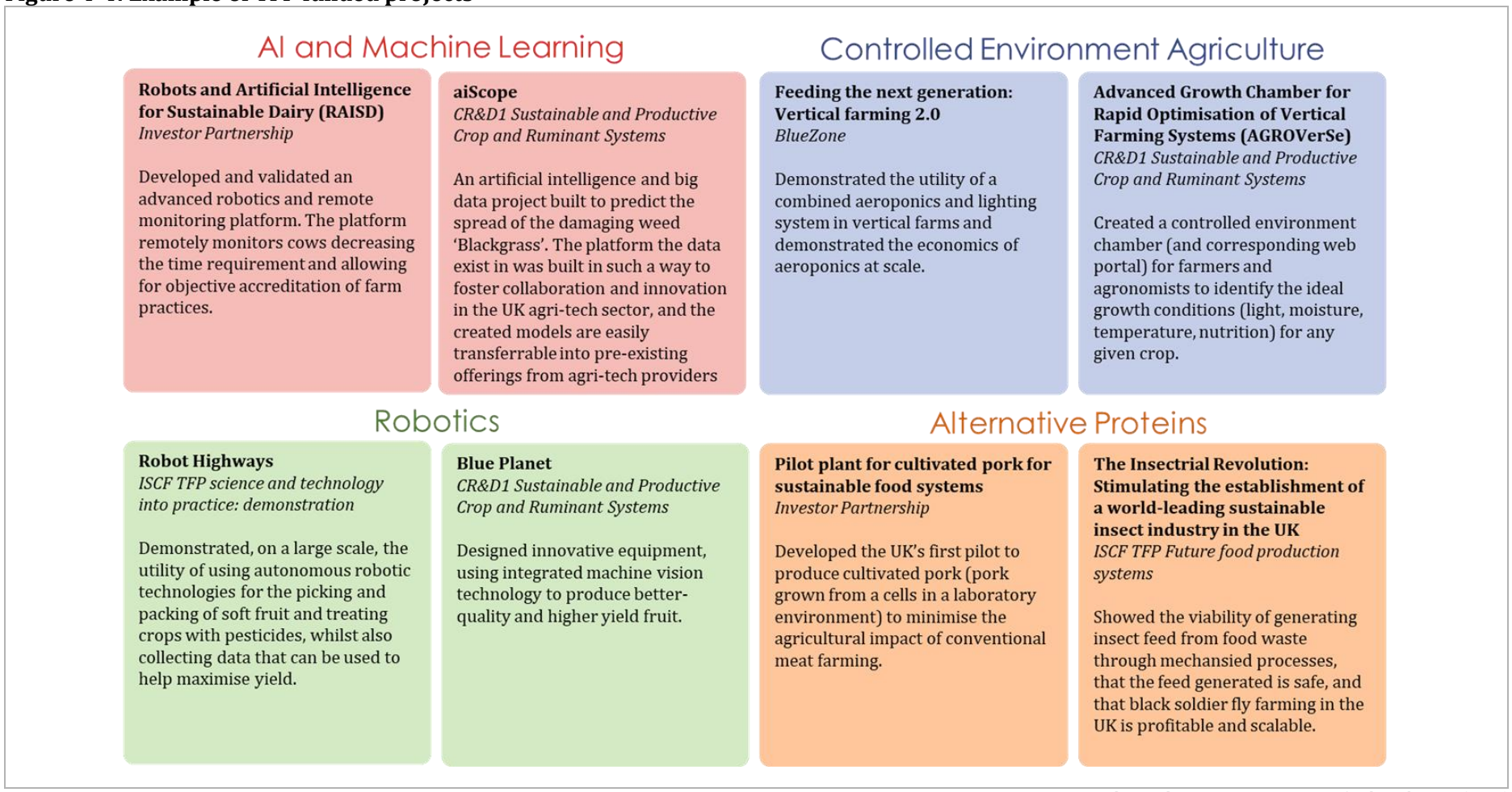


Source: SQW analysis of beneficiary surveys

4.13 Feedback from stakeholders emphasised that the programme had established a **strong portfolio of projects**, covering a range of technologies and topic areas. Consultees felt there was a mix of 'exciting' and 'cutting edge' projects with the potential to deliver significant impacts. However,

given the breadth of TFP is very wide, resources have been spread relatively thinly (compared to other more targeted ISCF programmes). Illustrative examples of the types of projects supported by TFP funding are provided in Figure 4-4.

Figure 4-4: Example of TFP funded projects



Source: Catalysing the transition to net zero food production (UKRI)

Characterising the organisations involved

4.14 Across all strands, **217 unique organisations have been involved in delivering projects.**[23] Analysis of programme monitoring data shows that approximately, **three quarters are businesses** (74%, 160), with comparatively smaller numbers of academic and research organisations (26%, 57). **Over two-thirds of businesses are small** (71%, 106), with medium and large businesses accounting for 12% and 17% of businesses respectively.[24]

4.15 To provide an insight into the stage of development of beneficiary businesses at the time they applied to TFP, we analysed Beauhurst data. Whilst this is not comprehensive, it provides a reasonable coverage of programme beneficiaries at the baseline stage.[25] This shows that the programme has **attracted a mix of firms**: for example, at the time of application, 28% of firms in Beauhurst were at 'seed' stage, 33% were at 'venture' stage and 30% were 'established'. Over half of firms (58%) were classified by the 'Professional, scientific and technical activities' SIC code, whilst 'Manufacturing' firms accounted for a quarter.[26] This demonstrates the role of TFP engaging organisations outside of the 'core' food production sector.

4.16 The majority of projects have involved collaborative R&D and multidisciplinary inputs, and engaged widely with a range of actors across the innovation landscape.[27] For example:

- **Universities and agricultural colleges** have been extensively involved in the programme, partnering and/or leading on projects. These include Harper Adams University, University of Lincoln, University of Nottingham, Scotland's Rural College (SRUC), and University of Sheffield.

- The **Agritech Centres** led/were partners on projects, which is important in the context of the UK Government's Strategy for Agricultural Technologies and Innovate UK's wider support to establish a new single Agritech Catapult. Three of the four Centres (Agri-EPI, CIEL, and CHAP)[28] were involved in a total of 15 projects (including one Seeding Award).[29] However, the grant value is relatively low: across these projects, the Agritech Centres were awarded grants totalling £1.8m. The projects spanned various programme strands, with STiP demonstration and CR&D1 accounting for around two thirds of projects involving the Agritech Centres (67%).

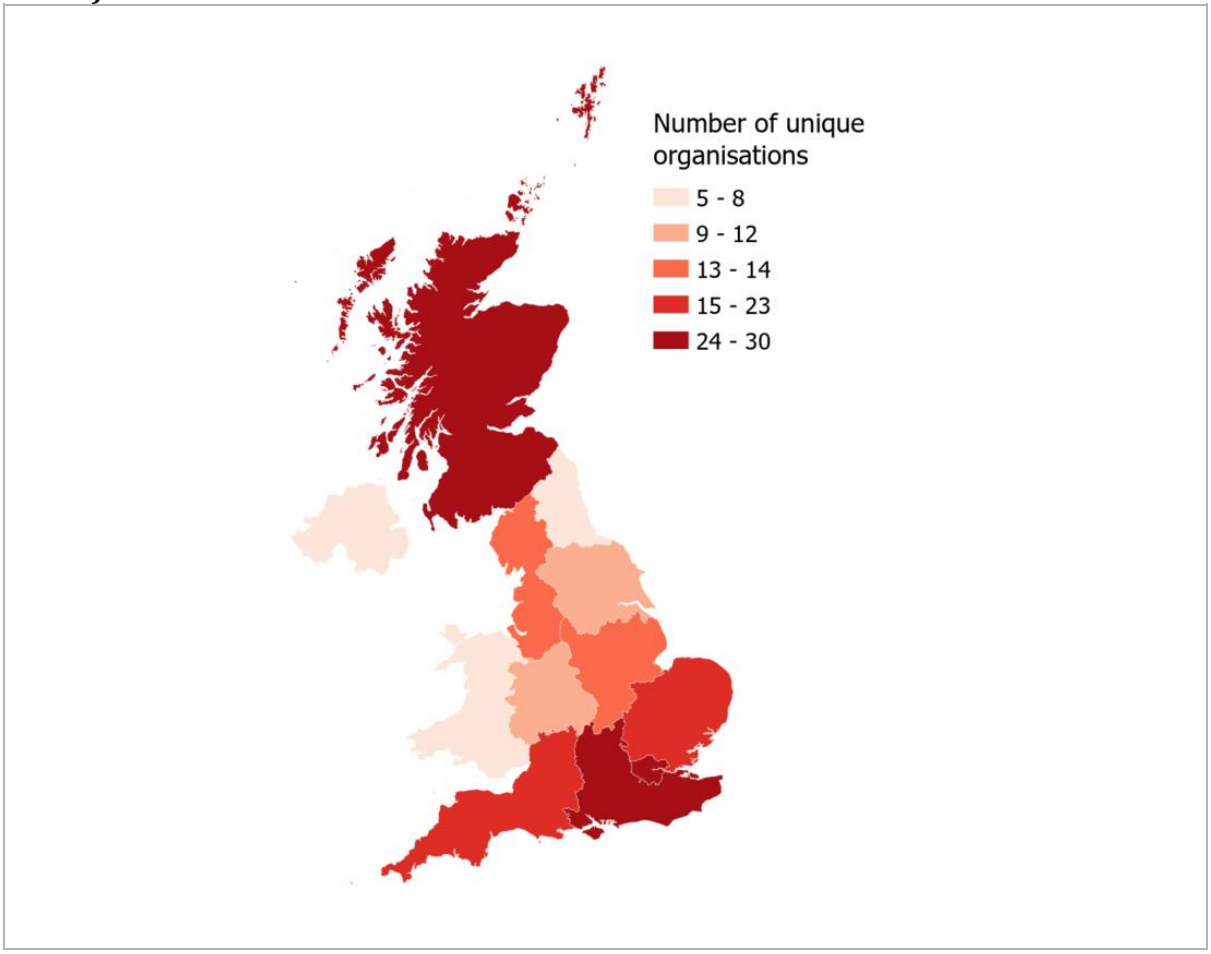
[23] Note this figure excludes organisations which have withdrawn and only includes lead research organisations for Seeding Awards as the number of unique partners is unknown.
[24] Excludes 10 businesses where size is unknown.
[25] At the baseline stage, N=79 beneficiary firms were tracked by Beauhurst. Most of the remaining beneficiary organisations were research organisations, public sector or charities, or firms that do not meet any of Beauhurst's high growth triggers (and are therefore not tracked). The number of tracked beneficiaries has since increased to N=85, due to additional TFP beneficiaries and previous beneficiaries having been added to Beauhurst since the Baseline Evaluation.
[26] Note, SIC codes are not mutually exclusive.
[27] When compared with the systems map developed at the baseline stage showing key actors involved in the food production innovation landscape (see Annex A)
[28] Agrimetrics was not involved in any TFP funded projects.
[29] This figure refers to unique projects. For one project, two Agritech Centres were involved in the project.

- There is also some evidence to suggest that projects have also been supported/led by **BBSRC's strategic research institutes** such as the Earlham Institute, Rothamsted Research and Pirbright Institute and **UKRI-funded Catapults** including the Centre for Process Innovation and Manufacturing Technology Centre.

- A range of **other public/private research and innovation centres** have been partners/led on projects, such as the James Hutton Institute, Stockbridge Technology Centre, The National Institute of Agricultural Botany (NIAB) and Fera.

4.17 **Beneficiary organisations are spread across the UK**, with concentrations in Scotland and Southern England (mainly London and the South East), as illustrated below.[30] Around two-fifths of the beneficiary organisations mapped (61%) were located outside of London, South East and the East of England.

Figure 4-5: Regional distribution of unique organisations (leads and collaborators, n=196)



Source: SQW analysis of TFP monitoring data. Location data available for 196 beneficiaries. Produced by SQW 2023. Licence 100030994. Contains National Statistics data © Crown copyright and database right 2023

[30] Note, this is based on company headquarter locations and may not reflect where all research takes place.

Pre-intervention experience and capabilities

4.18 According to the survey evidence, **most beneficiaries came to the programme with prior collaborative R&D experience.** For example, of the beneficiaries for whom we have pre-intervention data, 89% (120/135) had invested in R&D for the purposes of innovation in the three years prior to applying for TFP funding, and around three quarters (76%, 103/135) had done so in collaboration with others.[31] This is important context as it suggests that TFP has supported organisations with the relevant experience and capabilities to deliver projects effectively. These findings corroborate our analysis of Beauhurst data, which found many were well versed in applying for public sector innovation funding: according to the data, beneficiaries were more likely to have secured public sector innovation grants before their TFP application compared with sources of private growth finance (50% and 14% respectively according to Beauhurst).

4.19 However, the programme also **attracted organisations with no/limited experience of R&D in the agri-food sector specifically.** Whilst over half of respondents (n=135) had extensive experience of R&D in agri-food (56%), notable proportions had limited (27%) or no (14%) experience of this sector, providing potential opportunities for synergies with more mature technologies from other sectors. Project leads included those with limited/no prior experience of R&D in agri-food. Further, TFP has engaged with organisations who had not received other public sector support for R&D in the three years prior to TFP (39%).

4.20 There is also evidence of TFP **projects involving end users** and **facilitating the formation of new partnerships**, including working with private sector partners for the first time. Aggregating the baseline and final evaluation survey responses indicates:

- over half of business collaborators were agricultural end users or practitioners (62%, 193/313)
- the majority of the business partners were new collaborators for respondents (65%, 204/313)
- over half of other (non-business) partners were new collaborators (58%, 93/160).

4.21 These findings suggest the programme has engaged effectively with end users as intended, which was a key assumption in the ToC. Furthermore, the programme has facilitated the creation of new partnerships, which is directly addressing fragmentation and co-ordination failures that underpinned the rationale for intervention.

[31] Note, this data combines responses from the baseline and new respondents in the Wave 2 survey (i.e. those who did not complete the baseline)

Project progress to date

4.22 This sub-section draws primarily on monitoring data (on spend to October 2023 and the latest RAG assessment by monitoring officers) in order to assess project-level progress to date. Note, this analysis excludes Seeding Awards.

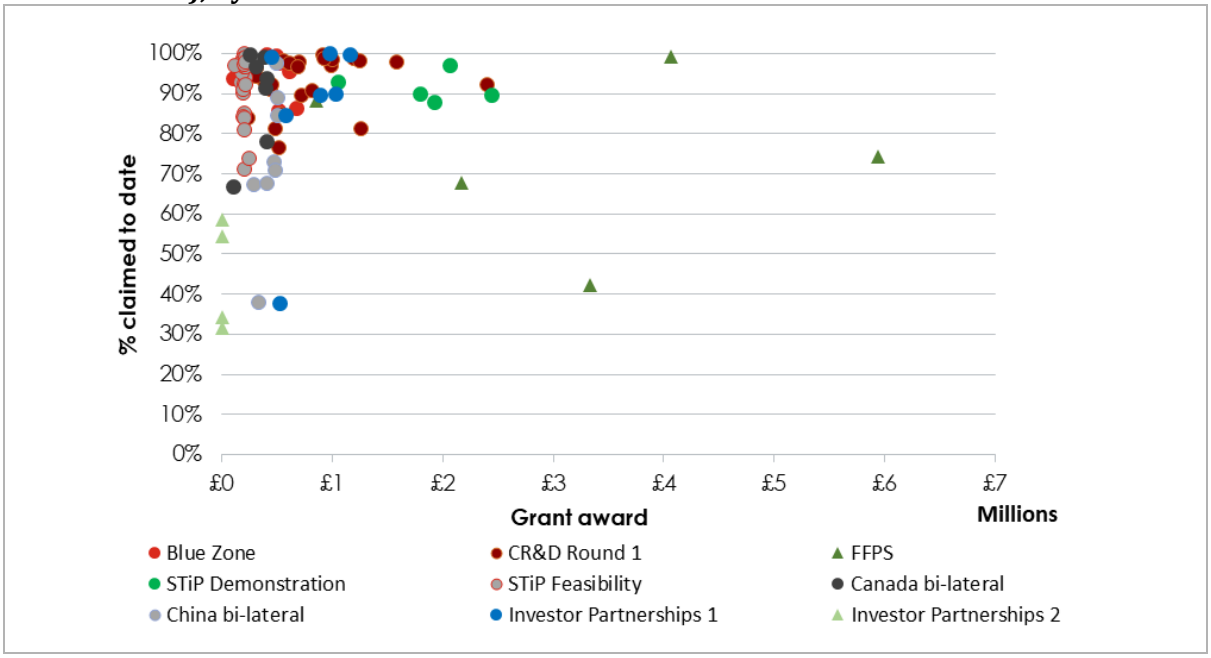
4.23 Figure 4-6 presents more detailed data on spend (as a proportion of grant awarded) compared to grant size by strand. Overall, **four fifths of projects had spent 80% or more of their grant award by this point**. Key findings by strand are as follows:

- Projects with the largest proportion of grant award yet to be claimed were predominantly FFPS (74% claimed) and Investor Partnership projects (89% claimed for Round 1 and 47% of Round 2), and which largely reflects planned end dates (i.e. early 2024[32]). The FFPS projects account for a substantial amount of outstanding spend, as noted above.

- The China bilateral projects had claimed only 76% of the grant awarded, which reflects challenges associated with this strand (discussed further below).

- The Blue Zone, CR&D1, STiP Feasibility and Demonstration, and Canada bilateral strands have all claimed more than 90% of the grant awarded (on aggregate).

Figure 4-6: Project-level expenditure – total grant award vs % claimed to date (by October 2023), by strand



Source: SQW analysis of TFP monitoring data October 2023. Note excludes Seeding Awards.

[32] It is noted that one FFPS project has an end date of September 2024

4.24 We have also assessed the status of TFP-funded projects (i.e. whether the project is closed, at final claim[33]) and associated expenditure to understand whether the programme is likely to spend the full £70m commitment.

4.25 Figure 4-7 below shows that the **majority of projects (83%) had completed delivery** (i.e. closed or at final claim) by October 2023. In summary:

- **Two thirds of projects had closed** (61/92) between October 2020 and June 2023, and in aggregate they had spent approximately £30m out of £32m (94%) of funding awarded.
- **Fifteen projects were at the final claim stage** (16%, 15/92), and they had claimed £14.5m, with £3m of their grant yet to be claimed (17%).
- **Less than a fifth of projects (17%) were still live** (16/92). In aggregate, these projects had claimed £12.9m, with £5.7m (31%) to be claimed over the remaining delivery period.

4.26 This analysis suggests there is **likely to be a small underspend by the end of the programme**, notably from projects that have already closed, but potentially also from projects that are at final claim or still live.

Figure 4-7: Project-level expenditure – total grant award vs % claimed to date (by October 2023), by project status

Source: SQW analysis of TFP monitoring data October 2023. Note excludes Seeding Awards.

4.27 On a quarterly basis, UKRI's monitoring officers assess each project's progress and performance in six areas: scope, time, cost, exploitation, risk management, and project planning. Against each

[33] i.e. Projects where end dates have passed and active delivery has completed, but the final UKRI claims process was ongoing by October 2023.

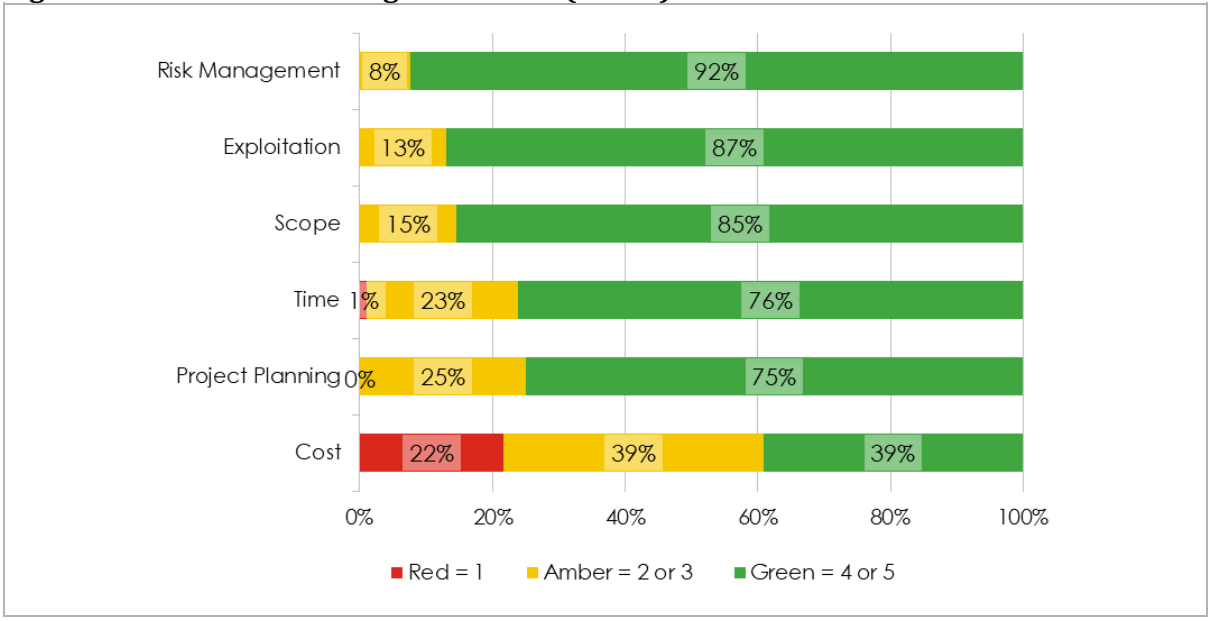
indicator, each project is scored as red (significant issues), amber (some/minor issues) or green (on track/good performance).

4.28 Overall, the data in Figure 4-8 suggests that **the majority of projects were progressing well** at their latest (where live) or final report (where closed) and, against **most indicators were rated as green and 'on track'**.

4.29 **Fewer projects were on track in relation to costs.** Cost issues were apparent across all programme strands. A review of qualitative commentary provided by the monitoring officers suggests that cost issues commonly related to underspend on inputs including materials, delayed invoicing from suppliers / contractors, staff turnover, and changes to project scope. This aligns with and helps to explain the expenditure analysis above. **Around a third of these projects also scored red/amber in relation to time.**[34] The causes of time issues were wide ranging but included slower/more challenging than anticipated technology development, Covid-19 related restrictions, difficulties in accessing materials/supply chain issues, challenges with partners, and key deliverables (e.g. field/lab trials) not being completed within the project delivery timescales.

4.30 By strand, STiP Demonstration, Investor Partnerships Round 2, and the Canada bilateral competitions had no projects scoring red in any of the categories. In contrast, the STiP Feasibility strand had the highest incidence of projects rating red / amber overall.

Figure 4-8: Latest monitoring scores data (n=92*)



*Source: SQW analysis of TFP Monitoring Scores Reports up to October 2023. * N=92 (for all areas excluding 'Scope' where three scores are missing in the latest report so n=89)*

4.31 Stakeholder feedback suggests that the **projects have performed well overall, despite the challenging delivery context.** Whilst some challenges were identified (e.g. relating to delays and under-spend), stakeholders emphasised that this is not unexpected given the innovative/novel projects being delivered, and it demonstrates the level of risk taken by the

[34] 19 of the 56 projects that scored red/amber on cost also scored red/amber on time.

programme. The ISCF model included the ability to cancel/close projects where they were not meeting objectives – this has only been called upon once in TFP, where a project decided to close early after disproving its hypothesis (which itself can be seen as an important outcome, preventing further investment and activity on a concept which was found not to be viable). Beyond that project, no other projects have closed early.

Knowledge exchange and dissemination

4.32 **Projects have become increasingly outward-facing** over the course of project delivery engaging in a variety of dissemination and knowledge exchange activities. The majority of survey respondents have already disseminated findings from their TFP project (70%) or are planning to do so in future (18%).[35] In flight survey data provides insight into the types of knowledge exchange activities projects have delivered. As illustrated in Figure 4-9, the **most commonly reported activity was knowledge exchange events** (401 delivered in total), but others included training courses, placements, and apprenticeships.

Figure 4-9: Knowledge exchange activities – in flight survey (136 respondents)

Source: SQW analysis of TFP In flight survey data.

4.33 In terms of academic-led dissemination, across the 45 close out reports filled out by academics, **26 academic outputs have been produced as a result of TFP projects**[36], with over a quarter of these (7, 27%) coming from one project alone.

[35] Wave 2 beneficiary survey (n=74)
[36] Where multiple academics from the same project responded, the higher

5. Outcomes and impacts at project level

Key messages

- Almost all projects expect to achieve their objectives in full or part. This is a positive finding.
- There is strong and consistent evidence to demonstrate how TFP has strengthened knowledge exchange and collaboration, including with end-users. This has improved the quality and pace at which technologies have been developed, facilitated systems integration and helped to develop products that are better attuned to market needs. TFP is also having a legacy effect on collaboration.
- It has also had a strong impact on capabilities, knowledge and skills, even though the majority of participants were innovation active prior to TFP. This includes enhanced technical and research skills, knowledge of the agricultural sector, understanding of commercialisation processes, and wider business development and management capabilities.
- There is strong and consistently positive evidence that TFP has accelerated the development of technologies more widely (i.e. pre knowledge exchange/commercialisation stage) and progression through Technology Readiness Levels (TRLs). There are examples of (mainly small-scale) commercialisation and adoption, particularly of precision technologies, but it is too early to assess performance in this respect. Many projects are taking steps to towards commercialise, but most will require further funding to reach the market.
- TFP has led to further investment in R&D, including from private sector sources which is an important early signal of commercial potential. TFP funding has played an important role in securing follow-on finance.
- TFP is contributing to the growth of UK agritech firms, both in terms of generating high quality employment and turnover in some beneficiary organisations to date (albeit small-scale for most). Impacts are likely to be more widespread over the next three years. However, exporting appears limited and there is little evidence of FDI. These are 'gross' findings, they do not consider the 'net' effects, including by comparing to unsupported firms, which is discussed in Section 7.
- Unexpected or unintended consequences are limited and largely positive, e.g. raising the profile and reputation of organisations involved, encouraging firm retention in the UK.

Implications for the contribution story

- There is strong evidence that the large majority of expected results have occurred. It is too early to assess fully some intended outcomes and impacts (e.g. exports and adoption).
- The anticipated impact of TFP-funded technologies are well aligned with the overall purpose of TFP, i.e. improving productivity and reducing greenhouse gas emissions in the agricultural sector.

5.1 In this section, we assess the extent to which the programme has achieved outputs, outcomes and impacts at a project level as intended. The section has been structured to align with the key types of effects set out in the TFP logic model. For each type of anticipated effect, we provide a summary assessment of achievements to date which is colour coded to reflect performance: dark green indicates extensive/strong performance to date, light green indicates reasonable performance, orange is limited/mixed evidence, and grey denotes where it is too early to assess progress. This

is followed by a narrative description drawing out the evidence and examples from the evaluation research in more detail.

5.2 The findings below draw primarily on monitoring data analysis, feedback from stakeholder consultations, the beneficiary survey and project-level case studies undertaken in Phase 5. Further detail on the coverage of monitoring data, the characteristics of beneficiary survey respondents (and their representativeness) and the coverage of case studies is provided in Annex F. We recognise there may be some positive response bias in the survey, whereby projects that have 'gone well' may be more likely to respond. To address this issue corroboration with close out reports was undertaken because participants are required to complete these as part of their final payment. There may also be some optimism bias in the close out forms, with projects reporting positively to mitigate any concerns around grant draw down and/or follow-on funding opportunities. We also include evidence from consultations with project participants and stakeholders undertaken in Phase 4 where appropriate.

Overall performance against outcomes

5.3 **Overall, the evaluation evidence indicates that TFP funded projects have achieved their original objectives in full or in part.** According to the beneficiary survey, nearly all respondents reported that their project had achieved or is expected to achieve its original objectives either in full (45%, 33/74) or in part (49%, 36/74). Of those reporting that objectives have been/will be achieved *in part*, this includes both live and closed/final claim projects (18 and 18 respondents respectively), suggesting a proportion of projects (i.e. the 18 completed) will not fully deliver on their original intent. As explained elsewhere in this report, a number of factors have influenced this, including delays in delivery, capacity issues, unanticipated technical challenges (notably related to systems integration), technologies less 'optimised' than hoped, and wider contextual factors. There may also be some degree of unrealistic expectations at the start. That said, the evidence below demonstrates how projects have achieved substantial and wide ranging outcomes/impacts nonetheless.

