Department for Business, Energy & Industrial Strategy

Interim Impact Evaluation of the Agri-Tech Catalyst

Phase 1 - Final Report

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SQW

Acknowledgements

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Executive Summary

1. The Agri-Tech Catalyst (ATC) was introduced in 2013 as a key programme under the UK Strategy for Agricultural Technologies. The programme secured £60m from the Department for Business, Energy and Industrial Strategy (BEIS), Innovate UK and the Biotechnology and Biological Sciences Research Council (BBSRC) to support UK-based innovation projects in the agri-tech sector[1]. The ATC programme aimed to:

   "accelerate translation of research into practical solutions, best practices and applications of new technologies in agriculture – ultimately to contribute to improvements in agricultural output and productivity, whilst reducing the environmental impact of agricultural production".

2. Over five competition rounds, the ATC awarded funding to 103 UK-based projects, led by 80 separate organisations, and involving nearly 230 collaborators. Three grant types were available, reflecting different stages of the R&D process:

   - early stage awards to test commercial potential of scientific ideas/feasibility of new technologies, with grants of £150k to £500k (37 projects)
   - industrial research awards to develop innovative solutions through technology development, lab-based prototyping, pilots, trials market testing, with grants of up to £3m (54 projects)
   - late stage awards, to test/trial innovations in real-life context ahead of larger-scale deployment, including commercial assessments for technologies that are closer to commercialisation, with grants of up to £1m (12 projects).

3. All projects had to be collaborative in nature – early stage grants could be led by a business or academic, but industrial and late stage grants had to be industry-led. Any sector or discipline could apply, and funders were keen to see spill-in of typically non-agricultural partners to encourage technology convergence.

4. SQW in partnership with Martin Collison and BMG Research, was commissioned by BEIS in December 2017 to undertake an interim impact evaluation of the ATC, in two phases: phase one (the focus of this report) reviews early and late stage projects; phase two (to be delivered over late-2018/early-2019) will focus on industrial stage awards, draw together findings from both phases, and provide recommendations for future longer-term impact evaluation.

5. The evaluation is theory-based, comparing evidence on what has actually happened as a result of ATC against the original Theory of Change of what was expected to happen, including a 'contribution analysis', considering the role and relative importance of ATC alongside other factors. Phase one has involved review of data and documents, stakeholder consultations, surveys with project leads and collaborators (covering 36 of the 49 early and late stage projects), surveys with unsuccessful applicants (mainly of

[1] £10m was also provided by the Department for International Development for international projects. These projects are excluded from this evaluation. Throughout this report, 'the programme' refers to the UK-based aspects of ATC only. In total, the 103 projects, which excludes DFID projects, received £28.3m from IUK and £22.7m from BBSRC.

projects that were ‘fundable’ but not funded in each round), and in-depth case studies with seven projects.

Programme portfolio and rationale

6. Most early stage and late stage applicants were active in collaborative R&D before they engaged with ATC, funded mainly by internal resource or UK-based public funds. However, ATC has been successful in attracting new organisations to public sector R&D programmes, particularly in a collaborative capacity. The Catalyst has also encouraged – and in some cases accelerated – the spill-in of non-agricultural disciplines and companies who are new to agritech to engage in R&D in the sector, for example, those with a focus on digital technologies, defence, engineering, energy and healthcare. The programme’s role in enabling technological convergence is encouraging, creating opportunities for new and innovative products, services (and in some cases, processes) to be developed in an agricultural context.

7. The programme has stimulated new collaborations: of the early stage and late stage beneficiaries surveyed, over a third had not worked with any of their ATC partners before (half of late stage beneficiaries), and three-quarters worked with at least one new partner through their ATC project. Existing collaborations have also been developed further and refreshed through the inclusion of new partners offering particular skills and expertise.

8. The evidence from phase one (focused on early stage and late stage projects) endorses essentially the original rationale for the programme, as set out in the Theory of Change. Uncertainty and risk associated with the proposed R&D activities (and, in part, the risk associated with working with new partners) were key drivers for applicants, alongside coordination failures that can inhibit collaborative R&D on high-risk projects.

9. A lack of finance was also raised by the majority of applicants surveyed as a reason for why ATC support was needed. However, phase one does raise some questions around the validity of this aspect of the rationale, particularly given that most were already “innovation active” and had a track-record of investing internal funds in R&D activity before ATC. In this context, there is some uncertainty whether in all cases ATC was required genuinely to enable the R&D activity to progress; there is a risk that the public funding has been used in place of private investment.

10. That said, finance for R&D is complicated, and varies across different types of participant, subsector and stage of R&D. The agri-tech sector is relatively immature and suffers from a lack of sector-specific finance (especially from private sector investors) and often unfavourable terms, limited alternatives in the innovation support landscape at the time (especially for high-risk, early stage R&D), and a lack of awareness amongst businesses of alternative finance sources. Alongside other ‘feeder programmes’, the ATC programme also had a catalytic effect in stimulating new ideas, especially for early stage projects, which were considered high-risk. This issue will be a focus in phase two; probing further the underpinning issues around financing of the R&D activity supported by ATC, particularly for industrial research awards.

Activities and technological progress

11. There has been a close fit between the activities delivered by the Catalyst and the intentions of early and late stage awards. This said, the projects are very varied and bespoke in technical/scientific focus, implementation model, and delivery progress. For example, in delivering the projects, partners have collaborated in different ways, from genuinely collaborative working through to more sub-contractual relationships. The R&D process has been non-linear in many cases – where activities have varied from their initial plans (often for good or unforeseen reasons) – and some projects have been very iterative in nature, raising new research questions that would need to be explored in order for a new technology to reach the market. This is fully consistent with wider evidence on R&D support interventions and highlights the varied routes – and timescales – to outcomes (intermediate and final) of projects of this type.