5.4 Evidence from the close out reports was slightly more optimistic on performance against objectives at a project level. Across the 62 project lead responses available at the time of writing, 45 (73%) reported the project had fully achieved the intended project outcome, with the remaining 17 (27%) reporting it had 'partially' achieved this.[37] Taken together, given the level of risk and uncertainty associated with funded projects (and hence the need for intervention), these findings are encouraging. Indeed, some project-level 'failure' is to be expected (and arguably important) for an innovation support programme delivering across multiple strands and in a challenging and evolving delivery and contextual landscape.

[37] Of the 74 respondents to the beneficiary survey, 58 have also completed the close out form (for the same project). Across the 51 projects surveyed, 41 have at least one response (partner and/or lead) to the close out form. We therefore recognise there is some overlap in cohorts.

5.5 The beneficiary survey assessed whether key outcomes in TFP's logic model had been achieved to date or were expected in future. As illustrated in Figure 5-1, the key findings are as follows:

- The large majority of respondents have already strengthened their relationships with industry, improved R&D skills/capabilities and gained a better understanding of the agri-food market. These qualitative, 'softer' outcomes have been realised quickly through the process of delivering the R&D project.

- The majority of respondents have or will improve their management capabilities, understanding of commercialisation processes and market positioning – these outcomes are also important for the commercialisation of new technologies.

- The least common benefit achieved or expected is related to applying for or securing IP, with 42% of respondents (31/74) noting that this is not expected.

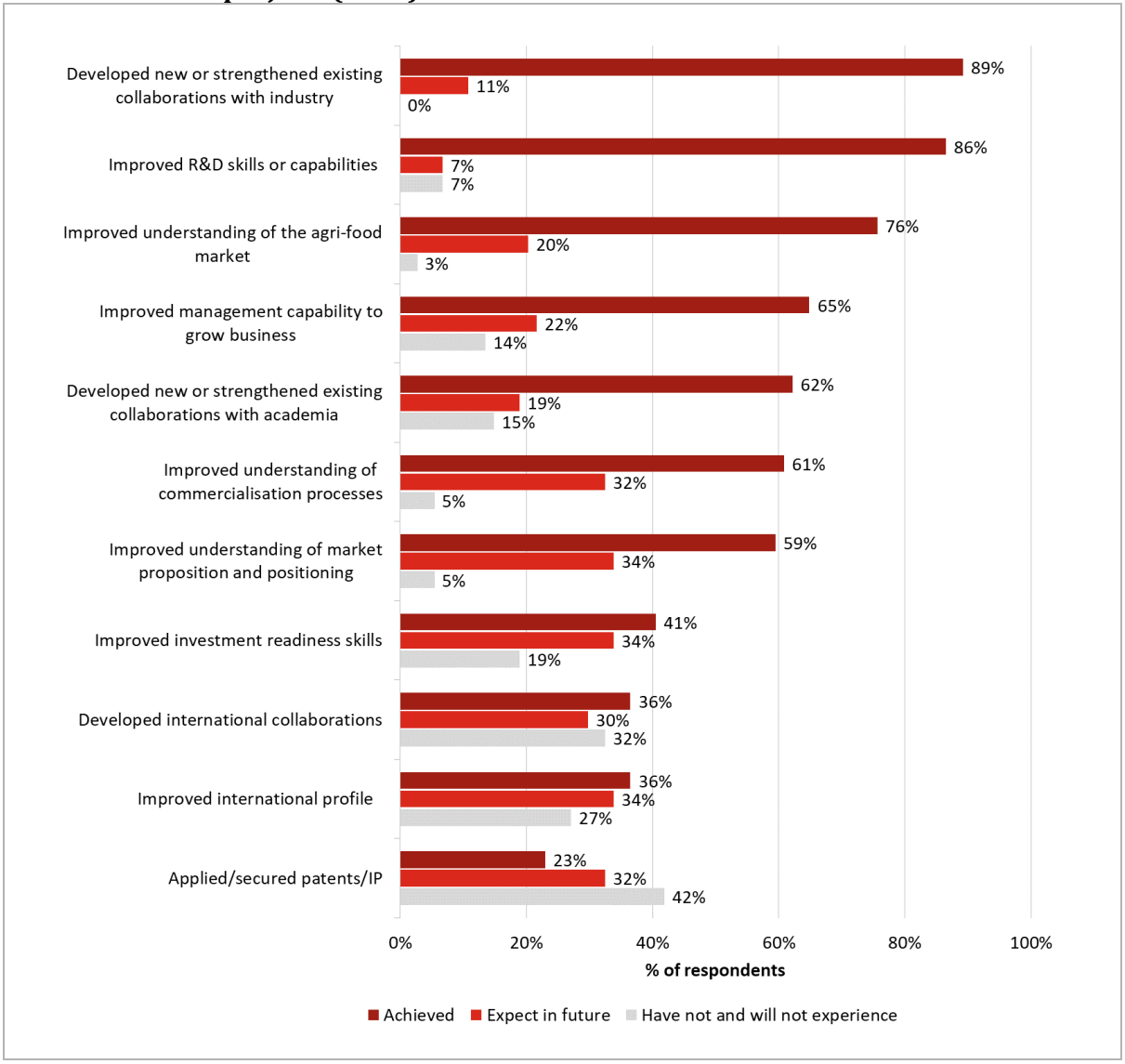
5.6 The survey suggests that project leads are more likely to achieve benefits compared to collaborators, but the most common outcomes observed are similar for both leads and collaborators.

5.7 We have also explored whether outcomes achieved vary between beneficiaries with and without prior R&D experience in the agricultural sector. The analysis found no statistically significant difference on 10 of the 11 outcomes considered in Figure 5-1. However, the proportion of beneficiaries with no prior agricultural R&D experience reporting an 'improved understanding of market proposition and positioning', was significantly higher than those with prior experience (at 87% and 54% respectively).[38] This does suggest that encouraging 'spill-ins' and the involvement of sectors/technologies that are new to agriculture has been effective, and these organisations are just as likely to observe benefits from TFP as those with prior R&D experience in the agricultural sector.

5.8 We explore these outcomes in more detail below.

[38] Statistically significant at the 5% level

Figure 5-1: Phase 5 beneficiary survey: Outcomes observed to date or expected in future as a result of TFP projects (n=74)



Source: Beneficiary survey analysis. Note, 'achieved' and 'expect in future' are mutually exclusive

Detailed evidence

Knowledge exchange, strengthened relationships and collaboration

Strong and consistent evidence of strengthened relationships and collaboration between project partners and with potential customers/end-users through TFP projects, both during and in some cases after delivery. This is helping to accelerate/improve technology development and generate commercial benefits.

5.9 The most common benefit achieved in the Phase 5 beneficiary survey was the **development of new or strengthening of existing collaborations with industry** (89%, 66/74). TFP has also

led to new or strengthened collaborations with academia (62%, 46/74). As we discuss further in Section 8, knowledge exchange between project partners and continuous feedback loops throughout the R&D process is a key success factor.

5.10 These outcomes were also explored in more detail in the Phase 4 consultations with project participants, where almost all project-level consultees (n=37) said they had been able to share knowledge and strengthen relationships with project partners. This had reportedly **improved the quality and pace at which technologies have been developed, facilitated knowledge/skills development and continuous feedback loops, led to a better understanding of how to integrate technologies, and improved understanding of the market** (see below). For the majority of project-level consultees consulted in Phase 4, the role of TFP has been to strengthen existing relationships rather than forge new ones. However, consultees described how previously "ad hoc" contact with partners has been strengthened substantially by the continuous engagement and structure associated with delivering a TFP project. The consultations also identified a small number of examples where partners had not worked together previously, with the programme therefore establishing new relationships across the sector.

5.11 TFP has also enabled the organisations involved to strengthen relationships with end users, potential customers, distributors and wider stakeholders, through delivery of the project (notably trials), partners' networks, and wider outreach and dissemination activities. For example, in one case study (STiP Demonstration project) the project partners' network has enabled extensive engagement with growers, which has in turn led to further grower engagement in trials and initial contracts for the technology, while another case study (Investor Partnership) has secured and identified further end-user test sites through the project. A STiP Feasibility project also reported gaining greater understanding of the key metrics required by growers (i.e. light, CO2, temperature, air pressure and relative humidity) to inform operations and their assessment of performance, and subsequently focused on these when developing their device. Similarly in Phase 4, another project had built a relationship with the Health and Safety Executive and the Institute of Agricultural Engineers via the TFP project in order to influence guidance and regulation relating to autonomous agricultural vehicles. These types of effects were found elsewhere in the case study research, as illustrated in the quotes below.

"The collaboration with [x project partner] and the other Canadian partners worked really well. We had really good relationships, with all parties working very openly to share ideas and achieve mutually beneficial objectives."

Case Study Consultee (UK-Canada)

"The level of our conversation with industry was changed completely."

Case Study Consultee (CR&D1)

5.12 Evidence also indicates that **TFP has a longer-term legacy effect on collaboration**, both in terms of partners continuing to collaborate and/or having a higher propensity to collaborate in future (including end users). For example, in the Phase 5 beneficiary survey:

- almost all beneficiaries reported they were more likely to collaborate with other industry partners in R&D activities in the future as a result of the TFP project (92%, 68/74).
- for completed projects, 67% (28/42) of respondents had continued to work with academic partners and 81% (34/42) had continued to work with industry partners.

5.13 Consultations with project participants in Phase 4 also found cases where **TFP partners have started to collaborate on other R&D and are sharing knowledge beyond the TFP project** (e.g. in CR&D1, FFPS and STiP Feasibility projects). This includes R&D that is both related and unrelated to the TFP project, suggesting TFP-backed projects have played a role in stimulating wider R&D system effects. There were also examples of organisations working together for the first time in their TFP project and planning further collaboration alongside or after TFP.

5.14 **These strengthened relationships can also lead to commercial benefits**. For example, in Phase 4, a project lead reported that a partner had "seen what we can do" through TFP and subsequently commissioned other work (not related directly to the TFP project). In other cases, TFP partners were expected to "present some really good commercialisation opportunities in future".

5.15 These survey findings were corroborated by consultation feedback in Phase 5. There was consistent and strong evidence across consultees that TFP has led to improved collaboration and knowledge exchange within projects, and some evidence to suggest this has been sustained since TFP projects closed. As one consultee suggested, TFP has "created a community" for agritech innovation. This includes encouraging new technologies and players into the agritech sector (especially in relation to robotics and AI) and attracting international organisations to the UK (e.g. from Norway and Australia). External stakeholders consulted also recognised how the Investor Partnership strand of TFP had facilitated partnerships between investors and innovators, and created a forum for greater interaction between investors themselves, as illustrated in the quote below.

"Our own involvement has opened us up to a lot of investment [opportunities] and a lot of other investors. We are taking to investor houses that we would never have been talking to before"

External stakeholder, Phase 5

5.16 Improved collaboration is key outcome for the programme, given the underpinning rationale for intervention relating to a fragmented sector where collaboration is a challenge. When triangulating these findings with evidence in Section 4 showing how TFP has enabled new relationships/collaborations to form, it suggests that **TFP has helped to tackle the original challenges underpinning the rationale**. Moreover, an assumption in the ToC was that industry

engagement during the R&D process was an important success factor. This is discussed further in Section 8.

Capabilities, knowledge and skills

Strong and consistent evidence of improvement in (i) technical and research skills, (ii) knowledge of the agricultural sector, (iii) understanding of commercialisation processes, and (iv) wider business development capabilities. This is evident across all strands and for lead and partner organisations.

5.17 **The majority of beneficiaries surveyed in Phase 5 said that TFP had led to improved R&D skills or capabilities** (86%, 64/74). Even though many were innovation active prior to TFP, as noted in Section 4, the programme is still helping to build technical R&D skills and capabilities further. Several case studies provided further insight on this outcome. For example, one STiP Feasibility project reported that through a new collaboration established through the project, the project lead has benefitted from knowledge exchange with a research institute partner, learning more about methodologies for testing substrates. A CR&D1 project lead said they had been "massively upskilled" in AI through the reading and research they undertook through the project. In addition, an Investor Partnership project reported that, while they already had extensive R&D capabilities, the grant funding had enabled them to expand the size of their engineering team, bringing in new skills and expertise to facilitate product development. In-depth consultations with project leads in Phase 4 also demonstrated how TFP has enabled participants to gain enhanced understanding of relevant technologies and how they operate in different environments (e.g. crop growth and stress tolerances), learn more advanced analysis and techniques (e.g. machine learning, AI), better understanding of whole systems and system integration (and an improved ability to understand/bring together multidisciplinary inputs), and improve their R&D project management capabilities. Projects have benefited from the expertise of project partners (e.g., scientific knowledge from RTO partners) and many have been able to recruit specialists (this is discussed further below). As one project in Phase 4 explained, the TFP consortium has provided access to expertise that they would have found difficult or too expensive to provide in-house or procure under contract.

5.18 Over three-quarters of respondents to the beneficiary survey in Phase 5 have **also improved their understanding of the agri-food market** as a result of TFP (76%, 56/74). This includes (but is not limited to) beneficiaries that were new to the sector prior to commencing their TFP project and demonstrates the role and value of TFP in transferring technologies from other sectors into agriculture. This was explored further in the case studies, with several projects highlighting the key role of co-development with farmers in projects to ensure the outcomes focus on the end-user and understand what would help/hinder adoption. For example:

- One STiP Demonstration project involved a co-development group of farmers (c.30) which was reportedly crucial to the success of the project and enabled the project team to co-develop the project outputs.

- One CR&D1 project involved three farmers as project partners (and subsequently engaged a wider steering group of 12 farmers) to test elements of the technology and identify what worked, what did not work and what else they would like the technology to offer.

- One CR&D1 project involved farmer engagement (both through one of the project partners and demonstration events) and noted this was key to success and gaining feedback on the functionality of different features in practice.

5.19 **TFP projects have also had an impact on commercialisation skills**. In the beneficiary survey, 61% of respondents (45 out of 74) had improved their understanding of commercialisation processes to date, and nearly a third expected to improve this in future (32%, 24 out of 74). This was explored further in the case studies. For example, one Investor Partnership noted that, in addition to the finance, the investor has supported the business in various ways, including by providing sector-specific advice (e.g. on market positioning and strategy) and training support, identifying test sites and making introductions. This aligns with findings in Phase 4, where in-depth consultations with project leads illustrated how they had gained a better understanding of their market and how to commercialise new products through testing, demonstration, market engagement and partnership working on TFP projects. This applied to both business and academic participants, as illustrated in the quote below.

"The universities we're involved with have learned a lot because they're not usually involved in taking R&D all the way though to commercialisation – so they've learned a lot from the process of trying to move the whole system up the TRLs from level 6-7 to 8-9"

Project consultee, Phase 4 (CR&D1)

5.20 Finally, **nearly two thirds of respondents had improved their management capability to grow their business** (65%, 48 out of 74) in the beneficiary survey and a further 22% (16 out of 74) expected to improve this in future as a result of TFP. This was explored further in the case studies, for example:

- One Investor Partnership project stated that as a result of the TFP funding, the company founder and previous CEO, an engineer by background, was able to move into a CTO role and focus on the technical aspects of product development, demonstrating how positive changes to management capability have been achieved through the injection of TFP funding.

- Likewise, for a STIP Feasibility project, TFP funding has helped to identify a key R&D needed to refine the product further, which has informed the ongoing business strategy of the company, alongside future priorities for making improvements to the product.

5.21 In the Phase 4 project consultations, this outcome appeared to be a feature of some Investor Partnership projects, where investors were supporting business development more generally (alongside funding to progress the technology)[39]. However, survey evidence from Phase 5 suggests a broader range of TFP projects are leading to improved management capabilities (i.e. not just Investor Partnerships).

5.22 The findings above were corroborated by stakeholders consulted in Phase 5, who had observed TFP's role in strengthening the skills/capabilities of **both businesses and the research base** across the UK. This included developing/bringing in new skills and better sharing of existing knowledge across the sector. Moreover, consultees also noted the role of TFP in **both attracting and retaining skills** in the agritech sector.

Technology progression

Strong and consistently positive evidence of positive effects on the development of technologies. This includes moving towards better systems integration and making technologies more accessible/scalable in the marketplace. There is also emerging evidence of projects securing patents.

Technology progression

5.23 The beneficiary survey in Phase 5 demonstrates how TFP has successfully supported technology progression towards market readiness for the large majority of respondents (84%, 62/74).

5.24 During in-depth consultations with projects in Phase 4[40] and case studies in Phase 5, consultees described how they have been using TFP funding to gather data, undertake analysis and adjust, and trial new technologies with end users. By doing so, projects are progressing through the Technology Readiness Levels (TRLs) either by being able to validate/prove their concepts or move from PoC to more "real world solutions". For example:

- For one Investor Partnership project the TFP grant was described as "transformational" for the company. Fundamentally, the funding has enabled the organisation to expand from a small research and development consultancy into an engineering company with the capability to design, produce and sell products to consumers. The technology has progressed from TRL 3 to TRL 7.

- One CR&D1 project started at TRL 2 and progressed to TRL 6, with partners being able to demonstrate the prototypes of individual parts in the field, including private testing as well as demonstration events.

[39] For example, in one project, the investor is now an Executive Director and so involved in developing commercial opportunities for the business.
[40] All 31 project leads consulted in Phase 4 had made technological progress at that stage

- For another CR&D1 project, the main outcome has been the progression of the technology from TRL 3 at the start of the project to TRL 9 by the end. The project lead successfully commercialised the technology, with initial contracts for two systems secured before the project completion.

- Another STiP Demonstration project started with a "primitive version" of their software that had been subject to limited testing. TFP funding has enabled an expansion, scaling-up and broader scope of testing activity. As a result, according to the lead, "*the scope of the technology has increased significantly*" (Phase 4 project consultation).

- For a FFPS project, their field demonstrator was at TRL 4/5 prior to the project, but it was described as "*literally handmade*". TFP funding has enabled the firm to move from field demonstration to a "*massively refined*" and consistent field operation. By the end of this project, the lead was confident that all the systems relating to quality control and automation that were necessary for more mature systems operation will be complete (Phase 4 project consultation).

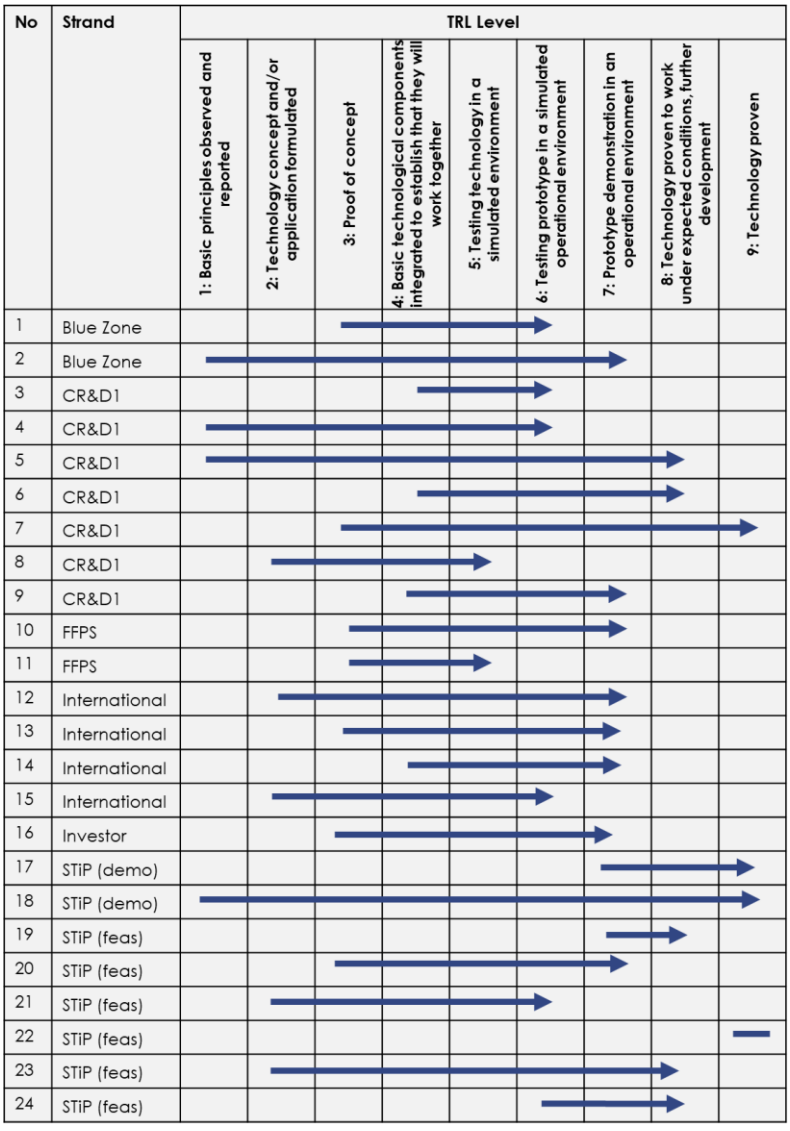
5.25 Further, some projects that have used TFP funding to develop sub-system technologies **have moved towards system integration**. Whilst some projects reported finding the system integration process a challenge, collaboration with project partners in the development of sub-systems/components was seen as helpful in facilitating and de-risking this process. Other later stage projects had focused their TFP-funded R&D on **making technologies more accessible and scalable in the marketplace**, which is key in the process of commercialisation and adoption. This has included R&D to reduce unit costs of production, optimising size/weight/compatibility of their product, or adapting existing technologies systems to UK contexts. For example, one STiP Demonstration project consulted in Phase 4 had moved from concept through to pre-production prototype, including re-engineering their product to allow for its integration with existing technology, which was critical in encouraging farmer uptake.

5.26 These positive findings in relation to technology progression were corroborated by stakeholder consultees in Phase 5, all of whom reported strong performance in this area and described how TFP had effectively catalysed and supported technology progression across the portfolio.

5.27 We have also explored the *extent* of technological progression using TRL levels. Technology Readiness Levels (TRL) are a measure used to assess the maturity of a technology, ranging from basic research (TRL 1) to fully deployed and operational systems (TRL 9). Figure 5-2 compares the pre-intervention TRL position (using baseline survey data, the start of the arrow) to the latest TRL position (at the time of the Phase 5 survey, the end of the arrow) for 24 projects where data is available for both points. The starting points vary within and across strands (consistent with the different intents of the strands). We note the self-reported data below suggests that a minority of projects started at an earlier TRL than anticipated, although projects can include a range of technologies at varying stages of development. **Almost all project leads had observed TRL progression** (23/24, 96%), and this progress **ranged from one to eight TRL levels forward, with a median improvement of four TRLs**. Given that some of these projects were

still live (e.g. FFPS) and others were relatively small and short in duration (e.g. STiP Feasibility studies), the extent of technology progression observed below is very encouraging. These findings align with the close out reports, where 50 of the 51 project leads who provided data reported a progression in the project's TRL, with a median increase of three levels. Furthermore, three projects reported progressing eight TRL levels in their close out reports. Again, while there is a need to recognise the risk of response bias across both sources, these are positive findings.

Figure 5-2: Phase 5 beneficiary survey: TRL Progression (n=24, leads only)



Source: Beneficiary survey analysis. Note, some respondents had been surveyed about a different project at baseline, or had changed from collaborator to lead, and so did not have a relevant pre-intervention response to this question. One response was excluded due to conflicting information provided during case study interviewing.

Patents

5.28 As illustrated in Figure 5-1, **patents and IP was the least common outcome observed in the Phase 5 beneficiary survey**. Around a quarter, 23% (17/74) of respondents had applied for or

secured patents/IP and a third, 32% (24/74) expected to do so in future.[41] Across the 41 beneficiaries who had achieved/expected to achieve IP related outcomes there was a large number of patents filed and secured:

- 352 patents had been filed (and a further 434 patents are expected to be filed)
- 22 patents had been secured (and a further 167 patents are expected to be secured)

5.29 Over two-fifths of survey respondents (42%, 31/74) said they have not and did not expect to generate patents/IP.

5.30 Data from the close out reports showed a similar number of patents secured (32 across the 203 responses), in addition to a further nine unpublished or pending patents. The close out reports also illustrate the global reach of these – for example, one project reported filing patents in America, Europe, China and Australia.

Commercialisation and adoption

It is too early to assess fully TFP's impact in terms of commercialisation and adoption at a programme level, but some examples of (mainly small-scale) commercialisation have been identified. Many projects are optimistic about taking TFP-funded technologies to market in the near future and taking steps to commercialise; most will require further funding to realise this intent.

5.31 In assessing TFP's performance on commercialisation, it is important to re-emphasise that many projects have recently closed or remain live, so insufficient time has passed to evaluate this fully. The findings should be considered in this light.

Commercialisation

5.32 Of those who reported technological progression in the Phase 5 beneficiary survey, **40% had introduced their product to the market** (25/62). This proportion was approximately the same across all competitions, with none statistically significantly above or below 40%. Of these 25 respondents, 13 were leads and 12 were collaborators. If we consider this from a project perspective, 46 of 51 projects covered by the survey reported progression, and 19 of these had been commercialised. Projects reaching market tended to be further along TRLs when starting their TFP project (i.e. Proof of Concept onwards), which is logical. Given the TRL data above, and feedback from case studies, it appears that some products have been sold at small volumes whilst at earlier TRLs in some contexts (as noted in a case study example above). The large majority were in precision technologies, e.g. robotics, automation, diagnostics, sensors, AI, and decision support management. There does not appear to be a relationship between grant size and the

[41] When we analyse survey findings at a project level, the findings are similar: of the 51 projects covered by the survey, 16 projects (31%) had a lead and/or partner who had applied/secured patents/IP

likelihood of introducing their product to market. Commercialisation appeared to be most common in CR&D1 and STiP Feasibility studies – however, this is likely to reflect the time passed for CR&D and shorter duration TRLs for STiP Feasibility studies.

5.33 The Phase 5 beneficiary survey also explored the extent to which technologies had been adopted and by whom, and found some evidence that **TFP-funded technologies have been adopted by the wider sector**, i.e. organisations not directly involved in the project. Specifically:

- 39% of respondents said the technology had been adopted by project partners (24/62)
- 45% reported that the technology has been adopted by those involved in demonstrations/pilots (28/62)
- 32% reported adoption by the wider sector (20/62)
- 62% reported that the technology had been adopted by at least one of these three (39/62).

5.34 **Most of the technologies adopted to date relate to precision agriculture**, including diagnostics and sensors (9 of 39, 23%), technologies to assist with advanced management decision support (8 of 39, 21%) or Data/AI/Machine learning (7 of 39 – 18%). UKRI's project end survey also found that the large majority of technologies that had been adopted in the UK by that point related to precision agriculture (13 out of 69 respondents said their TFP-funded technologies adopted in the UK, of which 12 were in precision agriculture).

5.35 The Phase 5 case studies and Phase 4 in-depth project consultations explored the scale and nature of commercialisation further. This reveals a mixed picture: **a small number of projects have gained good market traction, but the majority are in the early stages** (e.g. small scale contracts for new technologies with a limited number of customers, or exploiting new technologies in existing products, alongside ongoing product testing and refinement) and have not yet scaled. Case study evidence suggests the scale and nature of commercialisation to date varies significantly by project activity. In addition to the case study box on GelPonics below, other examples include the following:

- For one STIP Feasibility project, the company has successfully begun an initial phase of commercialisation. Since mid-2023 the product has been sold in 'trial' batches to several large agri-food manufacturers and retailers in the UK. This is leading to the progression and growth of the business, which has since moved from a pre-revenue to revenue-generating stage. In addition to these commercialisation benefits, the case study reported that the project has been important in informing business strategy and decision making, and the lead organisation now has a better understanding of key R&D activities required to refine the product going forward.
- One CR&D1 project progressed their technology from TRL 0 to TRL 6/7 during the project, with further development since the project taking this to TRL 9. The system has been proven in an operational environment and was launched commercially in late 2022. At the point of

the case study research in late-2023, the project lead reported that the technology had been adopted by 20 farms.

- For one UK-Canada project, a partner-level route to commercialisation has been followed, with aspects of the technology having entered the market via individual partner businesses, although the overall system developed through the project remains at the pre-commercialisation stage.

- For another UK-Canada project, the main route to market will be through integration with, and enhancement of, the company's existing service offer, and its existing customer base. Specifically, the plan is to integrate new analytical capabilities developed into the existing delivery systems so that it is accessible and easy to use for existing customers.

5.36 UKRI's monitoring data for live projects also indicates that 32 of 160 respondents had secured 139 new customers through their TFP project (4.3 per respondent on average excluding those who did not receive any new customers, or 0.8 including, with values ranging from 1 to 15).

Progress towards commercialisation

5.37 In addition to respondents who reported they had commercialised their technology in the Phase 5 beneficiary survey, **the remaining 60% expected to commercialise** (i.e. 37 of 62 who had progressed their technology). These respondents were optimistic on the timescales for this: a third expected to commercialise within a year and over 40% within two years. However, survey findings suggest **this will depend on further R&D activity in most cases** (81%, 30/37). As noted by stakeholder consultees, this is to be expected – routes and time-paths to commercialisation vary, and further investment/support may be needed. The survey also suggests that projects that have not yet commercialised were at slightly earlier TRLs at project start, i.e. Proof of Concept or earlier; the need for further funding in this context is not unexpected.

5.38 The close out reports provide further evidence on this: across the 200 responses, 73% (145) of respondents planned on conducting further R&D to commercially exploit the project, with a median anticipated spend of £150,000 required (estimated at project completion). However, the range in follow-on funding required was wide, with a maximum value given of £20m.

5.39 **Qualitative feedback suggests many projects are taking steps towards commercialisation**. This includes building commercial testing facilities, undertaking trials, demonstrations and market testing with end users/customers (e.g., farmers, chemical firms), engaging with key stakeholders/intermediaries who will facilitate adoption (e.g., vets), networking and discussions with potential customers, refining technologies to achieve a more accessible price point, and (in a minority of cases) developing business models and plans. Several consultees described how they are able to secure "traction" with customers by being able to demonstrate, through their participation in the programme, that they are progressing their R&D strategy and undertaking industry-leading research. TFP funding has helped some firms to better identify appropriate routes to market and given them "greater confidence" in their product and its ability to deliver

intended benefits to customers. These findings provide helpful evidence to underpin respondents' confidence in commercialising in the near future (discussed above), especially when considered alongside emerging evidence of beneficiaries securing private follow-on investment (discussed below). That said, as noted above, the majority will require further investment that had not been secured at the point of the survey and is therefore uncertain at present. In the context of current challenges in accessing private finance for larger scale/later stage innovation, this may be a challenge.

"We've built a real-world solution rather than something that's just running in simulators … we've generated a huge amount of real world data and insight into how these machines work and where improvements are required [by developing it on-farm] … I think that means our product is much closer to market because its being continuously trialled as it is developed"

Project lead consultee, Phase 4

5.40 Examples from case studies of projects moving towards commercialisation are as follows:

- One CR&D1 project is currently working on a follow-on project to progress the technology towards a "field operational machine" by May 2024 which is ready to be taken to market. The project lead's business model is to seek a buy-out from a larger industry player with the resources to fully commercialise the technology and manufacture it at scale.

- One STiP Feasibility project intends to offer the project to market from January 2024, requiring customers to purchase the initial equipment and pay a small annual fee for maintenance and support. To take the product to market, the company has partnered with an organisation specialising in global solutions with established frameworks for distribution in the USA, South America, and Australia, while in the UK market, the company will use their own contacts and has partnered with another organisation to widen their customer base.

- One STiP Demonstration project has now secured follow-on funding through Defra's FIP, to focus on honing the platform and adding further capabilities. Elements of the platform are available to customers now, but the full launch and commercialisation is not expected until June 2024.

- Another CR&D1 project progressed their technology from TRL 3 to TRL 9 during the project and successfully commercialised the technology, securing initial contracts for two systems before project completion via a distributor.

5.41 Evidence from the close out reports also demonstrates confidence in future commercialisation: of the non-academic responses, 78% (122/156) of respondents thought their commercial opportunity had 'greatly' or 'moderately' increased because of the TFP-funded project.

5.42 That said, in Phase 4 a minority of leads did not expect their technology to be as 'optimised' for commercialisation as expected by project end. This was due to various reasons relating to technological challenges and external factors (see Section 8 for further discussion), but this will

inevitably impact on requirements for further R&D funding to commercialise and timescales to impact. Case study evidence in Phase 5 also provides examples of this:

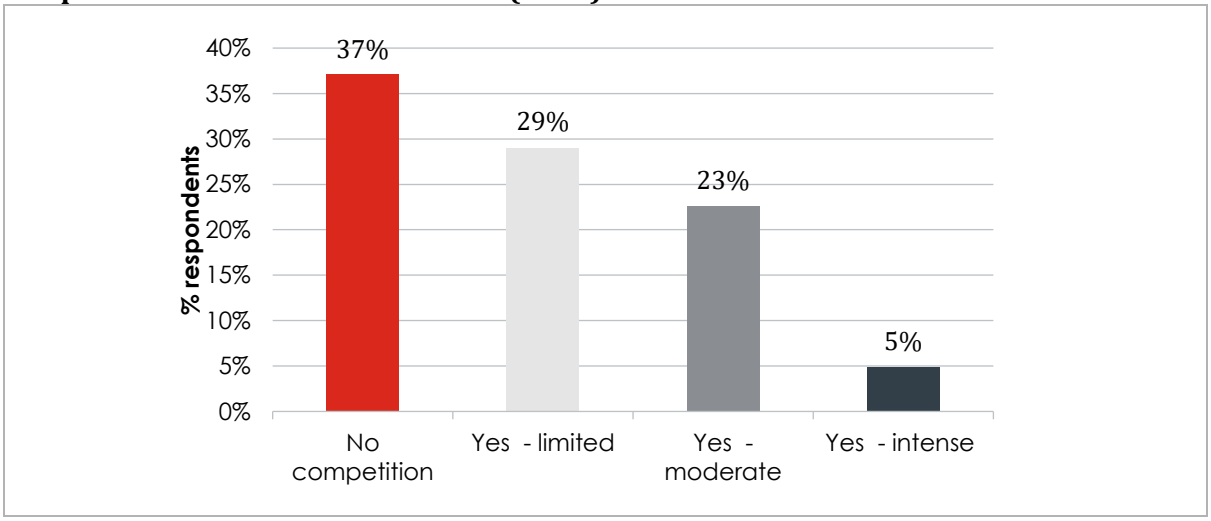
- One CR&D1 project said that, while they have commercialised the technology developed through the project, before the firm starts to generate any significant revenue stream from sales it will need further funding to refine the technology further.

- For one Canada bilateral project, the project had expected to take the product to market within the project timescales, however realised this would not be feasible after the scale of activity associated with R&D on product formulation increased took a larger share of the project timescales than first planned. That said, at the time of interview, the prototype was awaiting regulatory approval, with the intention to launch commercialisation activity promptly once approvals are made. The company are currently in conversation with UK and international partners to determine the most effective commercialisation route.

Displacement

5.43 **Displacement is expected to be low to medium**, based on Phase 5 survey findings. As illustrated below, two thirds (66%, 41/62) of respondents believe there will be no or limited competition with other UK firms, which suggests the majority of TFP-funded technologies are new to market or (if not) relatively distinctive.

Figure 5-3: Phase 5 beneficiary survey: Is the technology competing / Will the technology compete with other UK-based firms? (n=62)



Source: SQW analysis of final evaluation survey. Note: the remaining 6% of respondents stated "Don't know"

Follow-on investment in R&D

Encouraging evidence of follow-on investment in R&D due to TFP, with funding helping to progress technologies to a stage that de-risks internal and external investment, provides credibility and more robust evidence to underpin business cases, and strengthen investment readiness. This includes follow-on

investment from private sector sources, which is an important early signal of commercial potential.

5.44 There is emerging evidence to demonstrate that TFP projects are leading to further R&D investment, and how the TFP grant award has played an important role in securing follow-on finance. It is, however, difficult to provide a comprehensive statement on the amount of follow-on investment secured at a programme-level attributable to TFP. We therefore provide evidence from a range of perspectives to inform the contribution story.

Total follow-on investment secured since TFP funding award

5.45 Below we provide evidence from three sources on follow-on investment secured: the Phase 5 beneficiary survey (sample only); UKRI's monitoring data (sample only); and analysis of Beauhurst data (population). Three points are highlighted. First, none of these sources is comprehensive individually. However, when triangulated they provide a useful overarching indication on follow-on funding secured when considered from different perspectives. Second, the data in each case are different to and excludes match funding discussed in Section 4. Third, the beneficiary survey and UKRI's monitoring data both focus on funding associated directly with the TFP project. Beauhurst data represents funding secured by an organisation which may not related directly to TFP.

Follow-on finance associated directly with TFP (beneficiary survey and monitoring data)

5.46 In the Phase 5 beneficiary survey, **follow-on funding to progress the TFP-funded technology had been secured/been allocated by 66% of respondents** (49/74) and this amounted to £51.6m in total. As noted in Section 3, it is important to remember the survey was with a sample of beneficiaries, representing 38% of all beneficiaries.

- **Around two-thirds of businesses have invested *internal* funds** to progress the TFP-funded technology since being awarded the TFP grant (65%, 42/65)[42]. This amounts to **£15.2m** of investment from internal private sector sources, with an average of £476k per business[43].

- The extent to which project participants had secured *external* follow-on finance was more limited, but still **over a quarter of all organisations surveyed had secured further external funding** (26%, 19/74). Project leads were more likely to have secured external funding compared to collaborators (41% and 14% respectively). The total value of external funding secured was **£36.4m** across these 19 respondents. Just over half of this came from public sector grants (£20.6m, 56%) and most of the remainder was private equity investment

[42] This excludes and is further to the match funding commitment made alongside the TFP grant
[43] Ten businesses reported investing but did not quantify this - these have been excluded from this calculation

(£13.6m, 37%). Three respondents had secured Farming Innovation Programme funding, which accounted for 1% of external funding by value. Programme documentation also points to one project that secured follow-on funding from UKRI's Strength in Places Fund to optimise dairy value chains in Scotland and Cumbria, which will build on the success of their TFP-funded STiP Feasibility project.

- For those who had not secured external finance, often this was a timing issue, whereby they expected to secure external funding but their application was in progress or not yet started (20% of respondents, 11/55) or because it was not required (24%, 13/55). There was evidence that some respondents that had not secured external finance felt that funding was needed but there had not been any appropriate or relevant funding available (16%, 9/55). As noted above, continuity in support is key for projects that have not yet reached commercialisation.

5.47 According to monitoring data gathered by UKRI[44], **£348m of follow-on private investment aligned to the TFP-funded technology has been secured by 26 organisations**. Of this, approximately three-fifths was UK investment and two-fifths was from overseas. However, it is important to note that the large majority of this investment (c£300m) was secured by one organisation. Without this outlier (who did not complete the evaluation survey above), the value of external private investment secured remains slightly higher than the survey findings above. It is also interesting to see in the TFP programme documentation that one project has successfully crowdfunded over £2m from over 600 investors, many of whom were UK livestock farmers which demonstrates strong demand-side interest in that technology.

SQW has sought to collate data from the beneficiary survey and UKRI's monitoring data to provide an overall estimate of follow-on investment secured. In doing so, the beneficiary survey has been taken as the primary source of data (given it provides the most up-to-date picture for those surveyed). Monitoring data has then been used to fill gaps (i.e. the data have *not* been added together, rather a single source of evidence – monitoring or survey – has been used in each case where relevant).

Overall, this analysis suggests that the total follow-on investment to progress the TFP-funded technology further (from internal and external sources), for those organisations where data are available, is £391m. This draws on data from 65% of the unique organisations involved in TFP projects (although for the beneficiary survey, the data only relate to their first TFP project). This total is therefore likely to under-estimate the true value of follow-on funding across the full portfolio. It is also important to reiterate that follow-on investment secured by one beneficiary organisation (of £300m) accounts for around three-quarters of the total.

5.48 The evidence from the survey and monitoring data above directly links follow-on funding to TFP-funded technologies. To strengthen the attribution argument further, the evidence also suggests the **TFP funding has played an important and direct role in securing follow-on finance**. For

[44] This data merges data from inflight and close out reports on follow-on investment secured, excluding any double counting from participants who completed both datasets

example, the beneficiary survey in Phase 5 found that 41% (30/74) of respondents had improved their investment readiness already, and a further 34% (25/74) expected to see improvements in future. Consultations and case studies with projects demonstrated how TFP funding has supported technology development to a stage that de-risks both internal and external investment. TFP has also helped firms to:

- demonstrate/communicate the technology more effectively to investors
- present higher quality and more robust evidence (not just on technology effectiveness but also demand) to investors than would otherwise have been the case
- boosted entrepreneurs' confidence in their proposition
- helped to develop the business in parallel to the technology (including recruiting business advisors, staff with fundraising capabilities, or high-profile/credible senior staff more generally).

5.49 UKRI backing, and their assessment and due diligence processes, were also perceived to be an important indicator of quality to external investors. TFP's focus on net zero was reported to have been an important signal in terms of UK priorities to investors. All of these attributes of TFP are helpful in the fundraising process. A number of stakeholders consulted also said the level of follow-on finance secured was greater than anticipated at this stage, and argued private sector investment was an important signal of the technologies' commercial potential.

Case Study – GelPonics

GelPonics received £1.05m of TFP funding in 2020 under the STIP Demonstration strand to develop hydrogels to enable precision control of growing in vertical farms. AEH Innovative Hydrogel (AEH) is a micro firm in the North West of England a nd led the project. AEH partnered with Crop Health and Protection (CHAP), one of the UK's four agri-tech innovation centres. Compared to existing substrates used in this sector (such as stone wool, peat and coco coir), the hydrogel is biodegradable, higher in nutrient content, uses less water and GHG emissions are much lower (both in terms of its production and transportation).

The TFP grant enabled AEH to secure £300k in match funding from an angel investor, which was fully contingent on AEH securing the TFP grant. TFP was an important signal of potential, with robust due diligence processes in place to reassure the investor. TFP funding was used to undertake five large-scale trials to refine the technology and host demonstration events, engage with a wide range of potential customers (in the UK and overseas) and fund the input

from advisors. The project included dedicated responsibly and resource for knowledge exchange, which encouraged AEH to engage with potential customers much sooner than would otherwise have been the case. CHAP's knowledge of the sector and networks played a critical role in connecting AEH to customers. Crucially, TFP funding has enabled AEH to test the technology and develop the business in parallel. Alongside grant funding and CHAP and their partner Stockbridge Technology Centre (STC)'s expertise and facilities, AEH benefited from the facilities, expertise and profile of the Graphene Engineering Innovation Centre at the University of Manchester, where AEH is now based and small-scale manufacturing is taking place.

Progress made through the TFP project has led to significant investor interest. During the TFP project, AEH secured £3.5m equity investment from an overseas investor which has funded the construction of AEH's first dedicated manufacturing plant in Manchester. AEH said that "*without a doubt, TFP helped to secure that investment*" because the firm was able to demonstrate the technology worked and growing customer interest, and had Innovate UK backing. The knowledge gained through the TFP-funded R&D also helped AEH to secure a better valuation and terms associated with that investment. Consultees described securing VC investment as "a challenge for female founders" in the UK.

The project ended in 2023, after a non-cost extension due to Covid 19 which hindered the delivery of trials. AEH was able to progress the hydrogel from TRL 3-4 at the outset to TRL 8 at the end of the project (exceeding expectations, the goal was to reach TRL 6). By the time the project closed, AEH had secured small-scale contracts/trials with 21 customers from around the world (c.£10,000 revenue, 70% is from overseas customers). The firm now has 32 customers who have issued letters of intent to purchase the product (e.g. one UK customer intends to purchase hydrogel sheets to the value of £225k pa) once the new manufacturing facility is operational and able to manufacture at scale. Based on customer orders and letters of intent, turnover is expected to be £26m in

three years' time and the firm expects to employ 100 people (of which 60 are expected to be in the UK). AEH is also exploring the potential of hydrogels for other crops and in other markets, e.g. using the manufacturing by-product as a soil additive to improve nutrient content.

5.50 Some further examples of feedback related to the role of the programme in securing investment are set out below:

"[TFP] has enabled us to increase our investment in R&D dramatically. We also expanded the headcount of our internal R&D team. It has helped in securing investment – it gives technical credibility in a sense. [Grant funding] also de-risks private sector investors …. a lot of private sector investors don't particularly like technology/R&D risk, they prefer to see a finished product, so to see that you have funding from other sources to de-risk that is certainly helpful"

Project consultee (FFPS), Phase 4

"Off the back of this [TFP] work …. we raised a £7m round in October, part of which was venture capital, angel funding and an Innovate UK grant"

Project consultee (CR&D1), Phase 4

"The confidence which comes from UKRI due to due diligence approval should not be underestimated"

External stakeholder consultee

Follow-on finance secured after TFP application, but not necessarily directly associates with TFP (Beauhurst)

5.51 We have also tracked beneficiaries in the Beauhurst database to assess external funding secured since the TFP application. If a business has secured private finance or an innovation grant, Beauhurst will provide data on the value of that funding. The key findings are as follows (see Annex D for further details):

- **18% of beneficiaries had secured private investment** (42 beneficiaries) since their TFP application, with a **total value of approximately £247m.**[45] Investor type data is available for around half of these deals (108/207 deals[46]), which suggests 37% of deals are from private equity and venture capital, and 45% are from business angels/angel networks or crowd funding. In terms of private investor locations, 72% of deals were with UK-based investors and 28% were with overseas investors.

[45] Note, two businesses did not disclose the fundraising value.
[46] Note, a fundraising can comprise multiple deals. There were 103 fundraisings, which comprised 207 deals. Investor type data is only available by deal.

- **43% of beneficiaries had secured public sector innovation grants** (99 beneficiaries) since their TFP application, **with a total value of £177m.**[47] Innovate UK accounted for almost all grants secured (99%).

5.52 It is important to note that fundraising data in Beauhurst is not necessarily directly related to progressing the TFP-funded technology nor attributable to TFP. It is therefore not showing the scale of follow-on finance *associated with the programme*. That said, the ability of beneficiaries to secure follow-on funding (especially from the private sector) does suggest these are growing businesses and, as above, is an important indication on their commercial potential more broadly.

5.53 On private investment secured, we make two further observations: first, a high share of business angel funding suggests many of the firms securing private investment are still relatively early stage, with implications for timescales to market/impact; and second, £247m over 103 fundraising means the average value per fundraising is relatively small (£2.5m[48], which equates to £1.2m per deal). Whilst this may reflect the limited time passed since TFP projects, there may be a risk that subsequent funding is a 'drip feed' and insufficient to reach commercialisation and/or the scale-up required to have a material impact on the agricultural sector. It may also mean firms are spending a large proportion of their time pursuing investment rather than developing their products/markets.

Employment and turnover performance of beneficiary organisations

TFP funding has created high quality employment opportunities and increased turnover in some beneficiary organisations to date. Looking forward, impacts on turnover and employment are likely to be more widespread over the next three years (albeit relatively small-scale for most).

5.54 Evidence from the Phase 5 beneficiary survey suggests that some beneficiaries have observed a positive impact on their organisation in terms of turnover and/or employment, and around two-thirds expect these impacts to arise in the next three years. The findings are presented in Table 5-1. Leads were more likely to observe employment and turnover impacts to date.

Table 5-1: Phase 5 beneficiary survey: employment/turnover impacts of TFP (n=74)

	Employment[49]	Turnover
Achieved to date	• **31% of respondents had observed an increase in**	• **23% of respondents had observed an increase in turnover** as a result of the TFP project (17/74).

[47] Note, two businesses did not disclose the grant value. The value presented includes one £80.8m outlier.
[48] Note, the average fundraising value is based on 100 fundraisings as the value of three fundraisings is unknown.
[49] UKRI's inflight monitoring data 74 organisations had created a total of 197 jobs due to TFP (an average of 2.7 per organisation), and a further 283 jobs had been retained across 76 organisations. However,

	Employment[49]	Turnover
	employment as a result of the TFP project (23/74). • An estimated 180 FTE positions had been created, **an average of nearly 8 FTE per organisation** (where an employment effect had been realised).	• 14 of these were able to quantify the turnover increase due to TFP: the **total turnover uplift to date was over £8m, with an average of £584k per organisation** (where an effect has been realised).
Expected in the next three years	• **65% of respondents expect the TFP project to lead to an increase in employment** in the next three years (48/74). • This amounts to a further **457 FTE positions** across those able to quantify[50], an average of **10 per organisation** (where an employment effect is expected).	• **66% of respondents expect the TFP project to lead to an increase turnover** in the next three years (49/74). • This amounts to a **total turnover growth of £127m**[51], which is an **average growth of £3.5m per organisation** (where an effect is expected).

Note, 18 respondents had not and did not expect to see increases in turnover or employment; these spanned across strands and almost all are collaborators.

Source: Analysis of beneficiary survey results. Note, these are gross figures and therefore do not take into account additionality

5.55 Our consultations with projects in Phase 4 suggest the jobs created due to TFP were **highly skilled and well paid jobs, and were becoming embedded in those organisations**. For example, 14 of the 37 project consultees had taken on new staff to support the delivery of TFP-funded and wider R&D activities at that stage (mid 2022), including agricultural engineers, data scientists and software developers and temporary work placements for students and post-doc researcher opportunities. Moreover, R&D staff recruited to deliver TFP projects were becoming embedded - and in some cases, retained - within the firms. As illustrated in the quotes below, TFP funding and confidence gained from progressing technologies has encouraged agritech firms to create permanent positions, and better embed knowledge/skills in the process. In one case, the skills/knowledge gained as a result of TFP had led to changes in the business model, which in turn enabled the recruitment of more staff.

"We had two permanent R&D staff when we started, we now have seven and the people we brought in were kind of experts in specific domain areas. Before, our work on some of these sub-projects had been very stop start and dependent on availability of money, [so] we had been cautious of bringing on full time staff for more speculative development. In the past we had taken people on fixed term contracts to do specific bits of work. Our internal team and the pool of knowledge and skills we have is massively improved [since TFP]"

because the majority of this data was gathered in 2021, it is likely to be outdated and under-estimate job impacts.

[50] n=45. Three did not know

[51] n=36. 13 did not know

Project consultee (FFPS), Phase 4

"[With the large grant] we were able to hire staff. For example, we have a lot of data - environmental models, meteorological models and others - and so we needed data scientists … that data engineer and data scientist have been transformative for us"

Project consultee (FFPS), Phase 4

"[TFP has] allowed us to employ lots of talented personnel, who have now been moved to permanent contracts"

Project consultee (Investor Partnerships), Phase 4

"When we pitched for [the TFP project] we were five people in the organisation, we grew through the project to 12 FTE by end of 2021 and today [2023] we are 50, really all of that is attributed to the project."

Case Study consultee (CR&D1)

Case Study – SoilEssentials KORE Artificial Intelligence

The SoilEssentials KORE Artificial Intelligence (SKAi) project was awarded £609k through TFP's Collaborative R&D strand. The project was led by SoilEssentials, a Scotland based SME, with support from the University of the West of England, Scottish Agronomy and Deimos Space UK.[52] Building on previous Agri-Tech Catalyst funded R&D, the was to develop a ***market ready*** *technology to detect and spot spray weeds in grassland and vegetable crops, using machine vision. The purpose of this technology is to maintain (or in some cases, enhance) yield, whilst reducing the application of chemical herbicides.*

The key activities delivered with the funding relate to the development of the software and hardware elements of SKAi. Throughout the course of the 43-month project[53] (May 2019 to December 2022), the ***technology progressed from TRL 3 to TRL 9****. In the final month before project completion, SoilEssentials negotiated a contract for the sale of two systems to a Dutch onion grower, via a distributor. The systems were* ***adopted*** *by the grower the following season for the detection of volunteer potatoes in onions. As reported by the distributor, the grower was able to use the spot-spraying system as an* ***alternative to paying for manual removal*** *of the*

[52] A fourth partner started the project but voluntarily withdrew at an early stage.
[53] The project was awarded a 6 month no-cost extension

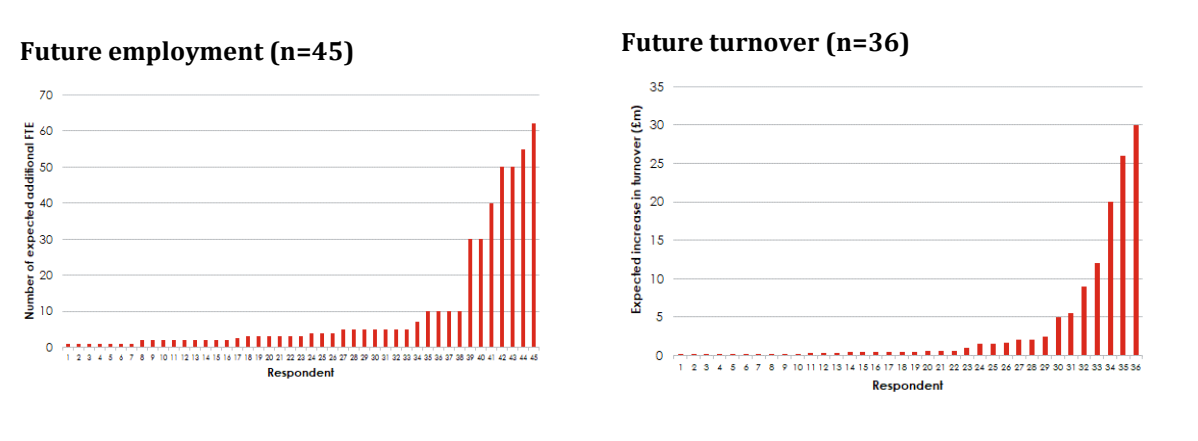
potato volunteers (at a labour cost of around €40k) and achieved a "fantastic yield". In other circumstances, the technology would be used as an alternative to blanket spraying, which can cause a 10% to 20% reduction in yield.

Since project completion, SoilEssentials has sold two further systems.[54] Sales of SKAi to date have increased the firm's turnover by £350k, secured 5 FTE positions, and created two additional jobs. Going forward, SoilEssentials expects SKAi to be a "prominent product" and generate further business growth. By leveraging its existing networks, SoilEssentials plans to expand the number of distributors selling the technology. It is also investigating alternative routes to market including working with large agrichemical companies to provide a ***service based supply model.***

TFP funding was essential for the project to go ahead – without it SoilEssentials would have deemed the R&D investment too risky. Other important factors contributing to the success of the project include the diverse skillset within SoilEssentials itself, as well as the expertise brought by each of the partners. The flexibility of the partners helped to minimise issues that arose, such as delays caused by Covid-19 or the withdrawal of one of the partners.

5.56 **In most cases, the impacts on employment and turnover were relatively small in scale.** For example, in terms of turnover most respondents have observed a cumulative impact to date of below £1m, with the exception of one outlier reporting an increase of £6m. The case study box above illustrates how TFP-funded technology has led to turnover and job creation. Looking forward, as illustrated below, the large majority of beneficiaries expecting an impact on turnover in the next three years anticipated an increase of less than £5m.

Figure 5-4: Phase 5 beneficiary survey: expected increase in employment and turnover by organisation over the next three years



Source: Beneficiary survey analysis

[54] One to be delivered in March

Internationalisation

Early evidence suggests international relationships and profile are emerging as a result of TFP (including beyond the international bilateral strand), but it is too early to fully assess the impacts of this on contracts and exports.

5.57 Data from UKRI's project end surveys[55] provides some **evidence of international activities**, including participation in international trials (19% - 14/73), beneficiaries engaging in contract work for overseas customers (11% - 8/73) and the export of systems/technologies (16% - 12/73).

5.58 In the Phase 5 beneficiary survey, just over one third of respondents had developed international collaborations and improved their international profile through TFP (both 36% - 27/74), and a similar proportion expected to do so in future (30% - 22/74 - and 34% - 25/74 - respectively). The international strand was expected to play an important role here but progress to date appears to be mixed. In the Canada bi-lateral projects, for example, Canadian partners have provided access to end users, facilitated trials in different environments and supported data gathering, and in future their networks are expected to unlock access to key agricultural equipment manufacturers and distributers in North America. However, for some international projects, Covid-19 hindered project progress including limiting the potential for UK-based project partners to travel to Canada/China as anticipated. These barriers are discussed further in Section 8. That said, all of the international strand respondents in the survey had or expected to improve their international profile as a result of TFP.

5.59 **Export outcomes at this stage appear to be limited**: around half of respondents in the beneficiary survey who had observed an increase in turnover due to TFP said none of this was accounted for by exports (53% - 9/17). The remainder had exported to varying degrees. However, given turnover uplift outcomes are modest to date, the value of exports associated with TFP is limited. Stakeholder consultees also struggled to identify examples of exports or FDI opportunities associated with TFP.

Anticipated impacts on agricultural sector

It is too early to assess the impact of TFP technologies on the agricultural sector, but early evidence suggests the programme is 'on the right track' in contributing to longer term improvements to agricultural productivity and reductions in GHG emissions, subject to the successful commercialisation and adoption of those technologies.

[55] Closed projects only n=69

5.60 The beneficiary survey gathered information on the anticipated impacts of the TFP-funded technologies on the wider agricultural sector. The purpose was to provide insight on whether the programme (and the technologies funded) is 'on the right track' to deliver against its overarching objectives (subject to successful commercialisation and take-up of those technologies). This is a high level assessment, but it does indicate the direction of travel towards those longer-term impacts.

5.61 Overall, if successful, **the TFP-funded technologies should impact upon agricultural productivity and GHG emissions:** across the 62 survey respondents who had or expected to introduce a technology to market, almost all thought that the technology would improve the productivity (98% - 61/62) and/or reduce the GHG emissions (85% - 53/62) of the agriculture sector as shown below.[56] Moreover, the majority anticipated the impact would be significant or moderate. The case studies provide further insight and examples of how technologies might impact upon agricultural productivity and GHG emissions in the future, although it was acknowledged that the scale of impacts will largely be dependent on the extent to which the technologies are used effectively to inform and change farming practices. For example:

- One UK-Canada project identified productivity benefits associated with their technology for users through improved livestock conception rates and subsequent reduced wastage. In turn, the technology is also expected to lead to reduction in greenhouse gas emissions, with end users able to achieve a similar level of output with reduced inputs.

- For one CR&D1 project, end users consulted identified a range of benefits of the technology developed through the project, including increased input efficiency, reduced input costs and improved productivity.

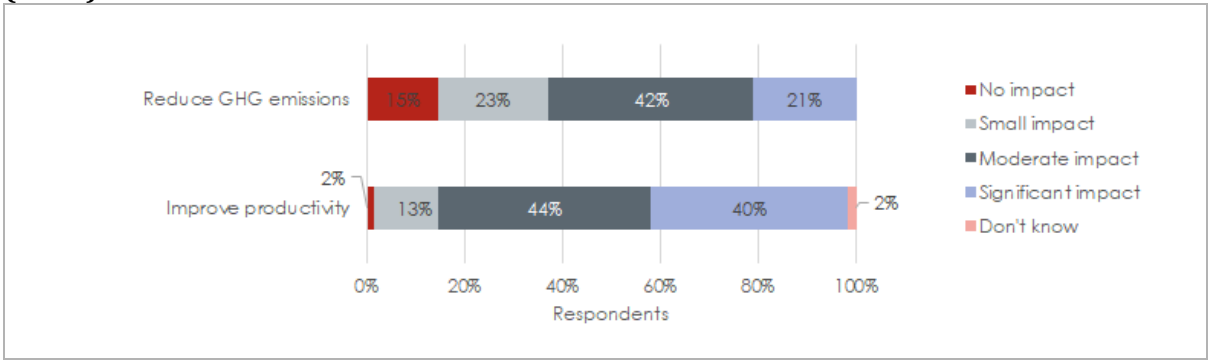
- A STiP Demonstration project reported that one of the technologies developed through the project will future-proof farms by removing the need for pesticides in farm practices, thereby reducing environmental impacts. In addition, one case study consultee noted that the application of the technologies developed will enable better yield forecasting through more regular monitoring, subsequently reducing food waste.

- Another STiP Demonstration project is expected to deliver long term benefits for the dairy sector, for example in terms of CO2 savings and productivity benefits through changing the types of feed used and reducing replacement rates due to livestock illness.

5.62 **Many of the TFP-funded technologies are also expected to have a wide reach** (rather than, for example, a narrow impact on a small subsector of agriculture): in terms of the target market, over half of respondents were targeting traditional agriculture in general (55% - 34/62), and most respondents thought the market for their TFP-funded technologies would be global (73% - 45/62).

[56] Respondents could select either or both productivity and GHG impacts

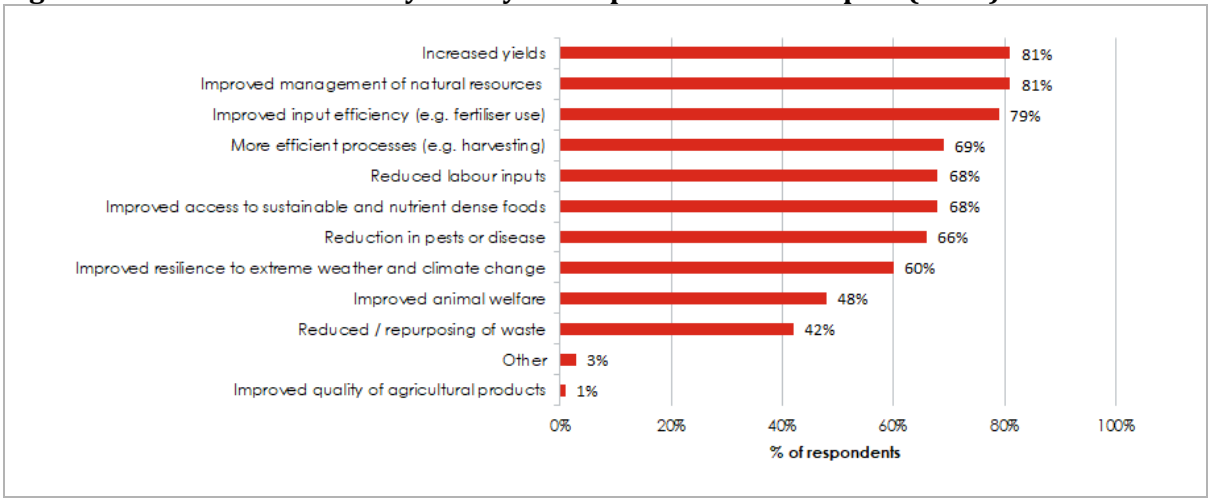
Figure 5-5: Phase 5 beneficiary survey: Anticipated impact of TFP-funded technology (n=62)



Source: Beneficiary survey analysis. Only asked if technology has been or is expected to be introduced to market

5.63 **Anticipated routes to impact varied, reflecting the diversity of technologies and agricultural sectors of funded projects.** As illustrated in Figure 5-6, technologies are most commonly expected to generate the impacts cited above by increasing yields, leading to improved management of natural resources, and/or improving input efficiency.

Figure 5-6: Phase 5 beneficiary survey: anticipated route to impact (n=62)



Source: Beneficiary survey analysis. Note, respondents could select either or both productivity and GHG impacts

Wider benefits and unexpected/unintended consequences

5.64 Consultations with projects and stakeholders highlighted the **role of TFP in raising the profile and reputation of organisations involved**. For example, project consultees described how their association with project partners (notably those who are "sector champions" and well respected in the sector) and the credibility of securing UKRI funding had helped to raise the profile of firms involved. There have also been reputational benefits for project partners – for example, one consultee said that taking part in the development of a leading technology has helped them become the "*go-to*" for stakeholders wanting to keep abreast of progress in that area.

5.65 TFP's impact on business creation appears to be limited, although this was not a key objective. However, according to UKRI's inflight monitoring data, nine organisations had established a new business as a result of the funding. Further, there is at least one example where **TFP funding had**

retained a firm in the UK. Prior to TFP, this firm had received interest from overseas investors who wanted to acquire a majority share and pursue a business model focused on non-UK licensing opportunities. The entrepreneur was considering a move to the UAE where grant funding was readily available. TFP enabled the business to "*progress and keep hold of the business*" in the UK.

5.66 Some survey respondents in Phase 5, case studies and project consultees in Phase 4 identified **unexpected or unintended consequences arising from the project, most of which were positive**. These primarily related to unanticipated market or exploitation opportunities arising during the R&D process. For example, TFP funding enabled one firm to run a full season demonstration of the technology and the results were significantly better than expected. Other projects identified aspects of the technology that can be exploited earlier than expected or market opportunities in unexpected sub-sectors (e.g., other crops or non-agricultural markets such as medical applications). Others mentioned unexpected environmental benefits. For example, one case study project determined that small autonomous vehicles can be used to reduce impacts of machinery on biodiversity, which was not anticipated at the outset of the project. For a Canada bilateral project, the strand's thematic focus on sustainability significantly influenced one company's strategic direction for the product and business more widely.

"This focus of the grant made us think about the increased relevance of the sustainability of our product, which we had not thought about in much detail before. We have now realised how important it is, and having clear links to how or product improves the sustainability of farming opens up massive markets for us"

Case study consultee

6. Strategic and wider impacts

Key messages

- The emphasis on TFP's wider strategic role has increased as the programme has matured, and there is evidence of progress in delivering positive strategic outcomes, both a project and programme level in the later stages of the programme.
- At a project level, the TFP team has made some progress in strengthening the ecosystem, by connecting TFP projects and wider support (e.g. the then Department for International Trade, DIT) and centrally promoting projects at events and in showcase documentation. There are also examples to demonstrate how projects themselves have also delivered wider strategic impacts, e.g. by seeking to influence the wider system and create an enabling environment for their technology.
- At a programme level, there are some strong examples of TFP's wider strategic impact. Key achievements include better co-ordination, aligned priorities and funding between UKRI and Defra in relation to agritech. TFP has also influenced Defra's significant financial commitment to the Farming Innovation Programme. TFP's thought leadership pieces and attendance at conferences has helped to raise awareness of opportunities in agritech. The team has also played a convening role, for example in relation to alternative proteins and VC investment, which has catalysed further support for the sector.
- The presence of TFP had an important signalling effect to the industry and investment community, demonstrating the strategic importance of this sector.
- However, strategic outcomes could have been greater, particularly by facilitating connections between projects, awareness raising/profile of TFP (and themes within it), wider ecosystem influencing and engagement with sector stakeholders/intermediaries (notably on adoption).
- TFP has played a role in the development of agritech technology areas, with the profile and partnerships catalysed by the funding opportunity particularly important. The nature and level of the contribution varied across the technology areas considered, influenced strongly by the external environment; this was not directly correlated with the level of programme investment. The contribution in Robotics was found to be most pronounced.

Implications for the contribution story

- There is evidence that expected strategic outcomes have occurred. TFP has added value strategically to the innovation landscape, helping to strengthen the ecosystem and influence the behaviours, policies and programmes of others. However, the approach to strategic impact was arguably not as cohesive as it could have been throughout the programme's delivery. Feedback suggests more could have been done to engage with other actors in the wider ecosystem to realise intended longer-term impacts.

6.1 This section is in two parts. The first presents evidence on the strategic impacts arising from TFP-funded projects and the programme as a whole, based on feedback from stakeholder and project-level consultations/case studies. The second assesses the wider impacts of TFP on the development of agricultural technologies, informed by a 'technology tracing' exercise, which involved a desk-based review and four expert workshops on the contribution of the programme to: Artificial Intelligence (including machine learning), Controlled Environment Agriculture (CEA), Robotics in production and harvesting, and Alternative Proteins.

Strategic outcomes

Evidence of progress in delivering positive strategic effects, both a project and programme level in the later stages of the programme. Key achievements include cross-governmental partnership working and informing policy/programmes and encouraging investor interest in UK agritech. However, strategic outcomes could have been greater, particularly awareness raising/profile of TFP (and themes within it) and engagement with sector stakeholders/intermediaries (notably on adoption).

Project level

6.2 Project level strategic effects were expected to be realised by TFP through facilitating connections between projects, and linking projects to the wider innovation landscape. To deliver against this ambition, the programme team held several 'collaboration nation' events (where related projects were invited to attend and network) and 'showcasing' events to identify potential synergies between projects. Feedback from projects suggests these events were helpful, especially to gather market intelligence from other organisations working in a similar (and usually very niche) sector. However, the evaluation did not identify evidence that these have led to formal collaborations or synergies between projects in practice. Overall, **feedback from stakeholder and project consultees suggests more could have been done to facilitate connections between projects**. This appears to be a missed opportunity to build cohorts/critical mass of connected projects in similar fields. That said, one FFPS case study noted that where projects are highly commercially sensitive, this can be difficult.

6.3 By contrast, consultee feedback was very positive on the role of TFP's team/monitoring officers in connecting and signposting projects to wider support and stakeholders. This suggests **TFP has helped to facilitate and strengthen the innovation ecosystem**. For example, the TFP team introduced a CR&D1 project to DIT who then promoted the project as an investable proposition, helped the project get in front of c.15 VC funders and opened doors to major international agri-food firms.

6.4 More broadly, qualitative feedback from project consultees indicated that the central TFP programme marketing, attendance at/hosting events and showcasing material was helpful in raising the profile and credibility of projects. For example, the TFP team attended a range of events to showcase TFP projects and engage with wider stakeholders – including a TFP showcase at the House of Lords and sector events such as Crop Tech, Dairy Tech and Fruit Focus. In some cases, the TFP team has been joined by project representatives which have provided projects with opportunities to promote their products/services to a wide audience and led to potential customers and investors engaging with some TFP projects.

6.5 The case studies identified examples of **TFP-funded projects that have generated a wider strategic impact**, by seeking to influence the wider system and create an enabling environment

for their technology. In the box below, the TFP-funded project has influenced a new code of practice for autonomous machinery, and undertaken wider engagement with key actors (including the Health and Safety Executive, Ofcom and NFU Mutual) to help ensure that wider regulations and infrastructure systems can accommodate the future use of autonomous systems in agriculture. In another examples, evidence generated by the TFP project has been used to influence regulatory policy for 'novel' fertiliser production methods at Defra and Environmental Agency.

Project Case Study – Hands Free Farm

The Hands Free Farm (HFF) project was funded under the CR&D strand of TFP. It began in May 2019 and ended in October 2022. Four UK partners were awarded a total grant of c.£1.6m: Precision Decisions Ltd (an SME); Harper Adams University (HAU); the Agri-EPI Centre (an RTO); and Farmscan Ag (a UK subsidiary of an Australian company).

The project successfully demonstrated that crops could be grown and harvested autonomously across 35 ha of farmland at HAU. It did this by developing a retrofittable automation system for small machines, such as the tractor shown above, including the ability for 'swarms' of machines to work together on the same field. Research from HAU suggests adopting such technology could reduce the cost of production for wheat by £20-30/tonne, crucial for small farm profitability.

Farmscan Ag is leading the commercialisation of the technology developed and demonstrated in the project, specifically software packages for retrofit vehicle conversion over ISOBUS (a standardised communication and control protocol used in agriculture machinery).

A predecessor study funded by Innovate UK (Hands Free Hectare) and the early stages of HFF highlighted a gap in relation to standards for the use of automated robotics in agriculture. Following two stakeholder meetings arranged by the HFF project team and wider HAU colleagues in the Global Institute for Agri-Tech Economics which discussed the possible enabling role of a Code of Practice, the British Standards Institution brought together a new development committee which in 2023 published a new code of practice for the 'Use of autonomous mobile machinery in agriculture and horticulture.' This has improved the UK strategic landscape for R&D and technology adoption.

In addition, the HFF team engaged with organisations such as the Health and Safety Executive on the safety implications of self-driving machinery, Ofcom on potential communications infrastructure requirements to support adoption of autonomous technology, and NFU Mutual on insurance implications. This has helped to influence the wider system in relation to the future use of autonomous systems in agriculture.

The team's open approach to knowledge sharing ensured that its achievements (and challenges) were disseminated widely, both in academic/R&D circles and also to farmers and the general public through traditional and social media. HFF continued to use the Hands Free Hectare Twitter and YouTube accounts and also featured on BBC One's 2021 Countryfile Harvest special, all of which raised awareness of what autonomous technology could achieve and helped encourage future technology adoption. The project also attracted wider media attention from over 80 countries which contributed to raising the UK's agritech R&D profile.

Source: SQW (including photo)

Programme level

6.6 TFP was also expected to have a strategic impact across the wider sector, for example, by demonstrating thought leadership, enhancing strategic partnership working, influencing policy and decision making, encouraging more investment in agritech R&D, and strengthening the UK's agritech innovation ecosystem and position as a world leader in agritech more broadly. These impacts also deliver against UKRI's wider remit to catalyse and convene.

6.7 Overall, there are **some strong examples of TFP's wider strategic impact**, and a greater emphasis was placed on TFP's strategic role as the programme matured. There was a consistent view amongst consultees that **TFP has played a role in supporting the continuity and capacity of the agri-food innovation ecosystem and support landscape, but at the same time, there was scope for greater impact in this area**. However, strategic activities had been constrained by a number of factors, most notably, Covid-19 restrictions, capacity challenges, and challenges associated with communicating TFP as it comes to an end alongside promoting Defra's new Farming Innovation Programme. We discuss this further in Section 8.

Thought leadership and awareness/profile raising

6.8 Consultees recognised consistently that the presence of TFP had an **important signalling effect** to boost the prominence of UK agritech. Government's prioritisation of agritech as one of the ISCFs with a substantial budget has "energised" the sector and raised its profile in both policy and business communities.

6.9 There are some specific examples of reports and thought leadership pieces produced by the programme. This includes **two showcasing documents** summarising TFP projects[57] and their impacts.[58] The latter was presented at the House of Lords, as noted above, which was attended by over 100 senior representatives from Government, industry and investors. The TFP team also partnered with Growing Kent and Medway Strength in Places Fund project to develop an **Alternative Proteins Roadmap**. The aim was to bring together relevant stakeholder experts to determine a consolidated view on capabilities, capacity, barriers, and investment and collaboration opportunities in the sector, and set the strategic direction for the sector. TFP's convening and leadership role in developing the Roadmap has catalysed further support for the sector (see case study box below).

6.10 Beyond these, the TFP team's attendance at conferences/trade shows has increased towards the later stages of the programme, as the programme has matured from portfolio set up/management to dissemination activities as 'successes' have emerged. Stakeholders consulted suggested these efforts have **helped to improve the 'public image' of agritech and raised awareness of challenges facing the sector** (see Investor Roundtable box).

6.11 However, during the evaluation, **external stakeholders raised concerns about the awareness of TFP (as a programme and its projects) across the wider sector**. They felt that awareness of TFP was either at a very high level (i.e., that the programme aimed to support the sector in realising net-zero ambitions), or at a very detailed project level (i.e., awareness of specific activities delivered), with a gap in understanding of how these two were linked in terms of the connecting 'themes' of activity – for example market or technology areas – supported by the programme, across its constituent strands. Their limited knowledge of TFP achievements mattered because, as a result, these external stakeholders then found it difficult to communicate/raise the profile of TFP on UKRI's behalf amongst their networks. The showcasing documents have gone some way to addressing this issue, but there remains a concern about profile across the wider sector. Leveraging the networks and communication channels of partners is a key route to achieving TFP's overarching goals for UK agritech in the longer-term, and may now be a role for the successor Farming Innovation Programme.

6.12 These findings were corroborated by the wider sector survey, where respondents were asked about their awareness of the TFP programme (at baseline) and whether this had changed (by the time of the final evaluation).

- **In the baseline survey, 60% (181/304) of respondents had not heard of TFP** and 22% (67/304) had heard of it but were not familiar with its activities. The remainder were familiar with its activities but not involved (14%) or involved in activities such as attending events

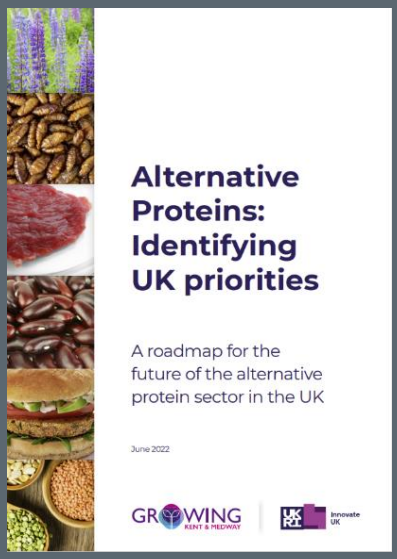
[57] Catalysing the transition to net zero food production, see here: https://www.ukri.org/wp-content/uploads/2023/07/IUK-100723-CatalysingTransitionNetZeroFoodProductionProjectsFromTransformingFoodProductionChallenge.pdf
[58] Catalysing the transition to net zero food production: delivering impact, see here: ukri.org/wp-content/uploads/2023/11/IUK-131123-CatalysingTransitionNetZeroFoodDeliveringImpact.pdf

and demonstrators (4%). Moreover, there was no variation in awareness of TFP between respondents who were 'adopters' or 'non adopters' of precision technologies.

- In the final impact survey, of the 126 respondents who were recontacted, nearly half said they had not heard more about TFP in the last two years since the baseline (48%, 61). A further 21% had heard more about TFP but was still not familiar with its activities.

Strategic Case Study – Alternative Proteins Roadmap

The development of a Roadmap for the alternative proteins sector was instigated by the TFP team and delivered in partnership with the Growing Kent and Medway Strength in Places Fund project. A workshop was convened with key public, industry and academic stakeholders across the sector to identify capabilities, capacity, barriers, and investment and collaboration opportunities in the sector. This informed the Roadmap publication in mid-2022, which set out strategic priorities for alternative proteins in the UK. This was the first time this had been done in a holistic way in the UK – previously, alternative protein sectors had been operating in silos.



According to consultees, the Roadmap has led to a number of strategic benefits:

- *It has raised the profile of alternative proteins in the UK, and developed a common understanding of 'what alternative proteins means' and the sector's needs. As noted by one consultee, prior to the Roadmap, it was not clear if alternative proteins was a strategic priority for public policy in the UK. In turn, this has raised awareness amongst other firms of opportunities in the sector, by 'adding legitimacy' and demonstrating that alternative proteins is a growing opportunity.*
- *It has strengthened the connectivity of the sector and helped bring the science base and industry together. It has also made some progress in simplifying and clarifying the landscape for alternative proteins.*
- *The Roadmap 'paved the way' for the prioritisation of alternative proteins as part of a new strategic relationship between Innovate UK and BBSRC, providing evidence and assurance that alternative proteins is a key opportunity area to focus on. As a result, the Roadmap helped to strengthen the business case for the recent Innovate UK and BBSRC-funded Novel Low Emission Food Production Systems R&D programme in late 2022. Whilst this was an open competition for any food production technologies relating to low emissions, two thirds of the projects funded involve alternative proteins. The Roadmap also informed the*

business case for the forthcoming Alternative Proteins Innovation and Knowledge Centre (IKC), particularly in terms of its scope and focus (e.g. need for scale up support).

Consultees agreed that the Roadmap has helped to accelerate further innovation funding for the alterative proteins sector. Without it, consultees estimated that BBSRC/Innovate UK funding for the sector would be two years behind where it currently is. Whilst alternative proteins may have still been a priority, innovation funding would have been less focused on the priority needs of the sector, smaller in scale and less co-ordinated.

Source: SQW case study, informed by consultations with UKRI, BBSRC, Growing Kent and Medway Strength in Places Project and the Good Food Institute

Investment in agritech R&D

6.13 The presence of TFP has also had an **important signalling effect across the investment community** in terms of the importance of Net Zero and agritech's contribution to this.

6.14 As outlined in Section 3, TFP has involved VCs directly in projects through the Investor Partnership strand. This has involved convening a pool of VCs, of whom 10 have invested in TFP projects. The total amount of VC investment into agritech firms is just over £30m, with a range of £1m to £5m per deal. According to stakeholders consulted for the evaluation, **this strand has attracted investors to the agritech sector** (including those who had not previously been active in the UK or not previously focused their investment strategy on agriculture or climate more broadly[59]), **connected VCs to the TFP pipeline of propositions, and encouraged larger-scale investments** than would otherwise not have occurred. This final point is reflected well in the following feedback from an investor involved in the IP strand:

"Looking back at that investment, we would not have done that investment without the TFP programme. I suspect that without the grant funding [the company] certainly would not have brought us to the table; they might have brought others in but ultimately I think the company would have raised £1m or £2m, not £7m."

"It has allowed private investors to tackle what is high risk technologies outside of your normal sector. It has encouraged companies within agriculture and the agricultural supply chain to invest in R&D, but I also think it has encouraged other VCs to support those companies."

External stakeholder consultees

6.15 The TFP team has also sought to have a **wider strategic influence on investment in agritech by convening an agritech investment roundtable**. As discussed in the case study box below, this has delivered a number of strategic benefits, including raising awareness of the fundraising

[59] This point was corroborated with Beauhurst data analysis

challenges faced by agritech firms at a Ministerial level and stimulating interest from the investor community.

Strategic Case Study – Agritech Investor Roundtable

Through the regular monitoring of TFP funded projects, the TFP team identified common challenges across portfolio in raising private sector investment. This promoted further internal analysis of investment data in the sector, which highlighted a lack of capital at Series A and (especially) Series B/C which was the main barrier to scale-up of agritech firms in the UK (alongside the slow rate of adoption of new technologies in the sector).

This intelligence led to an Agritech Investor Roundtable which was convened by the TFP team and chaired by the (now former) Minister for Science, Research and Innovation at DSIT. The event was held in mid 2023 as part of the London Tech Week, and was attended by a range of senior stakeholders from UKRI and Defra, investors and agritech firms. At the roundtable session, stakeholders discussed the challenges and potential solutions to de-risk larger-scale and later stage VC investment and strengthen the investment ecosystem in agritech. The discussion highlighted a number of issues, including difficulties experienced by investors in raising/closing funds in this space (especially in the UK where Sovereign/EU funding is not available to cornerstone funds), agritech firms struggling to secure investment, and (whilst strong support for investor partnership schemes) the lack of continuity or a strategic plan for Government support for this type of scheme.

The Roundtable has reportedly helped to raise the profile of agritech investment issues/opportunities at Ministerial level and amongst investors, and has 'crystallised' these as a priority for the UK. It has also helped to strengthen the investment ecosystem, by enabling UKRI to build relationships with investors who participated in the event. This includes one investor who has raised large-scale European funds but had a limited track record of investing in the UK – and is now involved in a subsequent round of the agritech Investor Partnership scheme as a direct result of attending the Roundtable.

Feedback from the Roundtable discussion is also being used to inform and refine subsequent support in this space. For example, the Roundtable highlighted the importance of capital investment for agritech firms, especially to enable scale-up - and UKRI are now considering allowing capital investment under future Investor Partnership schemes. However, there are ongoing challenges that are likely to require cross-departmental partnership working to resolve (e.g. UKRI, Defra and the British Business Bank). The sector arguably needs to attract larger-scale funds, including international funds, to increase the amount of investment available and the deal sizes. The sector can also require patient capital, but is a strong proposition for investors who also prioritise environmental impacts.

Source: SQW case study, informed by consultations with UKRI and an investor who participated in the Roundtable event

Strategic partnership working and influencing policy

6.16 **Feedback on TFP's strategic influence at a policy-level was very positive, particularly in relation to Defra**. As set out in the logic model, the programme intended to enhance evidence to inform policymaking, strategic partnership working and alignment of priorities/funding. These strategic benefits are evident in a number of ways:

- There was consistent feedback from consultees that TFP has strengthened the relationship and strategic partnership working between UKRI and Defra, particularly through Defra's involvement on the TFP Board (and subsequently the Board becoming a joint board for TFP and Farming Innovation Programme, FIP). This has led to **better co-ordination, aligned priorities and funding between Government departments** in relation to agritech. Consultees argued this was a real "culture shift" in terms of cross-departmental partnership working and "quite different to what has gone before".

- Consultee feedback suggest that TFP has played a critical role in raising awareness and demonstrating the benefits of investment in innovation at a senior level within Defra. This was reported to have **helped de-risk and secure Defra's significant financial commitment to the FIP,** which in turn is an important signal to the market about the UK's commitment to innovation in the sector.

- On a practical level, the **TFP experience has helped to shape the design and accelerated the delivery the Defra FIP**, by drawing on evidence of sector needs and lessons learned from TFP. Stakeholders argued it has also helped to stimulate demand for FIP – although there are no explicit mechanisms for TFP projects to progress to FIP and/or to help facilitate this process formally. Project consultations suggest awareness of FIP amongst organisations supported by TFP is varied, and, for the minority who were aware and have applied, success has been mixed. This also aligns with findings of the beneficiary survey, where only three respondents had secured FIP funding (see section 6) and examples in the case studies where TFP beneficiaries had been unsuccessful in securing FIP despite strong progress in developing their technologies. Some consultees expressed concern that their project did not align well with FIP, e.g., if they focused on the supply chain, were non-farmer led or primarily focused on UK markets, or were developing alternative food sources (e.g., lab grown meat). These findings suggest greater clarity is needed on how and in what circumstances FIP is seen as a bridge from TFP, and for this to be communicated transparently and consistently to supported projects.

6.17 As noted above, the Alternative Proteins Roadmap demonstrates how TFP has influenced strategic partnership working, policies and programmes within Innovate UK and BBSRC.

6.18 Finally, there are further examples of the TFP team engaging with other key stakeholders in the wider system to help pave the way for TFP projects (and other agritech firms) to commercialise new products (e.g., the Food Standards Agency, regulatory bodies). That said, **some consultees suggested more could have been done in this space to influence the wider innovation**

ecosystem and help to create favourable conditions for adoption. For example, this could have included engaging with key stakeholders in the college/university system to raise awareness of technologies developed (and skills required to implement them).

Wider impacts on progressing key technologies

There is evidence of the programme playing a role in the development of key technology areas, with the profile and partnerships catalysed by the funding opportunity seen as particularly important. The nature and level of the contribution varied across the technology areas considered, influenced strongly by the external environment, and this was not directly correlated with the level of programme investment. The contribution in Robotics was found to be most pronounced.

6.19 To provide a further perspective on the potential strategic and wider sector-level contribution of the programme, both emerging from individual projects and from cross-project activities, the evaluation has included a 'technology tracing' exercise. The purpose was to assess the extent to which the programme can be seen to have made a plausible contribution to developing several technology areas, including considering its role alongside other influencing factors and drivers.

6.20 Four technology areas were selected which reflected where the programme had invested substantial resource, and which were 'meaningful' in terms of their scope and coverage (recognising the linkage between technologies both across and within projects, and the risks of spurious precision and categorisation): Artificial Intelligence (including machine learning), Controlled Environment Agriculture, Robotics in production and harvesting, and Alternative Proteins. The scope of TFP investment/activity in each area is set out below.

Table 6-1: TFP investment and coverage in technology tracing areas

	Programme investment	Projects	Organi-sations	Coverage
AI	TFP: £35.9m Other: £19.7m	36	99	Focus on monitoring systems (crop, animals), and detection, identification and monitoring of pests/disease
CEA	TFP: £15.1m Other: £7.4m	13	38	Vertical farming emphasis, alongside other environments (e.g. greenhouses)
Robotics	TFP: £14.7m Other: £8.4m	19	39	Balance between soft fruit picking/harvesting, and weed/disease/pest control prevention to detection
Alternative Proteins	TFP: £14.4m Other: £7.5m	8	28	Focus across cultivated meat/cellular agriculture, insect farming, and animal feeds

Source: SQW based on UKRI data

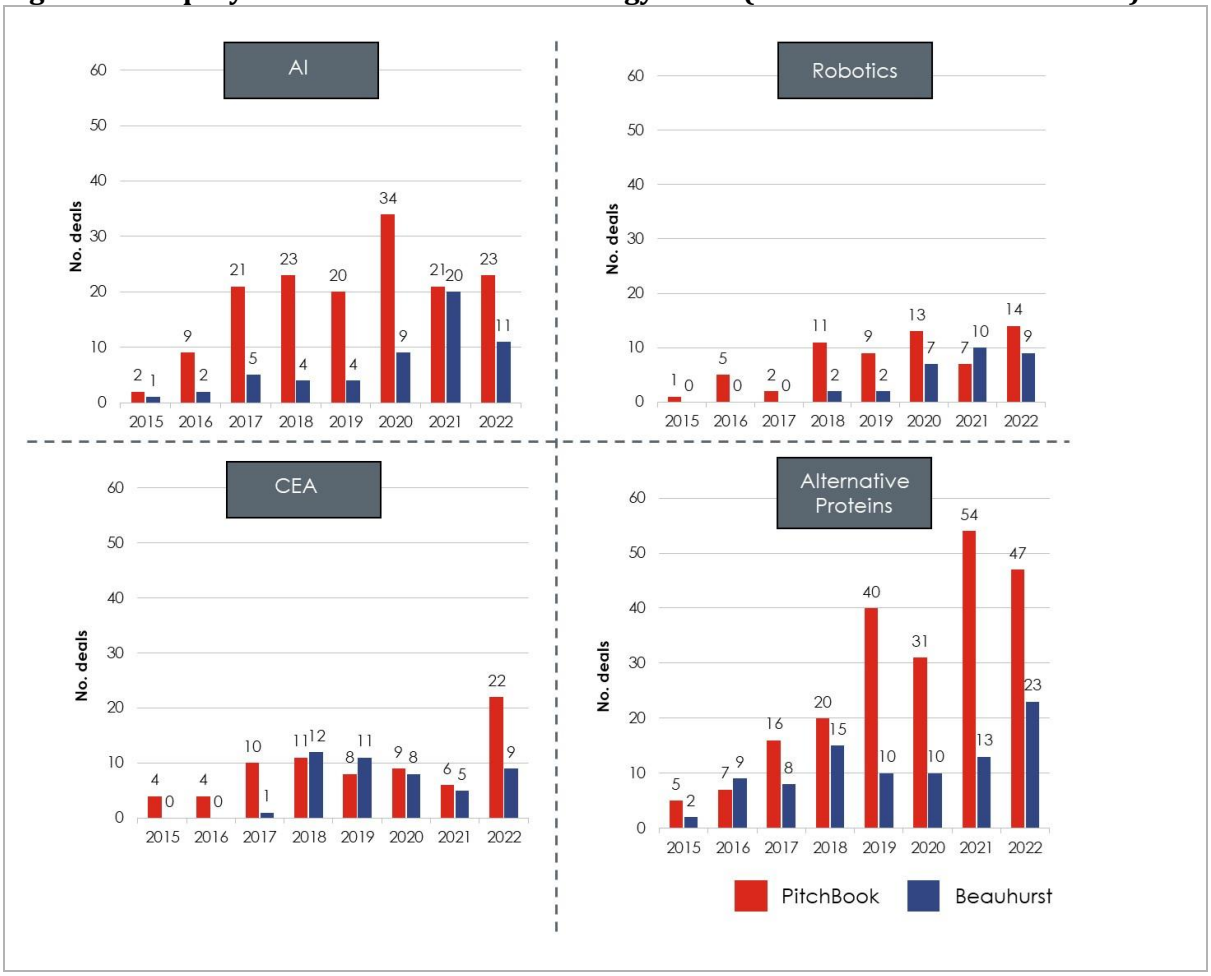
6.21 The technology areas (which each contain several component parts) are at different stages in terms of their technical maturity, commercial viability and position, and levels of adoption and usage across the sector. However, all four witnessed substantial change over the TFP programme period, as set out in the Technology Statements at Annex E.

6.22 There have been important external factors which have influenced the technologies over this period, both in term of challenges and opportunities. For example, global energy prices have led to particular challenges in relation to the commercial viability of elements of CEA (notably vertical farming). By contrast, labour market challenges in the UK (both in terms of labour costs and access) have been important in driving interest and adoption of robotics in production and harvesting. The rapid technical acceleration (and awareness) of AI technologies have increased interest on the potential role of AI in agriculture, and there has been a growing cohort of firms developing tailored agritech AI applications, including focused on AI to enhance and enable robotics and automation, satellite imagery analysis, and analytics to support animal husbandry. Wider market and consumer habits and expectations are also important, with elements of Alternative Proteins (notably plant proteins) commercialised but experiencing a market adjustment in recent years, and not yet widely adopted by UK consumers. Further, while there has been growing interest and activity in other forms of Alternative Proteins such as cultivated meat, this element of the sector faces significant challenges on the way to commercialisation.

6.23 More broadly, regulatory, skills, technology awareness and data-related issues (e.g. sharing, interoperability, access and associated infrastructure) have also been important factors influencing technology development across the four areas. Whilst these present differently across the technology areas (as discussed in more detail in each Technology Statement), this presents a complex landscape within which the programme has invested/supported activity.

6.24 This complexity is also reflected in the varied level and volume of equity investment recorded in these areas. The data suggest considerable levels of variability over time and no clear trend across most of the areas, with the exception of Robotics, where there has been a consistent growth, although the volume of equity deals in this area has remained modest relative to other areas (as summarised in the Figure below). The data suggest that equity investment has been most active in Alternative Proteins, although it is important to highlight that this data represented equity investment in early-stage businesses, it does not capture wider private investment, which has been considerable in some cases, for example in CEA (greenhouses and glasshouses).

Figure 6-1: Equity investments in the technology areas (number of deals 2015-2022)



Source: SQW based on Beauhurst and Pitchbook data

6.25 Against this complex and evolving landscape, the evaluation evidence suggests that the programme has played a role in supporting technology development at a technology/market level, both directly via projects and more widely.

6.26 An important factor here – recognised across the four technology areas – was the profile generated by the programme investments, which were seen to have been important in highlighting the offer and potential of the areas(s) in the UK research and innovation landscape. The specific mechanisms for this varied: in some cases it was related to individual high-profile projects (for example in Robotics and CEA), in others linked to strategic activities (such as the Alternative Proteins Roadmap developed by the programme). This is consistent with the broader evidence discussed above regarding the role of the programme as a 'signal' and high-profile demonstrator of Government support for agritech.

6.27 Further, TFP was seen to have been important in some of the technology areas in catalysing the development of new relationships, thereby helping to add depth and breadth to networks and relationships across the research and innovation landscape. Although there was feedback from some experts that more arguably could have been done, with targeted and systematic activity seeking to generate links between projects and the wider sector and generate a 'critical mass' in

specific technology areas, the programme was seen to have played a helpful role, particularly in the project development and application stage. It was also seen to complement other initiatives to generate links both across industry, and with the research base.

6.28 However, the evidence also suggests that the nature and intensity of the contribution has been varied across the four areas. This does not appear to be directly correlated with the level of investment. This is likely owing to the modest scale of the programme relative to wider investment (notably by the private sector including large corporates both in the UK and internationally), and the different pace of sector development as a result of wider technical and market drivers (for example related to AI). Further, the evaluation evidence suggests that the perceived level of contribution varies across stakeholders, which may in part reflect different levels of knowledge and understanding of TFP activity.

6.29 Recognising this complexity, the research suggests that **the contribution of TFP has arguably been the most pronounced in relation to Robotics in production and harvesting**. Feedback from the expert workshop (consistent with external stakeholder feedback from consultations) indicated TFP is seen as having played an important role in progressing robotics technologies towards maturity, particularly at the earlier TRL levels, and thereby helping to develop a "pipeline" of technologies that could be taken forward to maturity over the longer-term. This was attributed in part to the number of projects focused on soft fruit picking/harvesting in particular, but also the mix of projects including both large-scale and more targeted/focused activities.

6.30 The contribution of the programme in the other technology areas was also recognised related to specific individual projects, and it was seen to have invested in valuable and useful activities, and contributed to networks and profile. However, the external factors influencing the areas – notably energy costs for CEA and how this was influencing investments and innovation in this space, changing market dynamics for Alternative Proteins and on-going regulatory and technological barriers, and the rapidly developing technology landscape in AI and on-going issues related to data access and utilisation – were seen as providing a very challenging landscape in which to isolate the relative effects of the programme.

6.31 Two other points are noted. First, across the technology areas there was feedback related to the need for on-going, enhanced and better aligned support for both earlier stage (i.e. basic and fundamental science) and later stage (i.e. commercialisation and adoption and diffusion) activity. It was recognised this was not the core remit of TFP, however, it was seen as important to leveraging the potential from the technologies developed through the programme, and the strength and competitiveness of the UK in these areas. The modest level of TFP investment in advanced plant or animal breeding, Genetics and Genomics was also noted in this context.

6.32 Second, it is important to recognise that there were different views on the relative contribution of the programme to each technology area, and the related question on whether TFP supported the 'right' type of projects in each technology area. This is not unexpected, and highlights the complexity of TFP's delivery landscape and varied ways in which it has sought to generate outcomes and deliver change.

7. Additionality and counterfactual analysis

Key messages

- Outcome additionality of TFP appears to be strong, based on self-reported survey evidence. Partial additionality was most prevalent (nearly three fifths of respondents), whereby outcomes would have taken longer occur more quickly (for most, by 3-5 years or more), been smaller in scale (less than half) and/or compromised in other ways without TFP funding. Full additionality is also evident in some cases, albeit to a lesser extent (just over two fifths). Self-reported deadweight (where all outcomes would have been realised) was very low.
- By comparison, survey evidence suggests that just over half of proposed projects *had* been taken forward by unsuccessful applicants (UAs) since their TFP application. However, almost all were compromised in terms of scale, timing (i.e. started later), nature (less collaborative) and the outcomes achieved, which aligns with feedback from beneficiaries. Just under half of proposed projects had *not* progressed, mainly due to the lack of alternative finance. This reinforces the rational for intervention through TFP (i.e. lack of finance).
- The econometric analysis shows that TFP is associated with a statistically significant increase in employment change for beneficiaries when compared to the matched comparison group from the wider business population, but not turnover (which takes longer to realise). When comparing beneficiaries to UAs, beneficiaries progressed their technology faster through TRL stages than UAs, and this difference is statistically significant. Whilst export levels were generally low in absolute terms, TFP is also associated with a statistically significant increase in the likelihood that a beneficiary became an exporter following support compared to UAs.

Implications for the contribution story

- This evidence suggest TFP made an important contribution to accelerating the development of technologies and associated wider benefits. In some cases, where outcomes would not have been achieved at all without TFP funding, we conclude that TFP made a decisive difference. Where TFP helped to accelerate, scale up and improve the quality of impacts achieved, TFP was important alongside other factors.

7.1 In this section, we consider additionality (i.e. the extent to which benefits would have occurred anyway in the absence of TFP) from three perspectives:

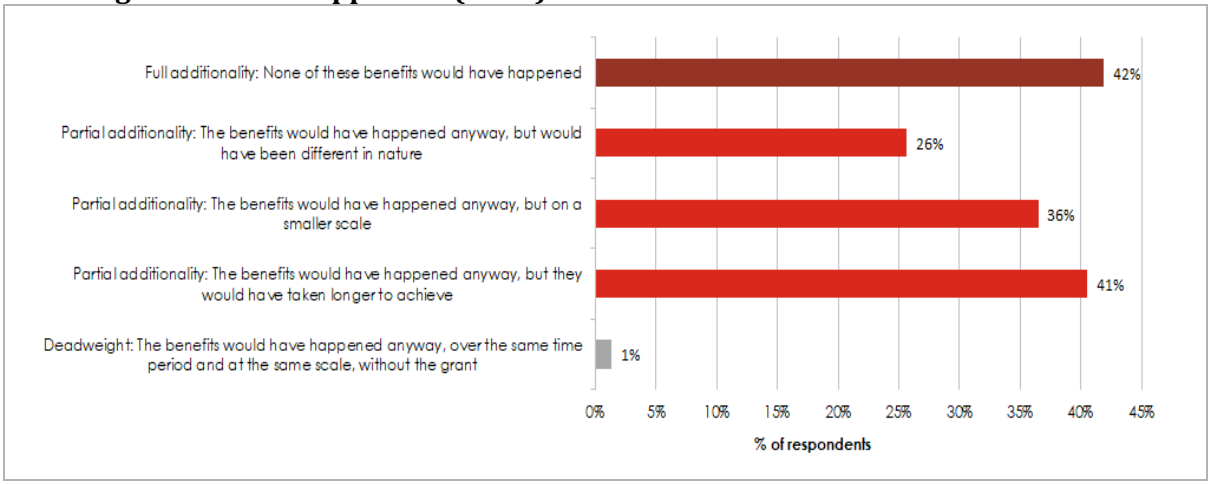
- first, self-reported views from beneficiaries, drawing on beneficiary survey evidence
- second, exploring whether unsuccessful applicants (UAs) have progressed anyway in the absence of TFP funding, also drawing on evidence from the UA survey
- third, econometric analysis to compare beneficiary outcomes to comparator groups.

Additionality – from the beneficiary perspective

7.2 The overall **outcome additionality of TFP appears to be strong,** based on self-reported evidence from the survey**. Partial additionality was most prevalent**, whereby TFP has enabled outcomes to occur more quickly, on a larger scale and/or generate outcomes that are different in

nature (57% of respondents, 42/74). **Full additionality was also evident in some cases, albeit to a lesser extent**, i.e. beneficiaries stated that outcomes would not have been achieved at all without TFP funding (42%, 31/74). Self-reported deadweight was very low at only 1%. This self-reported additionality picture was consistent across leads and collaborators.

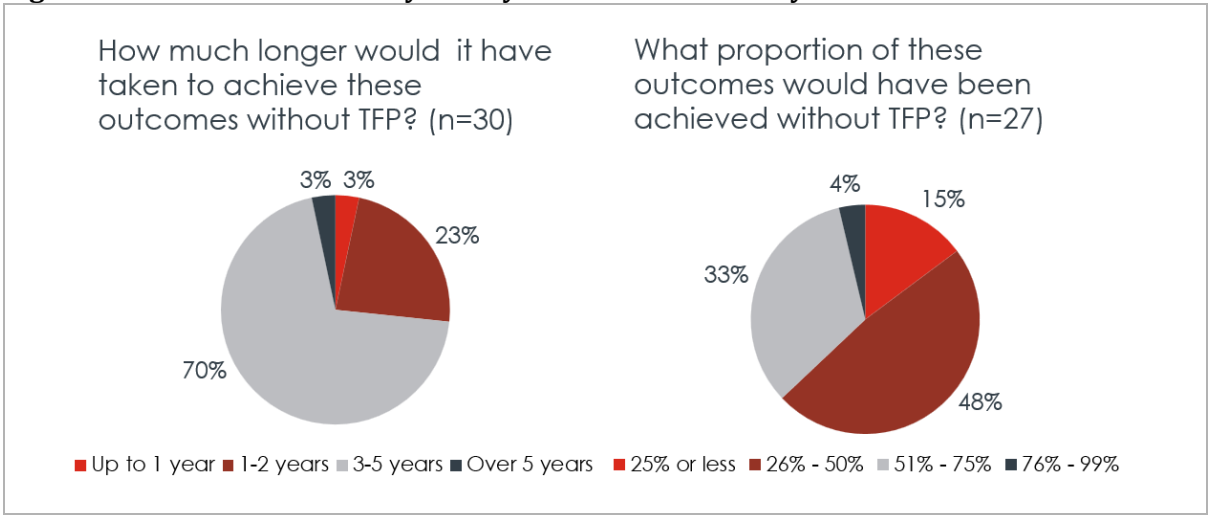
Figure 7-1: Phase 5 beneficiary survey: without this support from TFP, which of the following would have happened? (n=74)



Source: Beneficiary survey analysis. Note, partial additionality categories are not mutually exclusive

7.3 Where partial additionality was observed, beneficiaries were also asked what proportion of outcomes would have been achieved without TFP and/or how much longer it would have taken to achieve outcomes without TFP. As illustrated below, nearly two thirds of respondents citing scale additionality said outcomes would have been less than half what has been achieved (63%). On timing, nearly three quarters of respondents said TFP had accelerated outcomes by 3-5 years or more (73%). Given TFP's vision to 'accelerate the development' of technologies, and help firms to commercialise products/services ahead of global competition (putting UK agritech at the forefront globally), this is very positive. For those stating that the nature of outcomes would have been different, this was consistently worse in the absence of TFP funding, e.g. slower technological development, worse products/technology, fewer opportunities for partnership working, or more limited knowledge/skills development.

Figure 7-2: Phase 5 beneficiary survey: Partial additionality



Source: Beneficiary survey analysis.

7.4 The case studies provide further insight on how and why outcomes were deemed additional, and demonstrate how the challenges faced align closely with the original rationale for intervention (e.g. risk, co-ordination failures). For example:

- One Investor Partnership project stated that the project would not have gone ahead at all without the grant. Existing income would not have been sufficient to develop such an extensive range of new products and the company had not achieved sufficient market traction at that point in order to be an attractive investment proposition. TFP provided a sufficient scale of funding not available elsewhere, and helped to secure an investor (which, in turn, led to securing further investment): "*A £1m grant makes a huge difference to VC by improving the profitability of the company*." This was echoed by the investor partner, indicating that the Investor Partnership makes companies more attractive to investors – partly as non-diluted funding, but also as an "*accolade showing that the company has something specia*l".

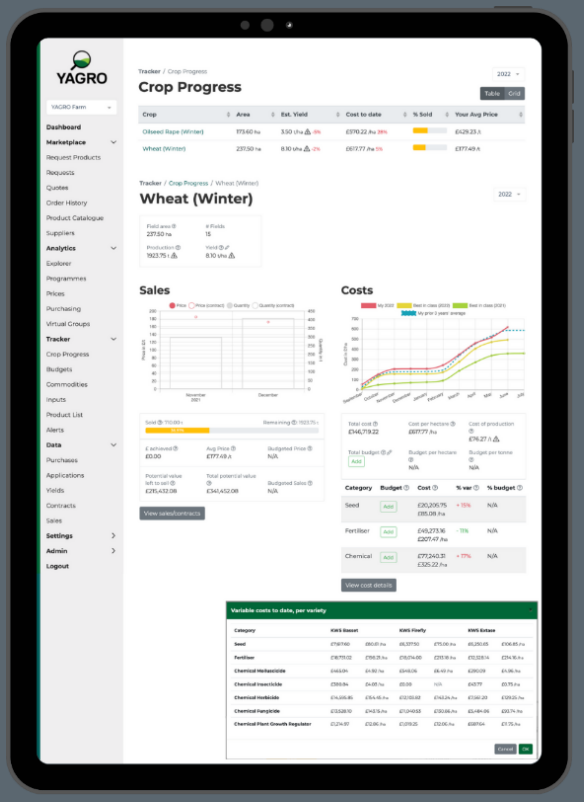
- A CR&D project stated that the project would not have gone ahead without the funding from TFP because it would have been too significant a commercial risk for the company to pursue: "*For a company our size, there is no way we could have put together a business case for this spending, or persuaded the partners to come together*".

- A STiP Feasibility project reported that the project would not have happened without TFP – *"There's no way that any of the partners would have joined together and self-funded this because it's too early stage. The technical and commercial risks were just too high."*

- For another CR&D project, views on the additionality were mixed across project members. For example, some noted that they would not have engaged with the project without the funding and so none of the benefits would have been achieved. On the other hand, some thought that benefits would have been achieved, but on a smaller scale and of a different nature because the project would have progressed without the collaboration.

- For another STiP Feasibility project, both the lead and partner stated that the outcomes associated with the project would not have occurred without the TFP funding. The lead explained that the project represented a significant *"divergence"* in business activity, thus the TFP grant sufficiently de-risked the opportunity for the company's shareholders.

Project Case Study – a commercial intelligence platform to optimise farm productivity



The project was funded under the CR&D strand of TFP. It began in May 2019 and ended in April 2021. Four UK partners were awarded a total grant of c.£560k: Yagro (Project Lead, SME) and three UK-based farms – JV Farming, Parker Farms and RH Topham & Sons. Building on Yagro's pre-existing platforms, MarketPlace (online procurement platform), and PriceCheck (price comparison tool), the project aimed to develop a commercial intelligence cloud-based software tool for farmers to understand, plan, and manage business performance, driving economic productivity.

The project focused on the development of two modules of the commercial intelligence platform using on-farm data: 'Analytics', providing full-season analysis of farm performance; and 'Tracker', providing up to date information for live tracking of farm progress. The Analytics module was launched as a prototype during the project to secure feedback from farmers and allow for sequential iteration, before being fully launched in 2020. Since the end of the project, the focus has been on the further development and launch of the Tracker module in 2022 and refining, scaling and adding additional features to the two modules. While adoption has not been the main focus to date, routes to market have and will continue to be, focused on two customer groups: farmers (c.200 users at the time of interview covering 250k hectares); and advisors and agronomists who can use intelligence from the platform to inform customers.

Alongside technology progression, the project has resulted in a range of wider outcomes. For Yagro, the project has contributed significantly to the growth of the company, both increasing company revenue and driving recruitment. Yagro had five employees at project start, growing to 12 during the project and reaching 50 in 2023, with this growth attributed directly to the project. More widely, for partners and end-users the Yagro platform provides confidence and

reassurance on ongoing practices, and allows them to gather insights and make informed decisions as to where changes can be made to improve productivity.

Enabling factors contributing to these outcomes were identified, including farmer involvement throughout to inform design, and wider sector drive towards data-led decision-making. Compared to these, TFP was the most important factor because the project was fully additional and would not have gone ahead at all without the grant. External funding was required for the project, as well as direct involvement with industry, and without TFP, Yagro would likely have focused on scaling MarketPlace and PriceCheck.

In 2021, Yagro was acquired by Frontier Agriculture Group of Companies. Yagro still operates as a standalone independent business, but now benefits from the support and financial backing from Frontier to further the development and scaling of the platform going forward. Importantly, Yagro noted that without TFP and the work delivered through the project, the company would not have been in a position to be acquired. Yagro has also secured follow-on investment via Defra's FIP, attributing this to the TFP project, to focus on forecasting and simulation features.

- One STiP Demonstration project lead reported that the TFP funding *"allowed an acceleration"* of R&D undertaken. In addition, the project was seen to enable the consolidation of resources and partners with different expertise,. According to the lead, *"without the project we would have been restricted"* in terms of the technology developed.

- A FFPS project reported that without the TFP funding they *"would be more or less where we were before"*; TFP provided the resource to deliver the project and engage and collaborate with partners, which would not have happened otherwise. The lead noted challenges in raising funding from private investors for hardware, and stated that in this context TFP funding was *"all or nothing"* in enabling project progress.

7.5 These findings align with feedback from stakeholders, with all consultees indicating some level of additionality. **Partial additionality - in terms of scale and speed - was also most commonly reported by consultees.** For example, they argued that VC investment would not have been at the same scale (as noted in Section 6) and there would not be the volume of agritech firms testing/developing ideas in the UK. Some consultees also argued the outcomes would have been different in nature – and specifically, lower in quality – because R&D would have been less collaborative (and less likely to involve industry or bring different disciplines/technologies together), less aligned with industry needs, less outward-facing/focused on knowledge exchange, and less risky or ambitious.

"We would have been much further behind because the really innovative, exciting and novel ideas wouldn't have been funded, as they don't fit in other research programmes that focus on silos.

If [TFP] hadn't been there, you would have academia leading research in a subject matter which wasn't really relevant and commercial enterprises sitting in the background having challenges that wouldn't be overcome."

External stakeholder consultees

Additionality – from the Unsuccessful Applicant (UA) perspective

7.6 The self-reported evidence from beneficiaries is positive, but may include some optimism bias. To strengthen the evidence on additionality, we have also explored the extent to which UAs have progressed their project without TFP funding and, if so, if this led to outcomes. Evidence was gathered from UA leads and collaborators, and compared to beneficiaries.

Progress in taking forward R&D activities

7.7 According to UA leads who completed the survey,[60] just over half of proposed projects had been taken forward since their TFP application (55%, 22/40) and just under half of proposed projects had not progressed (45%, 18/40).

7.8 For projects that did progress, common sources of funding included external equity finance (i.e. business angels) and other public sector finance (mostly provided by Innovate UK). However, as illustrated below, **21 out of 22 respondents who had progressed projects said the R&D activities were compromised in terms of scale, timing** (i.e. started later) **and nature** (i.e. taken forward by the lead organisation only rather than in collaboration). Only one respondent said the project was undertaken in full anyway, as set out in their TFP application.

7.9 Where projects have not been progressed (n=18)**, almost all UA leads cited lack of finance as the main reason for not taking projects forward.** The level of technical risk to 'go it alone' and a changing socio-political and economic situation were also cited in some cases.

7.10 It is also worth noting that of the 17 leads who had not taken forward their proposed project in Wave 2,[61] **nine still intended to take their project forward (53%), but only two were certain** about doing so, and seven said 'possibly'. Interestingly, where we have longitudinal data from leads in both surveys[62] who had not progressed in Wave 1 (n=13), only those who were 'certain' about taking forward their project in future (in Wave 1) have done so (by the time of Wave 2) and none of those stating 'possibly' (in Wave 1) have managed to progress their project since. **This suggests few of these projects are likely to progress in future.**

[60] Data on progress since the TFP application is available for 40 UA leads responding to the Wave 2 survey, of whom 21 completed the Wave 1 and 2 surveys and 19 completed the Wave 2 survey only.
[61] One non-response.
[62] i.e. the baseline survey in Phase 2 and the impact survey in Phase 5.

7.11 Project collaborators involved in unsuccessful applications were also asked about progress since the TFP application. Again, even where R&D activities have progressed without TFP funding, this has been less collaborative, smaller scale and/or different in nature.

- **The majority of collaborators said proposed projects have not progressed** (77%, 61/79) or they were not involved in the project (even though it did progress, 2). About one-fifth of these took forward some R&D activities in some form (22%, 14/63), even if the project did not progress as a whole, but for most their R&D activity differed from that planned in the TFP application.

- **Only a small proportion of collaborators said the projects have been taken forward** since the TFP application (14%, 11/79).[63] This is lower than the evidence from leads. This may reflect collaborators' lack of awareness that leads have taken a project forward, especially as the data above shows that most leads progressed without collaborator input. That said, where collaborators said R&D had progressed, this was often smaller in scale and/or different in nature/scope. Most were still involved in the R&D, but to a lesser extent.[64]

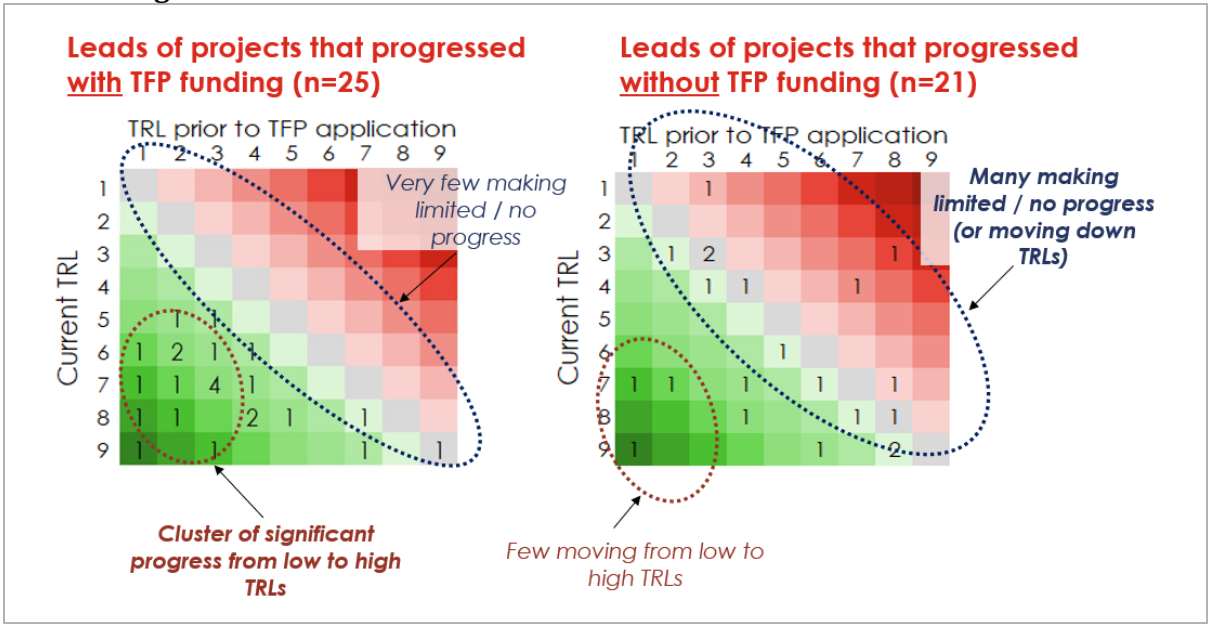
Outcomes observed by UAs (if R&D was progressed by leads)

7.12 Three other points are noted from survey evidence on UAs who did take forward the project:

- **TRL progression was more variable and limited compared to beneficiaries**. Figure 7-3 presents TRL progression of funded projects (the lefthand graphic) to progress made by unfunded projects (the right hand graphic). Each graphic presents the TRL stage prior to the TFP application on the horizontal axis, and the latest stage on the vertical axis. Projects in green boxes indicates that projects have moved forward TRLs over this period, grey indicates no change and red indicates steps back. As illustrated below, there is a cluster of funded projects that have made progress from low to high TRLs during their TFP project and very few have made limited/no progress. By comparison, few projects that were unsuccessful in their application to TFP have made progress from low to high TRLs since; the majority have made limited progress (and a minority have moved down TRL levels). Econometric analysis found this difference in TRL progression was statistically significant (see below).

[63] Some were not aware if the project had gone ahead or not (n=7).
[64] Nine were still involved in the R&D, of which six said they only undertook some of the R&D activities planned (not all).

Figure 7-3: Phase 5 beneficiary survey (left) and Phase 5 UA survey (right): Progression of technologies

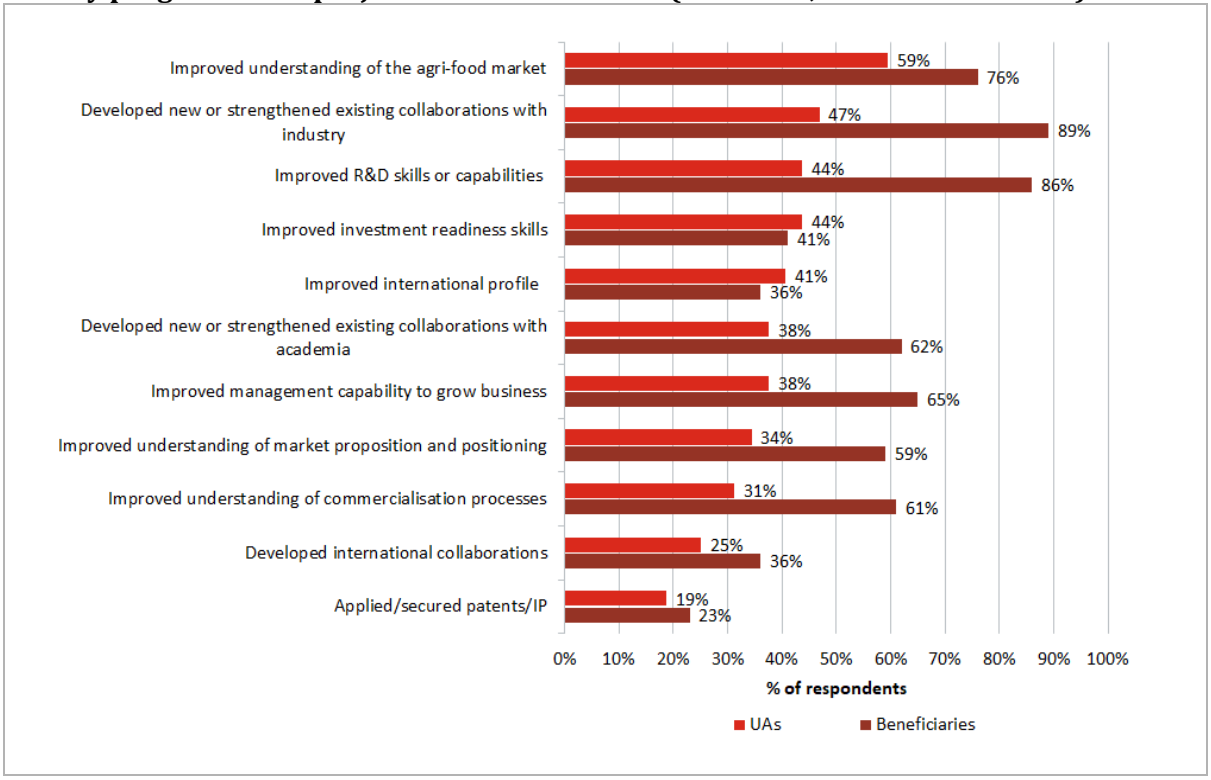


Source: SQW analysis of beneficiary and UA surveys, Phase 5. One response to the beneficiary survey was excluded due to conflicting information provided during case study interviewing.

- **Self-reported performance against objectives was lower compared to beneficiaries:** one quarter of leads said that their original objectives (as per the TFP application) have been achieved 'in full' (6/22, 27%). The same number had not achieved *any* of the objectives (6/22, 27%) and just under half had achieved objectives 'in part' (10/22, 45%).

- **UAs that had taken their project forward were less likely to have observed most outcomes compared to beneficiaries**, (based on data from both leads and collaborators). As shown below, the most notable differences were in relation to new/strengthened collaborations with industry, and improved R&D skills/capabilities. Substantive differences were also observed for improved understanding of commercialisation processes, improved management capabilities, understanding market positioning and collaboration with academia.

Figure 7-4: Phase 5 beneficiary survey and Phase 5 UA survey: Outcomes observed to date by progressed UA projects and beneficiaries (n=32 UAs, n=74 beneficiaries)



Source: SQW analysis of beneficiary and UA surveys, Phase 5

Econometric analysis

Approach

7.13 Econometric analysis has been completed to assess whether there were any differences in performance for those businesses involved in TFP compared to other comparable businesses – thereby informing whether engagement with TFP had led to business performance outcomes. The econometric analysis was performed on survey evidence and data on employment and turnover from the Business Structure Database (BSD) accessed through the Office for National Statistics (ONS) Secure Research Service. [65]

7.14 A quasi-experimental approach known as difference-in-difference (DiD)[66] was adopted. This compares the changes in outcomes over time between a treatment group – in this case businesses involved in TFP – and a comparison group. DiD estimates the *net* effect of support, as only the

[65] Office for National Statistics, released 10 November 2021, ONS SRS Metadata Catalogue, dataset, Business Structure Database - UK, https://doi.org/10.57906/7kh0-0910

[66] A quasi-experimental approach attempts to establish a cause-and-effect relationship in environments where a scientific experiment with random assignment of treatment is not feasible.

growth that is observed in the treatment group *beyond* what was demonstrated by the comparison group is attributed to engagement with the programme.[67]

7.15 Two separate comparison groups were used to facilitate a more robust analysis (i) unsuccessful applicants to the challenge (UAs[68]) and (ii) businesses in the wider population not involved with TFP which have similar observable characteristics (e.g. size, sector[69], age) identified from the BSD[70] using propensity score matching (PSM). PSM was used to create a comparison group consisting of businesses that were as likely to participate in TFP as the actual beneficiaries (based on their observable characteristics). This imitates a 'random' allocation that could have been achieved during a randomised control trial. This approach reduced the influence of selection bias on the results. Then, an analysis was conducted of the pre-matched and post-matched distributions of the probability to participate in TFP which showed that the matching was successful in reducing bias in observable characteristics of participants and the matched comparison group.

7.16 It is important to note that PSM is only able to match businesses on observable characteristics, i.e., characteristics that are recorded in datasets available. Differences in unobservable characteristics may remain (e.g. propensity to engage in R&D). Therefore analysis was also conducted on an alternative comparison group made up of UAs to TFP to check the robustness of findings. For employment and turnover results secondary data from the BSD was used for both comparison groups (Table 7-1). For all other outcomes we focussed on UAs only and used survey results (Table 7-2).

7.17 Finally, **this analysis has been undertaken at a relatively early stage** given, as outlined above, many TFP-funded projects had only recently completed or were still in delivery and so limited time has passed for impacts on employment and turnover to materialise. Furthermore, according to the beneficiary survey findings in Section 5, a large proportion of TFP-funded had not yet reached market. The findings below should be interpreted in that context. Given that many of those intending to commercialise technologies in future expected to do so in the next three years, it may be appropriate to revisit this analysis at a later stage (e.g. in 2028 or later).

[67] DiD analysis corresponds to level three on The Maryland Scientific Methods Scale (SMS), providing robust evidence of the programme's impact on businesses. This scale was first introduced in Farrington *et al.* (2003). It ranks evaluation methods on a scale from one to five with higher numbers indicating more robust methods. Randomised control trials are typically placed at level five, while a cross-sectional comparison of treated and untreated groups, or before and after comparison of the treated only, with no additional controls is normally scored as one. A guide to the up-to-date version of the scale is available at https://whatworksgrowth.org/

[68] We tested comparison groups consisting of all unsuccessful applicants and only those with an application score of 60 or 70 and above. The results shown are for the group of all unsuccessful applicants but findings were similar across all three groups.

[69] The sector composition of the beneficiary group (SIC codes) was used to inform matching with non-supported businesses.

[70] This analysis focuses on UK based firms only, including for the comparator group

Results

Turnover and employment using BSD data

7.18 Table 7-1 shows the regression estimates of the net impact of TFP on supported businesses' employment and real turnover using data from the BSD. Two outcome categories are presented:

- 'Impact of TFP' which sets out the findings of the DiD, comparing outcomes before and after intervention between treatment and comparison groups
- 'Group trend of participants' which shows whether there were pre-existing differences before TFP started between the participants and the control group.

7.19 The findings on **the 'impact of TFP' are *net* of the 'group trend' findings** in the table below, i.e. whether there is a significant effect of TFP above and beyond the group trend results.

Table 7-1: DiD analysis of employment and turnover impacts of TFP

Outcome:	Log (employment change)		Log (real turnover change)	
Comparison group:	**1) BSD, matched with PSM**	**2) UAs**	**1) BSD, matched with PSM**	**2) UAs**
Impact of TFP	**0.132** (i.e. 14.1% more employment growth following TFP) ** **(0.061)**	**Insignificant**	**Insignificant**	**Insignificant**
Group trend of participants	0.051 (i.e. 5.2% more employment growth before & after TFP) *** (0.012)	Insignificant	0.067 (i.e. 6.9% more turnover growth before & after TFP) *** (0.026)	0.055 (i.e. 5.7% more turnover growth before & after TFP) ** (0.024)

*Standard errors in parentheses, level of statistical significance: * p < 0.1, ** p < 0.05, *** p < 0.01. All regressions controlled for year fixed effects and business fixed effects*

Source: SQW analysis of ONS data

7.20 Three points are noted. First, the analysis indicates that **TFP is associated with a significant positive employment change for participating businesses when compared to the matched comparison group from the wider business population**. This impact of TFP is above and beyond growth in the group trend (i.e. even when faster prior growth of beneficiaries is taken into account).

7.21 No significant effect is found on employment when comparing against UAs. This may suggest that the significant findings on the matched comparison group from the wider business population is

owing in part to underlying differences between the beneficiaries and the comparison group that cannot be accounted for in the PSM, which is based on observable characteristics only.

7.22 Second, **the analysis indicates TFP has not led to a significant difference in turnover** to date when compared to either comparison group. This is perhaps not unexpected. As noted above, survey evidence indicates the turnover effects of the programme at this point are modest (with under a quarter of survey respondents indicating an effect to date). Further, it will take time for turnover outcomes to be realised as technologies are commercialised and adopted across the market.

7.23 Third, the group trend variable, which captures any pre-existing differences between the treatment and comparison groups, indicates that participating businesses are on a faster growth trajectory in turnover than UAs and the matched comparison group (and also employment for the latter). This faster trajectory was evident both before as well as after TFP, and therefore cannot be attributed to the programme. However, this does provide a supporting context for the realisation of outcomes in the future if this growth trajectory is sustained.

Other outcomes using survey data

7.24 Table 7-2 shows the regression estimates of the net impact of TFP on other measures of business success captured. This is based on DiD comparing pre- and post-support outcomes gathered via the surveys of beneficiaries and UAs. Full results are available in Annex G.

Table 7-2: DiD analysis of other impacts of TFP (latest position compared to pre-TFP)

Outcome	DiD estimate: treatment effect
Have participants increased R&D spending more than UAs?	Insignificant
Are participants more likely to have become businesses that invest in R&D following TFP than UAs?	Insignificant
Have participants increased the Technology Readiness Level (TRL) by more than UAs?	2.074 (i.e. two TRL levels)** (0.833)
Have participants increased their productivity (turnover/employment) by more than UAs?	Insignificant
Have participants increased their R&D spend per person by more than UAs?	Insignificant
Are participants more likely to export part of their turnover following TFP than UAs?	0.207 (i.e. 20.7 percentage points more likely[71])* (0.106)
Have participants increased their (self-reported) company valuation by more than UAs?	Insignificant
Have more participants started to collaborate on R&D following TFP than UAs?	Insignificant

[71] Growth in the proportion of exporters is 20.7pp larger for beneficiaries compared to UAs

Outcome	DiD estimate: treatment effect
Have more participants had other R&D support following TFP than UAs?	Insignificant

*Standard errors in parentheses, level of statistical significance: * p < 0.1, ** p < 0.05, *** p < 0.01. All regressions account for pre-existing differences between treatment and control groups* *Source: SQW analysis*

7.25 The estimates from DiD regressions suggest that **TFP participants progressed significantly faster along TRLs than UAs** (at the 5% level). TFP is also associated with a statistically significant increase in the likelihood a beneficiary became an exporter post-support (at the 10% level). No statistically significant effects were found in relation to R&D spending, productivity, company valuation, or the likelihood of collaborating in R&D or receiving R&D support.[72]

7.26 Our estimates also suggest there were some statistically significant pre-existing differences between beneficiaries and UAs. Beneficiaries were more likely to be at a lower TRL initially and were more likely to invest in R&D, which aligns with findings above. We also found that beneficiaries had significantly higher (self-reported) company valuations than UAs (around double), which may reflect the high levels of R&D investment.

7.27 In summary these findings show that **TFP has been successful in accelerating the speed of development for the funded technology for beneficiaries**. On average, at the start, beneficiaries were c.0.9 TRL *behind* unsuccessful applicants. However, by the second survey in Phase 5, beneficiaries had progressed through on average c.2.1 TRLs more than UAs (who progressed on average 0.9 TRLs), and were c.1.2 TRLs *ahead* of UAs. Although it is noted that TRL progression is not linear, since beneficiaries started lower and ended up higher than non-beneficiaries, **the evidence suggests that TFP has been effective in accelerating innovation.**

[72] Employment and turnover impacts were tested using survey results but no evidence was found of a statistically significant effect.

8. Factors influencing outcomes and impacts

Key messages

- The way in which TFP has been designed and implemented has been critical to success. In terms of design, this includes the challenge-led approach, scale, duration, ambition, flexibility, and innovation in approach. The balanced portfolio approach was appropriate, offering support for different types of technology at different stages of development to suit different needs. Most strands have worked well for different reasons (one strand, China bilateral, has worked less well). The emphasis on collaboration and end user engagement throughout has also been important in realising 'better' outcomes. The TFP team has also been key to success, with good continuity of key staff, sector knowledge and strong management and governance.
- However, impacts may have been maximised further in some respects. Reflecting the very diverse nature of this sector, balancing breadth of support and concentration of effort/impact has been a challenge (not helped by the loss of funding, which hindered TFP's ability to consolidate effort/impact in some areas). The programme has lacked clarity on its practical role in engaging with the wider ecosystem and supporting adoption. In addition, capacity has been very constrained within the TFP team, which has hindered outreach work. Together, these issues have had implications for strategic impacts.
- TFP has witnessed substantial changes in the external context during its lifetime, particularly linked to the aftermath of Brexit, Covid-19 and more recently the war in Ukraine – these have created both headwinds and tailwinds. The pandemic inevitably impacted on the programme – for example in terms of delays and hindering engagement/outreach – but the consequences of the pandemic were managed well by the TFP team overall.
- Looking forward, there are four key risk factors that could hinder ultimate goals being achieved: first, on the supply side, the availability of finance for scale-up; second, on the demand side, ongoing and significant adoption challenges; third, wider systems/infrastructure changes that are critical to enable TFP-funded technologies to gain market traction; and fourth, wider policy and regulatory challenges. That said, improving productivity and net zero remain a critical priority for the UK and should drive strong demand for TFP-funded technologies going forward.

Implications for the contribution story

- TFP's design and delivery has been critical to the outcomes achieved to date, especially at a project level. Looking forward, whilst the projects remain highly relevant to strategic priorities in the UK, there is a risk that external drivers (notably the availability of finance for scale up on the supply side, and on the demand side, adoption, wider systems/infrastructure, policy and regulatory barriers) will hinder the ability to 'shift the dial' in productivity and GHG emissions of the sector in the longer term.

8.1 To test the theory of change, we explored factors that have enabled or hindered outcomes/impacts achieved to date, or may do so in future. These are summarised below, drawing on qualitative feedback from projects and stakeholders, monitoring data and programme documentation. We have split the section into two parts: first, factors that relate to the design and delivery of the programme and the organisations involved in TFP-funded projects (and associated learning about 'what works'); and second, wider/external factors.

8.2 In this context, it is important to recognise that the programme is wide-ranging, with different projects, at different stages of delivery, addressing different rationales, involving different technologies, subsectors and beneficiary groups, and with varied and in some cases emergent outcomes and impacts. It has not been possible to explore factors at a fine-grained technology/sub-sector level within the scope of this evaluation; rather comment is limited to factors that have influenced performance at an overall programme level (or may do so in future). Further, the pace and scale of change in the sector has been greater than could have been anticipated at the outset of TFP (and when the evaluation's ToC was developed in Autumn 2020). The findings should be seen in this light: they will not apply to all projects at all times across the programme. However, they do provide insight on the factors that have influenced the overall contribution of the programme.

Factors relating to the design/implementation of TFP and organisations involved in projects

Key factors enabling outcomes and impacts

8.3 Table 8-1 presents key factors related to the design/implementation of the programme and the organisations involved that have enabled outcomes to date. The key message here is that **many features of TFP design and the way in which it has been implemented have been critical to success**. The most important factors relate to the design (i.e. challenge-led, scale, ambition, flexibility, innovation in approach) and the people involved in delivering the programme (i.e. their dedication, continuity, sector knowledge). More broadly, the factors identified below align with those anticipated in the ToC, particularly the value of a collaborative approach to R&D, engaging end users in the process, and effective project implementation and management.

Table 8-1: TFP-related factors enabling outcomes and impacts

Factors relating to ...
... TFP design
• The programme's **vision, ambition** and genuine **willingness to take risks** to achieve this. This was recognised by both project and stakeholder consultees. As one stakeholder consultee argued, "*there is an understanding and backing from the top that you've got to take risks to drive innovation and accept that some will fail*". That said, a minority of external stakeholder consultees questioned whether TFP has taken sufficient risks. • **The challenge/mission led approach has worked well**. There was consistent feedback from consultees that TFP was well aligned to sector needs, which is an important achievement in such a fragmented sector. In identifying high level challenges, the programme has provided 'direction' for the sector and a steer on what innovation priorities should be, encouraged innovative responses, and 'spurred interest' in new technologies. This has included a clear focus on net zero and strong communication on this. • **The scale and duration of the programme**. Consultees argued this long-term commitment 'sent a clear message to industry that government believes in the need for innovation' in this sector. In terms of delivering strategic leadership and influence, this has been important. That said, the scale of TFP funding was modest compared to the scale of the challenge faced in this sector, nor was TFP

Factors relating to ...

long enough to expect all projects (especially those developing more novel technologies) to progress through the TRLs (depending on their starting point).

- **A range of intervention types/strands available** to suit different needs. A **mixed and balanced portfolio approach** appears to be appropriate in such a fragmented sector where different sub-sectors/technology areas are at very different stages of maturity. That said, some consultees suggested a missed opportunity to invest in projects that developed new business models. Strands of activity that worked particularly well included:
  - The inclusion of projects with **large scale and longer-term funding**, which is enabling systems approaches, larger-scale data gathering/testing and greater maturation of technologies. These projects have reportedly had the necessary scale of funding, and associated 'bandwidth', to deliver more. It is also helping to raise the profile/image of new technologies. Projects have appreciated the "reliability and consistency" of TFP as a *"patient funder"* (e.g., under FFPS).
  - That said, **smaller, more accessible funding** has also been important for SMEs and/or those looking to test the initial feasibility of new technologies (e.g. STiP Feasibility Studies). As noted by one consultee, this can be *"the difference between success or failure"* of the firm.
  - The **Investor Partnership strand was consistently identified as an example of good practice** by stakeholders and relevant projects, particularly how it was designed to focus on a specific evidence-based gap in the market (and that gap was informed by bespoke research for the programme). The wider wrap around support, including investor readiness 'bootcamp', was important alongside the funding. As noted above, this strand has also generated wider strategic and ecosystem level impacts (see Section 6).
  - The **STiP Demonstration strand was highly commended** by stakeholders and projects, particularly in the way it placed a greater emphasis on (and clear responsibility, capacity and dedicated funding for) knowledge exchange, market engagement and demonstration. This generated a 'shift in thinking' towards and greater prioritisation of more/earlier end user engagement than would otherwise have been the case, and enabled projects to establish clear routes to market.
- **The focus on collaborative R&D,** providing access to partner expertise and networks (notably end users/customers and in dissemination more generally), knowledge exchange between project partners, continuous feedback loops throughout the R&D process, and the ability to undertake various strands of R&D in parallel. Projects consistently highlighted the value of the collaborative approach to accelerate and strengthen the quality of the R&D, and increase their chance of success. The programme has also encouraged 'spill in' of technologies that are new to agriculture and the creation of cross-disciplinary teams.
- **Prioritising industry/end user engagement** (as project partners, in testing/trials and wider dissemination) as an integral part of project implementation which, as discussed above, has strengthened R&D outputs, provided connections to potential customers, and given projects confidence that products are relevant/effective in a commercial setting.
- **Encouraging systems level approaches.** Integrating 'systems' language into the design of TFP was perceived by consultees to be an important signal to the market and has started to change thinking around the importance of a systems approach in tackling challenges in the sector. Some of the larger projects have also adopted a systems approach and included partners across the supply chain. That said, there was some uncertainty about what a systems approach meant in practice, and some stakeholders felt the programme should have gone further in this respect (e.g. wider systems/infrastructure required for TFP-technologies to be successful and more joined up

Factors relating to ...

thinking across wider domains). As one stakeholder put it, TFP "*struggles to define the system boundary and this means the wider actors who are need to help deliver change are not engaged*".

- **Alignment with successor funding programmes.** From 2020, it was envisaged that TFP would 'bridge' to Defra's Farming Innovation Programme. This continuity of innovation funding for the sector has perceived to be important both for projects and wider signalling to the sector (as discussed above).

... TFP implementation

- **The ability to pause and reshape the programme in 2020**, moving away from 'business as usual' CR&D activities in Phase 1 to more ambitious and innovative approaches in Phase 2. The Advisory Group provided critical feedback to prompt change and inform Phase 2 (and instigated a review of TFP's role in relation to adoption, see below). There was also an openness and willingness to try new things within the TFP team. Consultation feedback indicated that Phase 2 was better targeted, focused, planned and structured, with a more clearly articulated focus on targeting barriers that hinder technology development, embedding knowledge exchange and prioritising end-user engagement.
- **Effective and continuous programme leadership.** The programme retained the same SRO for most of its lifetime, and had a single Challenge Director for most of Phase 2 (notwithstanding capacity issues outlined below).
- **Effective governance structures and processes** through the Programme Board, which has reportedly ensured the programme remains focused on industry needs and underpinning market failures, and been proactive and agile in response to challenges and changing contexts.
- **Effective programme management**, with flexibility, responsiveness to shocks and agility where necessary. Some project consultees argued that flexibility has been critical to the progress made to date, as new opportunities arise from the R&D process and/or challenges are encountered. This includes effective management during Covid-19, with a strategic, flexible and supportive response.
- **A strong and consistent TFP team,** with a good understanding of sector needs. In consultations, the programme was described as *"extremely well run"* with *"a high performing team"* and a culture of learning and improvement.
- **The central marketing/promotion of TFP projects and signposting** to wider networks/support has also enabled outcomes (e.g. introductions to new/potential customers).
- **The structure, signposting, support and advice provided by the monitoring officers** was seen as genuinely helpful to projects. Monitoring officers have helped projects to overcome difficulties, supported project management and signposted to wider support/opportunities to showcase the technologies developed. Input from Innovation Leads has also been valued.
- **Enabling funding to be used for wider business development in parallel to R&D.** In cases where this has happened, it has been key to accelerating the firm's progress towards commercialisation (e.g. using TFP to fund advisory inputs, engage partners with extensive customer networks/intelligence, and/or through VC involvement in Investor Partnerships).
- **Close working with the InnovateUK's KTN** has been important, in terms of raising awareness of TFP competitions, facilitating consortia building, and providing investment readiness support alongside the Investor Partnership strand.
- **Some wider signposting to other UKRI and DIT support**. However, some consultees felt this could have been strengthened, especially in relation to wider business support to help scale-up and exports.

Factors relating to ...
... the organisations involved
• The ability to **build on previous R&D** undertaken by project partners. • Projects that have progressed well have demonstrated **strong project management** (with dedicated resource and effective communications), **clarity on partner responsibilities and commitment, and clear ambition and shared strategic priorities.** • **Flexibility and adaptability of partners** during Covid-19 positively influenced progress in some projects. • Projects with an **existing customer base and/or experience of commercialising products** have progressed well, and often have clear routes to market. • Projects' **ability to secure additional private finance** has accelerated progress – for example, enabling firms to scale-up testing and demonstration activities, build manufacturing facilities, and accelerate business development alongside the R&D more generally.

Source: SQW analysis of qualitative feedback and monitoring data

Key factors hindering outcomes and impacts

8.4 Table 8-2 presents key barriers that have hindered outcomes and impacts to date, or may do so in future, that are associated with the design/implementation of TFP or the organisations involved. **Three particularly important issues relate to TFP's resources and capacity**:

- the budget reduction of £13m hindered the ability to consolidate and build a critical mass of support in key thematic areas
- capacity constraints within the TFP team limited the ability to undertake strategic influencing, partnership working, linking and wider ecosystem building (both to maximise impacts of projects and deliver wider strategic/legacy effects)
- reflecting the diverse nature of this sector, resources have been spread relatively widely/thinly, reflecting the diverse nature of this sector, which may influence overall impact on aggregate. It is recognised this was a 'strategic choice' by the programme and there are clear advantages in responding to sector needs and demand, supporting a mixed and balanced portfolio approach, and mitigating risk. However, there are also implications and trade-offs in terms of balancing depth and breadth of impact.

8.5 Some other barriers reflect the nature of the activities funded and rationale for intervention (i.e. high risk and uncertain R&D, technical challenges), and align with those anticipated in the ToC. The impact of Covid-19, Brexit and war in Ukraine on implementation is covered below.

8.6 It is important to note that, based on the evidence gathered for this evaluation, **the most significant factors hindering impacts have been driven by external contextual challenges** rather than factors associated with the design or implementation of TFP.

Table 8-2: TFP-related factors hindering outcomes and impacts

Factors relating to ...
... TFP design
• **The loss of £13m from the TFP budget** has been significant. This was ringfenced for further investment to build on/create more critical mass in key themes already funded by the programme (e.g., alternative proteins), which has meant a loss of momentum. • **The breadth of TFP was necessarily very wide** (compared to other 'moonshot' ISCF funds) reflecting the diversity of this sector, its sub-sectors and their different needs. As a consequence, TFP resources have been spread more 'thinly'. This may have implications for the scale of impact in any one part of the sector, and the programme's ability to 'shift the dial' across the sector as a whole. • **A lack of clarity on how TFP was aligned with and expected to engage with the wider innovation ecosystem and support landscape in practice,** e.g. how TFP engages with relevant programmes within UKRI (such as the Agritech Centres, Catapults, Manufacturing Made Smarter) as well as other partners (such as Devolved Administrations, AHDB, agricultural colleges and universities). As noted above, effective partnership working with relevant actors/programmes in the wider ecosystem is important to ensure that TFP-funded projects are able to realise their intended impacts. • **A lack of clarity on TFP's role in relation to adoption.** The programme's vision included the intention to accelerate and embed the adoption precision approaches. However, the programme's route to impact on this outcome was not clearly articulated. The programme initially allocated £5m of budget to 'drive a trial adoption programme'. An internal review of TFP's role in relation to adoption in early 2021 identified 'key principles' for the programme, but failed to provide clarity on what TFP should be seeking to achieve in terms of adoption, nor what actions should be undertaken. • **Resource was not allocated for follow-on investment.** Whilst this was not anticipated at the outset, nor helped by the loss of £13m of funding, the evaluation has identified a potential gap in this respect. Looking forward, whilst FIP is seen as the successor programme, evidence suggests it is not supporting or suitable for all TFP-funded projects. Consultees also noted the tendency to favour 'something new' in applications instead of building on earlier investments. As one consultee described it, *"a seed is planted and then we turn off the water"*. Given that many projects will require follow-on finance to commercialise (as noted above), it raises a question as to whether programmes of this nature should consider ringfencing some funding for follow on investment to support 'successful' projects to move further towards commercialisation and/or to the point of being able to access private investment.
... TFP implementation
• **Capacity within the TFP team has been very constrained**, especially to engage in outreach, awareness raising and networking activities. This has been an issue at a leadership level (for example, with increasing demands on the Challenge Director's time (i.e. non-TFP responsibilities) and at an operational level (as the TFP team took on the additional responsibility to deliver Defra's FIP scheme). • **Innovate UK's systems were insufficiently flexible to accommodate innovative approaches**, especially for competition processes and monitoring requirements that deviate from the 'norm', which hindered the programme's ability to adapt/respond to changes in the sector, overall Challenge autonomy. Dealing with these issues was resource intensive.

Factors relating to ...
• The timing of competitions is particularly critical in this sector – many projects depend on trials which can only take place during growing seasons. **Minor delays in UKRI competitions** meant some projects missed the start of the growing season and lost a year of data collection. **The misalignment between competition windows and sector need for support** (e.g. to align with business plan or seamlessly follow precursor R&D activities) has created challenges, especially for small firms who need timely access to funding. • In terms of the TFP strands: ➢ **larger projects can take longer to get started**, especially where consortia are large and lack prior relationships (e.g. some FFPS projects). Building in time for this is important. ➢ **performance of the international bilateral strand has been more mixed**, and there was general agreement amongst consultees that the China bilateral was less successful than anticipated. In addition to challenges associated with Covid-19 (and extended lockdowns in China), consultees noted geopolitical/cultural issues and the lack of strong rationale for the bilateral. The Canada bilateral appears to have worked better, supported in part by wider partnership building between the respective innovation agencies and more similarities in terms of strategic intent/priorities. • At a project level, a minority of consultees reported **technical challenges and complexities** being greater than anticipated, especially relating to system integration and the process of bringing multiple strands of R&D together. Whilst a systems approach is a key feature of TFP, it has also brought about challenges.
... the organisations involved
• Some project consultees reported **capacity and recruitment challenges**, especially in skills such as electronics and software development which are key to many of the technologies. This delayed progress. Projects involving small firms have been particularly vulnerable to recruitment issues (where often they need to recruit staff to deliver the project but cannot begin that process until the grant is awarded) and staffing changes. • A small minority of project consultees have found it **difficult to manage different priorities and aspirations of partners**. In some cases, maintaining partners' commitment to the project has also been a challenge. **Partners have dropped out** of a small number of projects which has caused delays, e.g., to trials.

Source: SQW analysis of qualitative feedback and monitoring data

External factors

Key factors enabling outcomes and impacts

8.7 The general direction of travel in terms of policy, investor interest and customer demand has created helpful tailwinds for TFP, notably the growing policy prioritisation of net zero, sustainability and food security. Growing pressures associated with resource efficiency, in part related to labour supply post-Brexit and cost inflation following the war in Ukraine, have also driven the need for precision technologies and automation.

Table 8-3: External factors enabling outcomes and impacts

Factors relating to …
… the wider external context
• **Contextual shifts are well aligned with and reinforce the importance of TFP's overarching vision** e.g., growing pressure for resource efficiency, reduction in chemical use, GHG emissions (and greater awareness of the role of agriculture in achieving net zero), access to labour etc in the sector; growing public interest in food sourcing/net zero/food prices and alternative food sources such as cultivated meat and insects; and increasing VC interest in low carbon/sustainability investments. The rationale for intervention remains valid and relevant. • **(Re)-commitment to agritech innovation by UK Government**, with continuity in future funding available, including via a new Agritech Catapult, Defra's Farming Innovation Programme and new investor partnership scheme, and Innovate UK/BBSRC's subsequent Novel Low Emission Food Production Systems programme and forthcoming IKC for alternative proteins (noting TFP's influence on these, as well as the potential benefits in helping TFP realise its ultimate goals). • Where TFP projects are **closely aligned with UK and international government priorities,** this has encouraged greater interest in technologies. Also, changes in UK legislation, e.g., gene editing, will be key for some projects. • **Signs of growing awareness of new technologies/ability to adopt within the agricultural sector, and alignment with technologies that are closely related to those funded by TFP**. As highlighted in the wider sector survey (and discussed in more detail in Section 9), this includes progress towards adoption in automation/control, data recording/collection technologies and evidence that data recording/collection systems are most likely to be adopted in next 5 years.

Source: SQW analysis of qualitative feedback and monitoring data

Key factors hindering outcomes and impacts

8.8 As noted above, the most significant barriers to impact to date (and looking forward) relate to external contextual challenges. **The programme has witnessed substantial changes in the external context during its lifetime, particularly linked to the aftermath of Brexit, Covid-19 and more recently the war in Ukraine** which have caused delays and limited outward-facing activities. The challenges associated with Covid-19 are not unique to TFP and the food production sector more broadly, and it is difficult to disentangle the impact of the pandemic on performance compared to other factors. That said, the evidence suggests it has had implications for programme performance, not least because all TFP projects funded under Phase 2 were delivered during the pandemic.

8.9 Covid-19 (and the associated restrictions in place over time) hindered access to facilities and farms (which wiped out entire growing seasons for some projects), engagement with end users and customers, led to cancelled knowledge exchange/dissemination/networking events, and caused capacity constraints due to staff illness. Covid-19 also hindered collaboration and face-to-face interaction between project partners, although there were mixed opinions on the extent to which this has impacted adversely on progress; whilst it has meant that projects *"missed out on the added traction, interaction, rapport-building and enhanced feedback"* as reported by one consultee, and progress has been slower than anticipated, most projects have managed this

challenge well and there were some potential benefits (e.g. related to cost efficiencies, adoption of new engagement methods).

8.10 Looking forward, there are several external factors that may impact on TFP's goals being realised. On the supply-side, key factors may hinder the commercialisation of technologies including **finance and the wider system/infrastructure changes** required. However, **the main barrier to impact is adoption** – this is an entrenched and persistent challenge for the sector, and the support landscape has been very fragmented and lacking in organisational leadership. That said, we note that Defra's Farming Innovation Programme includes a forthcoming adoption programme that may help to address this issue. Linked to this, **wider systems, infrastructure and (in some cases) regulatory changes** are need to enable impacts to be realised fully.

Table 8-4: External factors hindering outcomes and impacts

Factors relating to …
… the wider external context
• **Covid-19 has influenced outcomes and impacts** in a number of ways: ➢ Covid-19 had differential impacts at project level. Many projects reported supply chain disruption and difficulties in sourcing key inputs/components, such as electronics/sensors/microchips which are key to many projects; it hindered access to facilities and farms, which has delayed trials; face-to-face interaction between partners and with end users/potential customers was more limited; knowledge exchange and dissemination events were cancelled; staff illness has reduced capacity to deliver; and, in a minority of cases, resources were diverted (e.g. in one project, a partner involved in diagnostics had to divert staff to focus on Covid-19 detection methods) ➢ At a programme level, Covid-19 hindered wider strategic, outward facing activities, including dissemination, profile raising and partnership working. • **Supply chain issues have been compounded by Brexit adjustment issues and, more recently, the war in Ukraine.** The implementation of changes/new rules following Brexit in particular has led to extended lead times for equipment/difficulties shipping to the UK and, for a minority of projects, staffing issues. • **Rising energy prices and cost more generally** have implications for project costs but have also raised more fundamental questions for projects that are developing technologies which are very sensitive to energy prices (e.g., CEA) and/or the cost of specific inputs about the affordability/markets for their products. Decision-making in relation to product development has been challenging in a context where the availability/cost of inputs very difficult to predict. • **Adverse weather conditions** (e.g. drought) has impacted upon some projects (e.g. shortening data collection periods). R&D in this sector and the seasonal nature of trials is particularly vulnerable to uncontrollable factors such as weather. • The generally *"unsettling"* global economic climate and inflationary pressures have **increased caution in investment decisions** – for TFP beneficiaries and their future R&D investment, investors in terms of follow-on investment and becoming more risk averse, and farmers in terms of adoption. It has also created difficult operating environment for small agritech firms. Difficulties in accessing finance to scale-up agritech firms was a key message from the Investor Roundtable event. On the demand side, in the beneficiary survey, the most frequently cited barrier that may hinder the adoption of TFP technologies was 'commercial/financial concerns' (71%, n=62). This

Factors relating to ...

was also evident in the wider sector survey, where cost was the most commonly cited issue that may prevent adoption of innovative technologies and practices in the future (by 58% of respondents)

- There are **ongoing and significant adoption challenges** in the sector. In the beneficiary survey, 'willingness to change and risk aversion' in the agricultural sector was the second most cited barrier that may hinder the adoption of TFP technologies in future (40%). Further, our wider sector survey showed a persistent gap between awareness and adoption of agritech and challenges in uptake of data analytics/decision support systems in particular (as noted above, many TFP-funded projects have developed technologies in this space). The wider sector survey and technology tracing exercise also highlighted (alongside cost, as noted above), uncertainty on benefits, concerns around data sharing and financial constraints limiting uptake. The landscape of support for adoption is also very fragmented, with a lack of clarity on organisational responsible for knowledge exchange and promoting adoption at a sector level. This means that TFP-backed technologies are likely to be launched in a relatively challenging market context.
- Whilst TFP has encouraged 'systems thinking', funding for wider systems/infrastructure development or ecosystem building (at a project level) was not within scope of the programme. As highlighted in the technology tracing expert workshops, these **wider systems/infrastructure changes are critical to enable TFP-funded technologies to gain market traction.** Consultees noted the lack of funding available to tackle wider system/infrastructure challenges (rather than developing a specific product).
- **Policy and regulatory issues** remain a concern for some projects, e.g., for novel fertilisers, vertical farming, and alternative proteins.

Source: SQW analysis of qualitative feedback and monitoring data

9. Quantitative and qualitative futures

Key messages

- Monte Carlo modelling suggests that the present value of additional turnover that may be expected to be generated by business leads and collaborators on TFP-supported projects by the end of 2028 is c.£175m (with 95% confidence interval between £106m and £262m). Of this, c.£22m has already been generated with further c. £152m expected over the next five years
- Considering the FFPS strand aims to deliver disruptive technologies and in most cases has yet to generate robust estimates of future effects, it is possible our mean estimate for expected additional turnover is conservative, and may be closer to the higher level.
- TFP's activities, emerging and anticipated outcomes are well aligned to the key factors and drivers influencing agricultural productivity and GHG emissions going forward. This includes challenges of labour, energy and other production costs, which provide a supportive environment (in principle) for the adoption of the sorts of technologies being developed through the programme.
- A characteristic of the programme supporting the development of integrated solutions, rather than 'single technologies' which is a key priority going forward for agriculture. This includes better collection, exploitation and analysis of data, AI and machine learning, diagnostics and sensors, robotics & automation/control systems.
- Concerns related to sector awareness, skills, and implementation (notably around data) are potential barriers, and building up trust in data storage and sharing among stakeholders is critical for the implementation of general technologies in agriculture. Addressing these issues has not been within the scope formally of TFP, but they may impede the realisation of impact going forward. Access to finance for commercialisation and market development activities for agritech firms and the fragmented adoption support landscape are also barriers going forward.
- Total GHG emissions from Crop and Animal Production are expected to decline by -2.4% p.a to 2030, and -5.1% over 2030-40, which is faster than the UK economy as whole. The impact of the programme on this projection cannot be estimated quantitatively given the very wide range of influencing factors. However, the anticipated routes to impact of projects are well-aligned with the key drivers, including increasing yields, improved management of natural resources, improving input efficiency, more efficient processes, and reduced labour inputs.
- Dissemination and knowledge sharing, and ensuring continuity with both follow-on innovation support schemes across the UK and the wider agricultural support system, will be key considerations going forward to maximise impacts of TFP.

Implications for the contribution story

- Quantitative and qualitative analysis suggest that TFP can be expected to make a material contribution to sector performance, productivity and reduced emissions going forward. These impacts will be realised in a complex landscape, and be reliant on linking effectively to follow-on activity, where the programme will be one of a range of factors influencing the UK's trajectory to these long-term goals.

Context

9.1 TFP was, by design, focused on the long-term, with a goal to accelerate the development and adoption of integrated precision approaches to primary food production productivity and resilience, and set the sector on a trajectory to net zero emissions by 2040. Further, as discussed in previous sections, at this final evaluation stage (developed as the programme nears the end of its delivery period), it remains too early to comment on many of the direct outcomes that are anticipated, as project ideas continue to progress to commercialisation. It will also take time for systematic changes to work through fully.

9.2 In this context, the purpose of the futures exercise is to consider from quantitative and qualitative perspectives the potential future contribution of the programme, recognising the limitations of precise estimates in complex and evolving systems.

9.3 Given the inherent uncertainties, the quantitative perspective is focused on the near-term future specifically. It considers the potential scale of additional turnover (i.e. economic value) that may be expected to be realised for programme beneficiaries over the next five years.

9.4 The qualitative analysis takes a longer view, thinking out to 2030, and beyond to 2040. It considers at a (necessarily) high and sector-wide level, the key trends, drivers of change and external factors influencing diffusion/take-up of agricultural precision technologies to 2030, the alignment of the programme to these, and in turn what this might mean for its potential to contribute to change over the longer term to 2040. There is a particular focus here in relation to delivering against the net zero imperative.

9.5 It is important to note that this is not a 'scenarios' or 'forecasting' exercise, rather the purpose is to provide some insight into how (and why) the programme may generate impact over the longer-term, and what this suggests about its deliver against its objectives at this final evaluation stage.

Quantitative perspectives: a Monte Carlo approach

9.6 Considering varied and long pathways to impacts for research and innovation projects, it is not unexpected that a relatively low proportion of surveyed beneficiaries (under 25% of the sample) reported that they had experienced an uplift in turnover. At the same time, as we discussed in the previous sections, two thirds of surveyed beneficiaries expect to see additional turnover over the next three years. Further, econometric analysis indicated that there were statistically significant differences between TFP supported projects and unsuccessful applicants in the speed at which they progressed through TRLs.

9.7 Based on the evidence collected during the evaluation, a Monte Carlo model was developed to provide an indicative estimate of the scale of net additional turnover attributable to TFP support that can be expected to be generated by beneficiaries by the end of 2028. This approach allowed us to derive a specific estimate, as well as the 95% confidence interval around it, by considering the uncertainties about commercialisation of TFP-supported projects, the variation in the scale

of benefits generated by each project for leads and collaborators, and the coverage of our survey (which was a sample, not the full population of beneficiaries).

9.8 The modelling considered the **future horizon of five years[73] and was performed at the project level.** The model considered realised and expected outcomes for TFP-funded *projects* and the counterfactual path (i.e. what would have happened to the projects in absence of TFP). This approach was selected over modelling at the *business* level because ultimately it is the project success that determines whether any additional turnover is generated. Further, some businesses participated in several projects (as leads or collaborators) and the chosen approach made it easier to match the model with what we observed in monitoring data.

Results of Monte Carlo modelling

9.9 The 10,000 simulations of the model revealed that the expected present value of additional turnover expected to be generated by business leads and collaborators on TFP-supported projects by the end of 2028 was c.£175m.[74] Of this, c.£22m has already been generated with further c.£152m expected over the next five years. This c.£175m estimate can be viewed against the c.£60m of public investment to date. Even when the confidence interval is considered and committed funding is included (bringing the total spend to c.£70m) this comparison reflects positively on the programme.[75]

9.10 Table 9-1 presents the means and 95% confidence intervals for the estimates. Figure 9-1 provides additional insight by plotting the distribution of possible values. The shape of the distribution is asymmetrical, reflecting the fact that the overall level of benefits from the programme depends on the number of 'outliers' or breakthrough innovations that will materialise. The analysis suggests that the lower boundary of the confidence interval is approximately twice as likely as the higher end, but four times less likely than the mean value.

9.11 The model was calibrated (or matched) to the monitoring and survey data (and incorporated results of econometric analysis). Only one of the surveyed FFPS projects reported they expected to generate turnover over the next three years and therefore only one of them contributed to shaping the assumptions in relation to the scale of benefits used in our model. Considering the FFPS strand aims to deliver disruptive technologies, it is possible that our mean estimate for expected additional turnover is conservative. If the FFPS projects do generate higher level of impact in practice, the overall result can be expected to be in the right half of the distribution presented below.

[73] In theory, this period could be expanded to ten or 15 years, however following our analysis of survey data and the econometric work we determined that the assumptions needed to accurately represent the levels of uncertainty beyond the five-year period would result in a confidence interval that would be too wide to be insightful or meaningful for policy applications.
[74] In 2023 £s, since turnover estimated are underpinned by responses to the survey carried out in 2023.
[75] Note that the figures relate to turnover rather than GVA. We did not perform any formal Value for Money analysis (out of scope for this evaluation).

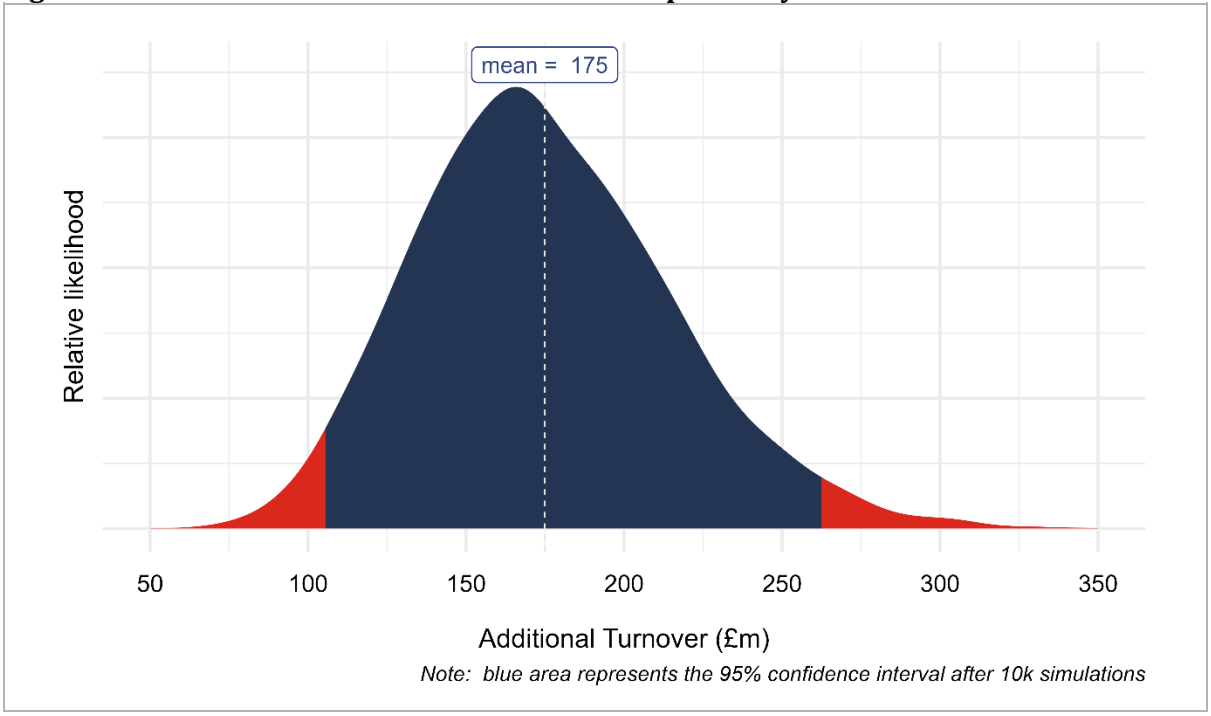
Table 9-1: Estimates of realised and expected turnover attributable to TFP support that is likely to be generated by the end of 2028

Measure	Mean value	95% confidence interval
Realised additional turnover	£22m	£7m – £48m
Expected additional turnover	£152m	£94m – £223m
Total additional turnover	**£175m**	**£106m – £262m**

Note: mean realised and expected turnover do not add up exactly to the total due to rounding. The boundaries of the 95% confidence interval for the sum are not equal to the sum of the boundaries of the 95% confidence intervals of components.

Source: SQW

Figure 9-1: Distribution of additional turnover expected by the end of 2028



Source: SQW

Qualitative perspectives

9.12 The analysis above suggests that the potential scale of the direct economic impact of the programme over the next five years can reasonably be expected to be substantive. This analysis considers programme beneficiaries only, and provides a partial perspective on the wider potential contribution of the programme. Estimating quantitatively the potential indirect and wider contribution is not possible given the very wide range of factors that will influence the potential early-adoption, exploitation and subsequent diffusion of the technologies across the across the agriculture sector.

9.13 However, qualitative analysis drawing on the varied source of evidence collected through the evaluation – including surveys, case studies, stakeholder consultations, technology tracing, horizon scanning and international review – can provide an insight into the key trends, drivers

and factors that may influence adoption and diffusion of technologies against which the programmes activities and potential outcomes can be framed.

9.14 The Figure below summarises, at high-level (reflecting the complexity of the landscape), the key drivers and factors – both enablers/facilitators that will stimulate the development and adoption of precision technologies to 2030 (including those that may represent 'challenges' for the agriculture sector) and barriers/inhibitors that may act to limit this – drawing on the evidence from across the evaluation. It is noted explicitly that this is a high-level depiction, it does not consider specific technologies or sub-sectors in detail, rather the purpose is to provide an overview of the drivers and factors at a sector level, which reflects the broad scope of TFP's activities.

9.15 The evaluation evidence suggests that the programmes activities, emerging and anticipated outcomes are well aligned overall to the key drivers and factors that will stimulate the development and adoption of precision technologies to 2030. As discussed in previous sections, the programme has been characterised by supporting the application of non-agritech technologies to the sector, and the development of integrated solutions rather than 'single technologies' which is a key priority going forward for the agriculture sector; the programme has had a strong focus on supporting data collection and analytics, AI and machine learning, diagnostics and sensors, robotics & automation/control systems. Given increasing technology convergence, and the scope of innovation across multiple sectors that can be applied potentially to agritech, this is notable.

9.16 Further, a recent patent landscape analysis indicates that primary innovations in precision agriculture are to develop software and control systems, based on data processing and communication technologies, specially adapted for agriculture. Improving the capability of pattern recognition and developing specific computational models are the directions of AI development in agriculture, and soil preparation and fertilisation are the most promising application scenarios for precision-agriculture hardware.[76]

9.17 Notably, the wider sector survey indicated that three quarters of respondents that had not yet adopted or decided against adopting[77] data recording/collection technologies are likely (based on their self-reporting) to adopt in the next five years (with a third saying this was 'absolutely certain'), and over a half data analytics/decision support systems or technologies. The wider sector survey respondents are "early adopters" and "early mainstream adopters" of innovative agricultural technologies and practices so this will not reflect the wider sector overall. However, this is encouraging given the emphasis of TFP in these technology areas.

9.18 It is also noted that a further characteristic of TFP has been a broad technology scope, and econometric analysis indicated a statistically significant effect on technology commercialisation

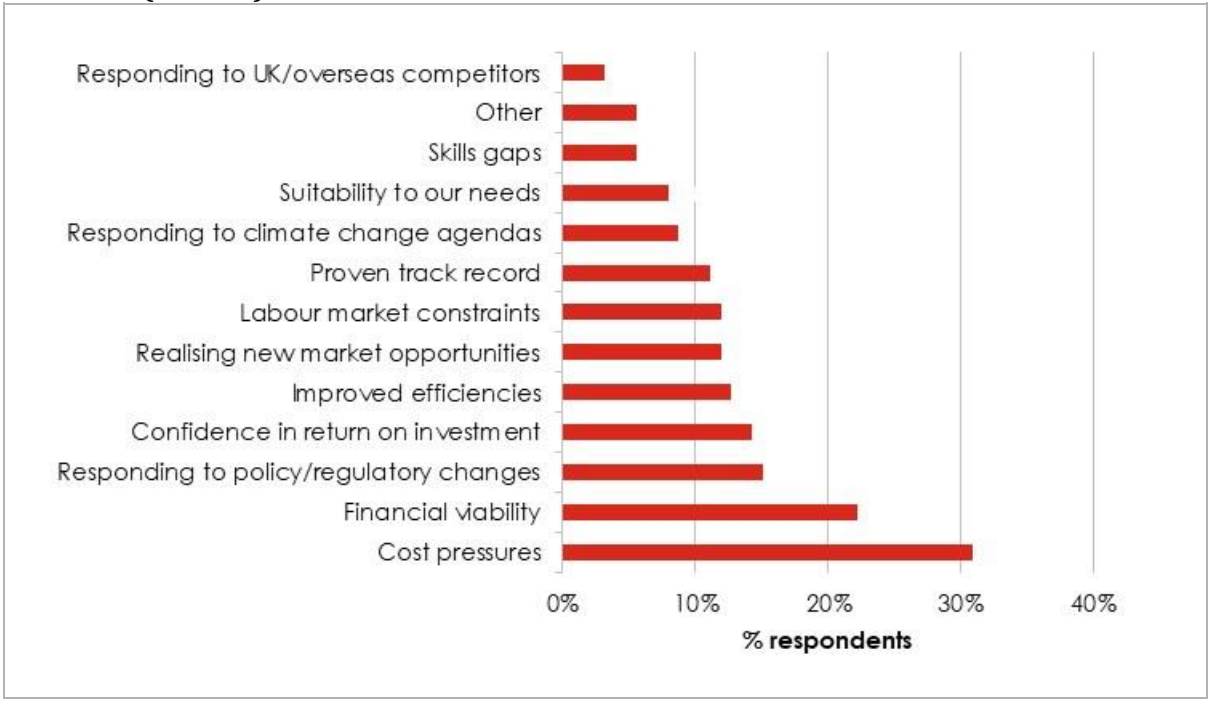
[76] Silva, W. de V. R. da, & Silva-Mann, R. (2022). Precision Agriculture: technological monitoring based on patent analysis. Research, Society and Development, 11(3), e42611326852. https://doi.org/10.33448/rsd-v11i3.26852

[77] That is, they have decided to adopt the technology in the future or are not sure if they will adopt it in the future

across the programme. This aligns with the varied levels of maturity and timescales to commercialisation across different technology areas evident in the sector.

9.19 Further, the challenges faced by the sector in relation to labour, energy and other production costs are also crucial, which provide a supportive environment (in principle) for the adoption of the sorts of technologies being developed through the programme. Notably, the wider sector survey found that when businesses were asked to identify what factors were likely to affect their take up of innovative technologies in the future, the most common factor identified was cost pressures, which was identified by around a third of businesses. Financial viability, confidence in return in investment and responding to policy/regulatory changes were also prominent.

Figure 9-2: What factors are likely to influence your adoption of innovative technologies in future? (n = 126)



Source: Wider sector survey Wave 2

9.20 This said, concerns related to sector awareness, skills, and implementation (notably around data collation, sharing and exploitation) are potential barriers. Notably, building up trust in data storage and sharing among stakeholders is critical for the implementation of general technologies in agriculture - for example a survey revealed that 20% of farmers worldwide express concerns about data sharing and cite this issue as a top obstacle for adopting farm-management software.[78]

9.21 Addressing these issues have not been within the scope formally of the programme, but they may impede the realisation of impact going forward. Further, access to finance for commercialisation and market development activities for agritech firms and the fragmented adoption support landscape are also potentially important barriers going forward. The programme has played a role here. For example, on finance through the Investor Partnerships strands which has the

[78] McKinsey (2023). Agtech: Breaking down the farmer adoption dilemma

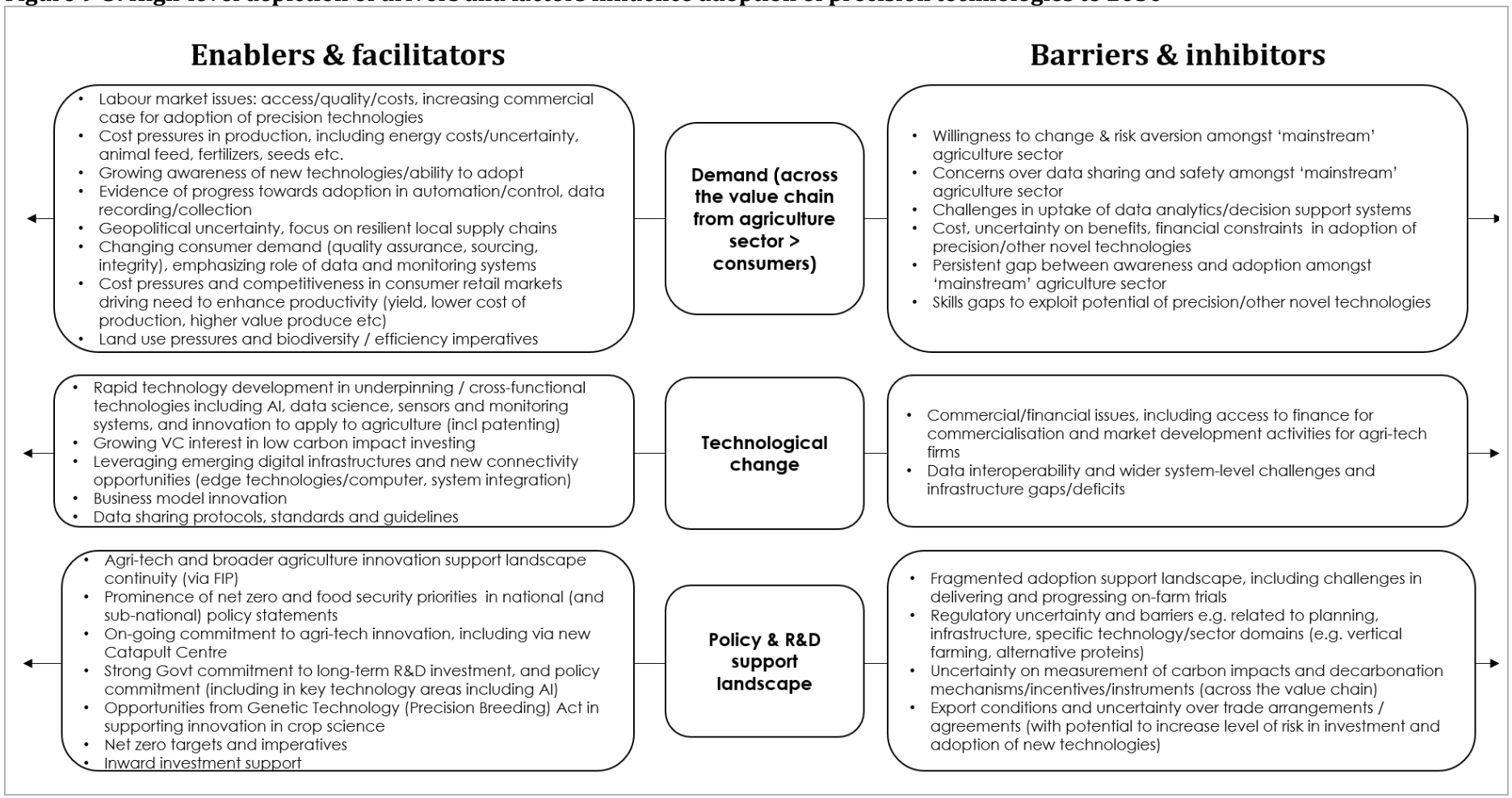
potential to influence behaviours and perspectives going forward, and as noted, there is an increasing interest amongst VCs in in low carbon impact investing, and on adoption through strategic engagement with Defra on adoption support. However, major challenges remain across the sector as a whole, and as we have seen from the technology tracing evidence, levels of equity in some technology areas have been inconsistent over time.

9.22 Taking a longer-term perspective, the anticipated routes to 2040, projections developed by Cambridge Econometrics for this final evaluation suggests that total GHG emissions from Crop and Animal Production are expected to decline by -2.4% p.a to 2030, and -5.1% over 2030-40, which is faster than the UK economy as whole. The size of the effect of the programme on this projection cannot be estimated with any accuracy given the very wide range of factors that will influence this performance, including policy and regulatory levers, other interventions, wider technology change, and changing market expectations and conditions.

9.23 However, the anticipated routes to impact of projects as identified by our surveyed beneficiaries are well-aligned with the key drivers of this anticipated trend (see Figure 9-3). There is also evidence of important contributions to specific technology areas, including robotics. Further, the evaluation evidence suggests that the strategic role of the programme is important, and it has represented an important 'signal' to the sector (and the investment community) of the importance of seeking to both enhanced productivity and address the net zero imperative through innovation, which will have important legacy benefits, including as projects as progressed further via follow-on funding.

9.24 Supporting enhanced links between agritech and technology developments in other sectors and technology areas will also be important, and the evaluation evidence suggests that the programme's role and contribution here is notable. The combination of both developing new systems specifically for agriculture, and demonstrating how technologies from related sectors can be applied in an agricultural context is an important factor in considering the ability of the programme to delivery against its objectives over the long-term. **The signs at this final evaluation stage are positive, with further dissemination and knowledge sharing, and ensuring continuity with both follow-on innovation support schemes across the UK and wider agricultural support system, key considerations going forward to maximise impacts**.

Figure 9-3: High-level depiction of drivers and factors influence adoption of precision technologies to 2030



Source: SQW

10. Conclusions

10.1 This section presents a summary of key findings against the evaluation's original research questions and in relation to the contribution stories (direct, indirect and strategic impacts). We then provide an overall assessment of the performance of TFP against its objectives, and provide some final reflections drawing on the evidence across the full five stages of the evaluation.

Key findings

RQ 1: Has TFP delivered / Will TFP deliver the attributable outcomes and impacts expected given its original rationale and objectives?

10.2 **There is strong evidence that short-term outcomes/intermediate benefits are being realised via TFP**, notably in terms of the following:

- Knowledge exchange and collaboration, including engagement with end-users and technologies that have been drawn in from other sectors. This has improved the quality and pace at which technologies have been developed, facilitated systems integration and helped to develop products that are better attuned to market needs. TFP is also having a legacy effect on collaboration.

- R&D capabilities, knowledge and skills, including enhanced technical and research skills, knowledge of the agricultural sector, understanding of commercialisation processes, and wider business development and management capabilities.

- Technological progression, including validating/proving concepts or progressing from "proof of concept" to "real world solutions", moving towards better systems integration, and making technologies more accessible/scalable in the marketplace. Crucially, there is strong evidence, including from econometric analysis, that the programme has accelerated the development of technologies at a pace that would not have been achieved without the support.

10.3 There is also encouraging evidence on commercialisation and the (initial) adoption of some of the technologies progressed, especially in precision agriculture. Many supported organisations are optimistic about taking TFP-funded technologies to market in the near future and are taking steps to commercialise. However, most of these will require further funding to realise this intent.

10.4 TFP has led to further investment in R&D. This includes internal investment from businesses involved in projects, suggesting TFP has sufficiently de-risked innovations and provided evidence to support internal business cases for investment in R&D. TFP has also played an important role in beneficiaries' ability to secure follow-on public and private external finance to progress TFP-funded technologies further. The scale of follow-on investment secured, especially from the private sector, is also a positive signal of the commercial potential of TFP-funded technologies over the long-term.

10.5 TFP is also contributing to the growth of UK agritech firms, via generating high quality employment and turnover via commercial sales in some organisations to date. The scale of this is modest at this stage for most businesses. However, econometric analysis indicates TFP has had a statistically significant positive impact on employment growth in beneficiary businesses compared to a wider, matched group of businesses. There also appears to have been a significant impact on supporting previously non-exporting beneficiary businesses to export for the first time, relative to similar unsuccessful applicants. These findings are encouraging, given the stage of many projects and the timing of the evaluation, and indicate the potential for TFP to lead to material economic impact over the longer-term.

10.6 **Evidence of strategic benefits has increased** over the last year as the programme has matured. At a programme level, key achievements include supporting better co-ordination, aligned priorities and funding between UKRI and Defra on agritech, notably in relation to the Farming Innovation Programme (FIP); providing thought leadership pieces and attending conferences; and playing a convening role on key thematic and priority areas, for example in relation to alternative proteins and VC investment. The programme also helped to strengthen the agritech innovation ecosystem, by connecting some TFP projects, signposting to wider support (e.g. international trade), and centrally promoting projects at events and in showcase documentation. The evaluation also identified examples of projects delivering strategic impacts, e.g. by seeking to influence the wider system and create an enabling environment for their technology. Delivering strategic impacts has not been without challenge in terms of capacity and the very complex/fragmented nature of this sector, but TFP appears to have helped to raise the profile of agri-food innovation, encourage greater investment into agritech R&D and support the development of this ecosystem.

10.7 **There is consistent evidence pointing to attribution and additionality, but other influencing factors are also evident.** The overall 'direction' of the evidence on the additionality of TFP is broadly consistent across sources, providing confidence in the finding that TFP is delivering benefits that would not otherwise have been realised or not achieved at scale or as quickly. Crucially, there is strong evidence, including from the econometric analysis, that the programme has accelerated the development of technologies at a pace that would not have been achieved without TFP funding.

RQ 2: Has TFP successfully set food production systems on a trajectory to achieve productivity and sustainability goals, and net zero emissions by 2040?

10.8 The evidence gathered for this evaluation indicates that TFP has successfully helped to better position the agricultural sector on the trajectory to achieve productivity and net zero emissions over the longer term by playing a key role in the development of the UK's agritech capabilities. Evidence on key 'leading indicators' that have informed this conclusion include the following: the programme has accelerated the development of technologies, technologies have been developed in collaboration with experts and end users from an early stage (and so should be more fit for purpose), a multidisciplinary approach has been taken (including drawing on technologies from outside the sector) to develop systems-based technologies, dissemination and exploitation have

been a priority, projects have made good progress and there are initial signs of commercialisation and adoption (albeit relatively small scale), and almost all technologies developed are expected to impact on productivity *and* GHG emissions in the agricultural sector.

10.9 The key question at this stage is whether the contextual conditions for the widespread adoption of these technologies are conducive to enable those longer term impacts to be realised. TFP has strengthened the foundations for this, especially from the supply side (i.e. the development/supply of technologies). As noted above, TFP has played an important role in building R&D capacity in the agritech sector, placing an emphasis on end user engagement and a systems approach, facilitating connections between actors across the ecosystem through an emphasis on collaborative projects, and raising the profile of UK agritech more broadly. The programme is also very well aligned to key trends, notably around data, integration and automation, which should aide longer-term adoption. Moreover, many of the drivers for adoption, whilst not 'good' for the sector itself (e.g. labour, input costs), should also provide that stimulus to adopt. However, in order to 'shift the dial' of agricultural productivity and GHG emissions, precision technologies will need to be adopted at scale and pace. There is a risk that wider conditions needed to enable the commercialisation of these technologies at scale and encourage widespread adoption will be hindered by significant external factors, particularly in terms of access to finance for agritech firms (at sufficient scale), wider system/infrastructures required to utilise the technologies, and demand-side challenges within the agricultural sector (i.e. awareness, capability, finance and willingness to adopt and fragmented support to do so). Whilst TFP has achieved a great deal within its scope and resources, these wider issues could hamper the long-term impact of the programme and the realisation of its vision. The continuity provided by Defra's Farming Innovation Programme is critical looking forward, both in terms on ongoing R&D funding and the forthcoming adoption strand, but the scale of the challenge is significant.

Performance against underpinning RQs and overall contribution stories

10.10 Drawing on the evidence throughout this report, Table 10-1 presents key messages against each underpinning research question and our 'contribution stories' for direct, indirect and strategic outcomes/impacts arising from TFP.

Table 10-1: Key findings against impact evaluation research questions and contribution stories

Overall performance	Contribution story
Direct and indirect/longer term impacts	
• TFP has performed well across the majority of intended outcomes and impacts, and performance has been strong across the majority of strands. • There is strong and consistent evidence to demonstrate how TFP has strengthened knowledge exchange and collaboration (including post-project) which, alongside grant funding, has had a substantial impact on capabilities, knowledge and skills (R&D and business skills). • TFP has de-risked and increased private investment in R&D, both via co-funding projects and subsequent follow-on investment. The latter is an important early signal of commercial potential. • TFP has stimulated and accelerated the progression of technologies, including precision technologies and novel high value production systems. There are emerging examples of (mainly small-scale) commercialisation and adoption, but it is too early to assess performance fully. Many projects are taking steps towards commercialisiation, but most will require further funding to reach the market. • The anticipated impact of TFP-funded technologies are well aligned with the overall purpose of TFP, i.e. improving productivity and reducing greenhouse gas emissions in the agricultural sector. • TFP is contributing to the growth of UK agritech firms (employment and turnover). Exporting appears limited and there is little evidence of FDI, but the econometric analysis suggests beneficiaries are more likely to become exporters than unsuccessful applicants. • Unexpected or unintended consequences are limited and largely positive. • There are examples where TFP projects have sought to influence the wider innovation or investment landscape.	**1: Is there a reasoned theory of change, and have activities been implemented as set out in the theory of change?** A reasoned theory of change is evident, which has remained appropriate and relevant throughout delivery to date. Activities were delivered and targeted as anticipated, with the types of organisations, technologies and collaborations supported closely aligned to expectations. Challenges have been faced in delivery (many of which were external to the programme, notably Covid-19) leading to delays and an anticipated small underspend. Overall, activities have been delivered well in a very challenging context. **2: Is there evidence that the expected results have occurred?** There is strong evidence that the large majority of expected results have occurred, notably in terms of technological progress, improved R&D capabilities, knowledge and skills, knowledge exchange and strengthened relationships. These benefits are evident across strands. Some benefits still need to be realised fully, particularly in terms of adoption, associated impacts for agri-tech firms and exports. **3: Was it the TFP programme, rather than other influencing factors that made the difference, or the decisive difference?** This evidence suggest TFP made an important difference to accelerating the development of technologies and associated wider benefits. In some cases, where outcomes would not have been achieved at all without TFP funding, we conclude that TFP made a decisive difference. Where TFP helped to accelerate, scale up and improve the quality of impacts achieved, TFP was still very important alongside other factors (to varying degrees). Other factors have included the characteristics/networks of organisations, prior/complementary R&D activities, the maturity of the technologies, and external economic and market conditions. However, TFP appears to have made a major contribution across most projects despite differences in the project, technology areas or characteristics of those involved.

Overall performance	Contribution story
Strategic/ system level effects	
• TFP has strengthened the UK's position as a place to undertake world-class research and innovation in relation to food production, providing resource to develop technologies and the UK's agritech firms. • The challenge-led and systems-based approach of TFP has been effective in delivering the intended impacts, with a strong emphasis on end user engagement and developing technologies that focus on an integrated solution rather than a single technology. • TFP has helped progress technology areas, directly via projects and through strategic activity. Its role catalysing new relationships, adding depth/breadth across the innovation landscape was important. TFP's contribution appears pronounced in Robotics in production/harvesting. • TFP has added value strategically to the agri-food innovation landscape, particularly in terms of improving cross-departmental partnerships working and co-ordination, convening wider partners in the ecosystem (notably in relation to alternative proteins and VC investment), influencing policy/programmes and catalysing further R&D investment, and helping to raise awareness of UK agritech. • At a project level, the TFP team has made some progress in strengthening the ecosystem, by connecting some TFP projects together and with wider support (e.g. DIT), and promoting projects. However, more could have been done. There are also examples of projects seeking to influence the wider system and create an enabling environment for their technology. • The emphasis on TFP's wider strategic role increased as the programme matured. However, TFP's wider impact on strengthening the ecosystem has been more limited, especially in terms of engagement with sector stakeholders/intermediaries (notably on adoption). Capacity constraints within the TFP team has been a key factor limiting this.	**1: Is there a reasoned theory of change, and have activities been implemented as set out in the theory of change?** A reasoned theory of change is evident. Strategic activities have been weighted towards the latter stages of TFP lifetime as the programme matured from committing funding/establishing the portfolio towards greater outreach and dissemination as 'successes' emerge. The exception is engagement with Defra, which was embedded from the start and where significant strategic engagement has been achieved. **2: Is there evidence that the expected results have occurred?** There is evidence that expected strategic outcomes have occurred. TFP has added value strategically to the innovation landscape, helped to strengthen the ecosystem and influence the behaviours, policies and programmes of others. However, the approach to strategic impact was arguably not as cohesive as it could have been throughout the programme's delivery, and capacity was limited. Feedback suggests more could have been done to engage with other actors in the wider ecosystem to realise intended longer-term impacts. **3: Was it the TFP programme, rather than other influencing factors that made the difference, or the decisive difference?** With regard to Defra's policymaking and investment, TFP appears to be a key factor alongside others (e.g. Ministerial priorities). More broadly, evidence suggests that TFP has an influence in specific areas (such as the maturing robotics for harvesting, raising the profile of fundraising challenges in agritech, and identifying priorities for alternative proteins) – the relative importance of TFP varies, but it is generally seen as playing an important role alongside other factors.

Source: TFP Evaluation Framework (2021)

Key findings for process-related evaluation questions

10.11 At a project level, TFP has engaged with its intended audience (including businesses, researchers and practitioners) and facilitated new collaborations that have involved a range of actors across the innovation ecosystem. This collaborative approach and end user involvement have been key to realising change. The emphasis has been on precision technologies, in line with the intended purpose of the programme, with a mix of technologies and many adopting an integrated system approach.

10.12 At a programme level, there is strong evidence to show how the design and delivery of TFP (including the different strands) has enabled TFP to achieve its objectives, and has maintained a strong focus on alignment with sector needs through its challenge led approach. Strong governance and management has added value. There has been a willingness to take risks/try new approaches, and be flexible, agile and adapt where necessary. Continuity and strong sector knowledge across the team has been important, but capacity has been an issue. The Covid-19 pandemic has influenced implementation at both a project and programme level, particularly in causing delays and hindering outreach activities. However, the consequences of the pandemic were managed well by projects and the TFP team overall.

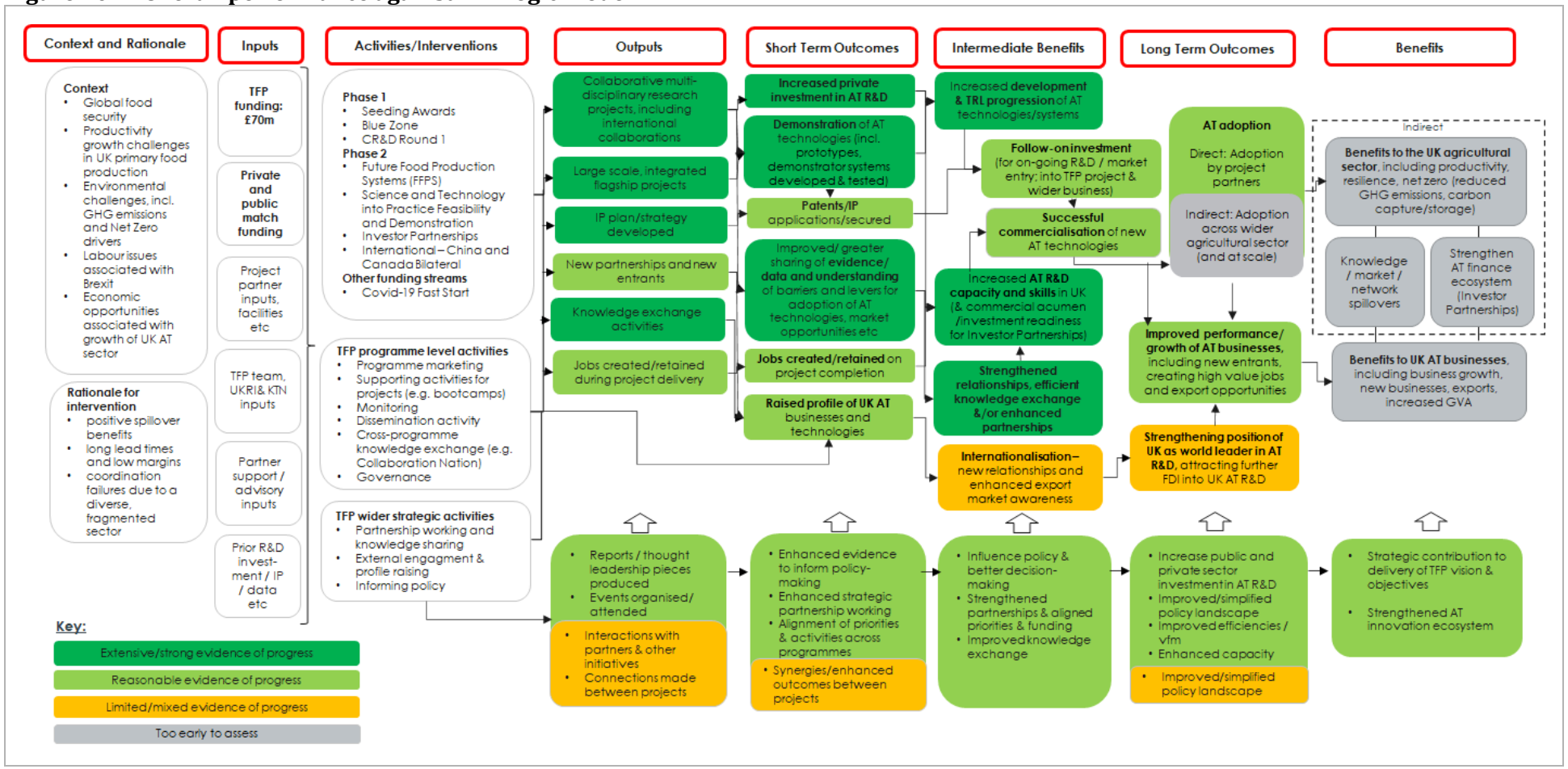
10.13 At a strategic/system level, as discussed above, there are some examples of where TFP engaged strategically with the wider innovation system, but this could have been maximised further (especially in terms of adoption) in order to pave the way for longer-term impacts.

Overall performance against TFP's objectives

10.14 **Overall, performance against TFP's original vision and objectives has been strong.** The programme has performed particularly well in relation to strengthening connections between researchers businesses and practitioners through projects, and accelerating the development of technologies, especially integrated data-driven solutions and novel food production systems that are designed to improve productivity *and* reduce GHG emissions. These outcomes demonstrate how TFP has tackled the original market and other failures that underpinned the rationale for intervention (notably fragmentation and coordination challenges, and underinvestment in R&D). TFP has also supported the growth of agritech companies in the UK, with emerging impacts in terms of the creation of high value jobs and turnover. Overall, as discussed above, **TFP has made an important contribution to setting food production systems on the trajectory to net zero.**

10.15 Figure 10-1 summarises our assessment of the performance of TFP against the programme's logic model. It is notable that in nearly all cases where progress at this stage can be fairly assessed, the programme is assessed as having delivered strong or reasonable progress. This is a very positive finding given the challenging delivery context.

Figure 10-1: Overall performance against TFP logic model



Source: SQW

Looking forward

10.16 Finally, we offer some closing reflections on the programme below:

- The programme has been delivered in a very challenging context, with a series of external shocks that have had significant implications for the agrifood sector. The programme has been flexible, with proactive management and a strong emphasis on continuous learning and adjustment. The programme should be commended for the stocktake and refresh in 2019: whilst the first phase supported good projects, the second phase was more ambitious, targeted and innovative. Throughout this study, we have also observed an openness to feedback emerging from the evaluation and a willingness to adapt in response. A key feature of this ISCF approach has been the degree of autonomy to evolve, adapt and test new/innovative approaches. Whilst the latter may or may not work, valuable lessons are learned. In the case of TFP some of the most innovative approaches appear to be very successful, and in the case of the China bilateral lessons were learned around the importance of a strong rationale for the intervention.

- A key challenge for the programme has been clarifying its remit and role in relation to adoption. This was always anticipated to be a long-term goal. Whilst it was important to frame TFP's purpose in the context of these longer-term impacts, including reference to accelerating and embedding adoption in TFP's objectives may have been too ambitious given the scale/nature of the adoption challenge and resources available to TFP. Greater focus on adoption could have led to trade-offs/compromises in the extent to which TFP could fund R&D projects. That said, the programme may have benefitted from setting out clearly and explicitly its roles and responsibilities in relation to supporting the adoption of TFP-funded technologies that were commercialised. This could have detailed TFP's role in laying the foundations for this, and at what point/to whom/how does TFP 'hand on the baton' to those who support adoption in the wider landscape. We recognise the difficulties in this, given the fragmentation/lack of support for adoption in the UK during TFP's lifetime. This would also require buy-in and engagement from other actors in the ecosystem. However, the development of a clear 'TFP pathway' – and potentially a 'joint roadmap' involving relevant partners, including Defra – could have helped to ensure that appropriate plans for adoption support were in place to support the realisation of impacts in the longer term. That said, adoption is a major, system-level challenge that requires system-wide and co-ordinated response – it was not within TFP's scope to lead on this.

- Linked to the point above, there is an important lesson from the TFP experience relating to the wider role of a programme like this in creating the 'foundations' or 'conditions' for success and influencing the wider ecosystem. In other words, creating the 'glue' or 'oiling the wheels' of the ecosystem. Whilst often intangible, it is critical to the success of R&D projects. In hindsight, the programme may have benefitted from a greater ringfenced resource for this type of activity and a more explicit delivery plan. There is a wider lesson here about the scale of opex required to deliver a programme of this nature and drive through impact (including by influencing the wider system in which collaborative R&D projects operate). Within UKRI,

it is also important that programmes with greater autonomy still tap into wider resources/functions (notably in terms of marketing and dissemination) when needed to support delivery and maximise impact.

- TFP has supported a very wide range of technologies and subsectors, reflecting the diversity/fragmentation/complexity of the agricultural sector and industry need, rather than focusing resources very narrowly on a small part of the sector. An assessment of impact must be considered in this context. Going forward, it is important that resource is available to consolidate/build on key themes and develop critical mass, if material impacts are to be achieved in the long-term. This is not to say that all funding should be narrowly targeted going forward – but *only* 'spreading the jam thinly' and continually seeking 'new' ideas may not fully exploit the opportunity from previously funded projects. This may involve strategic choices and prioritisation. The continuity provided by Defra's Farming Innovation Programme and other more recent UKRI schemes are extremely valuable in this context and help to realise some TFP impacts. We also understand that a 'follow-on fund' has been introduced to support projects that have been successful but not quite progressed enough to secure private investment. In our view, this is a positive step forward. However, given the diversity of technologies funded by TFP and the remit of FIP, there may be some gaps in future funding. A 'mapping and gapping' exercise is recommended.

- Finally, looking forward, there is a major opportunity to leverage and carry forward the valuable learning and legacy of TFP after the programme comes to an end in March 2024. The dissemination and promotion of TFP benefits will be key to this. There is also a need for 'knowledge management' going forward, to ensure the huge amount of knowledge generated is shared and built upon. It is encouraging to see continuity in terms of the TFP team (and their expertise, knowledge and experience) now implementing FIP Funds 1 and 2 (collaborative R&D) on behalf of Defra. Many of the lessons learned here are also relevant for Defra's forthcoming FIP Fund 3, ADOPT, and the establishment of an Agri Tech Catapult, particularly in terms of the scaling and adoption of new technologies across the agricultural sector. Ongoing stakeholder engagement will also be important to maintain the relationships, trust and networks that TFP has helped to develop.

SQW

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