12. This said, the ATC has performed well in terms of encouraging technology progression of early stage and late stage projects, supporting many of the projects surveyed and involved in the case study research to reach the intended Technology Readiness Level (TRL) for their respective grant type. Moreover, the majority of those surveyed observing technological progress said it was accelerated "to a significant extent" due to ATC. Many of the projects surveyed had also continued to make technological progress (to varying degrees) since the ATC funding came to an end.

13. It is notable that an encouraging number (eight) of early stage projects surveyed reported that their product/innovation had reached TRL 9 (i.e. proven technologies), but not all had taken these to market (see below). The evidence indicates that significant follow-on investment in R&D (post-ATC) has been, or will be, required to progress technologies and bring a new product/service to market. However, ATC has commonly played an important role in derisking projects sufficiently to secure some follow-on public sector investment and/or encourage greater investment in R&D by the participants themselves.

Outcomes and impacts

14. Our evaluation suggests that effects of the Catalyst on behaviour and capacities of participants can be significant, even in cases where the commercial application of the idea is not (yet) realised. The most common include improved R&D and commercialisation capacity, profile, credibility and reputation, staff skills and knowledge, and understanding of market position and opportunities – all of which align closely with the original logic model for the programme. These outcomes have been witnessed both for early and late stage participants, and by leads and collaborators.

15. Capacity building effects have been considerable, and it is plausible that these will have a sustainable legacy in terms of R&D and commercialisation behaviours and innovation looking forward. For example, the majority of beneficiaries surveyed have continued to work with some or all of their ATC collaborators after project closure (or if not, they were more likely to collaborate with other partners in future). Most said they were more likely to invest internal funds in other R&D and/or bid for Government funding to support other R&D activity in future, and others had developed more commercially focused business plans as a result of ATC. Academics consulted were more willing and able to collaborate with industry in R&D activities, more committed to continued research in

agri-tech, and had used the knowledge gained to inform their wider research activities. Taken together, the findings from phase one on these R&D capacity and behaviour effects of ATC are very positive.

16. There is also some evidence of new products/services, and in some cases processes, reaching the market, with more to follow in the near future, as a result of ATC. However, most will require further R&D investment to do so; ATC support is not in itself sufficient to enable the solutions and applications developed to be launched in the market and adopted by the sector in most cases.

17. Further, reflecting both this need for 'follow-on' investment and activity, and the time-paths to final outcomes, the overall impacts of ATC on employment and/or turnover amongst beneficiaries are modest to date. Most employment generated so far is associated with R&D activity, but growth in staff has provided businesses with greater capacity to explore new markets and undertake further R&D. This said, there are some exceptions, with a small number of strongly performing projects (both early and late stage) identified in the evaluation who have generated substantial levels of revenue, including through exports. Again, this is consistent with the wider evidence on R&D support, where the outcomes are often skewed, reflecting the levels of risk and uncertainty of planned activities and innovations.

18. Project participants have observed (and will in future) wider improvements to their environmental sustainability, yields/productivity (especially collaborators), and produce quality. Similar benefits are expected for the wider agricultural sector in future, but at a project-level there appears to be limited consideration of how projects will have a wider, large-scale impact on the sector (beyond sales of new products/services once the technologies are proven). Other benefits for those involved include spillover of technologies to non-agritech applications, networking benefits and (small scale) supply chain benefits. More broadly, the Catalyst has demonstrated a clear UK commitment to Agri-Tech innovation and was reported by stakeholders to have generated a "buzz and energy" across the sector – both are powerful tools in attracting industry investment.

19. Looking forward, the evidence raises some concerns around beneficiaries' awareness of – and ability to secure – secure private sector finance (at an appropriate stage) to progress their idea to market after ATC support ends, with scope to enhance linkages to complementary support interventions. There were also mixed views on the programme's influence on the wider investment community – whilst some argue it has "stoked" investor appetite and the pipeline of ATC projects has been helpful in setting up a new agri-tech VC fund, it is difficult to attribute supply-side changes to the Catalyst directly.

Additionality and contribution

20. Whilst the activities and outcomes described above are attributed to the Catalyst, the key question that follows is the extent to which they would have happened anyway in the absence of the programme i.e. the extent to which activities and outcomes are additional.

21. The ATC is catalysing new activity in the sector and encouraging high levels of 'activity additionality' – the evidence suggests that over half of activities may not have progressed without ATC. The programme has also brought about a considerable level

of additionality in terms of timing and quality of activities, even where the activity progressed without ATC amongst the unsuccessful applicants engaged. Importantly, there was consistency between what beneficiary leads said they would have done without ATC – where 40% thought they would have progressed with their projects – and what unsuccessful lead applicants actually did – where around 40% did in practice progress the project. This provides confidence in the beneficiary perspectives provided.

22. The evidence suggests that the programme has also achieved positive 'outcome additionality'. Whilst the unsuccessful applicants' evidence suggests some deadweight, and there will inevitably be some optimism bias in self-reported beneficiary estimates of additionality, there is a consistent message across the consultations undertaken that over half of the outcomes observed to date would not have been achieved without ATC, or would not have been brought about as quickly, to the same scale or quality. Most projects led by unsuccessful applicants did not progress, and those that did were substantially different and delayed in most cases. Even where unsuccessful applicants have progressed their activities, ATC stimulated some of these ideas in the first place (even though the activities were not ultimately funded by the programme).

23. For the outcomes that are additional, the next question relates to the contribution and relative importance of ATC compared to other factors in delivering these outcomes. The evidence at this stage of the evaluation suggests that ATC is one of a number of interdependent and reinforcing factors that have been important in realising outcomes. ATC projects have integrated with wider innovation support landscape during the delivery, and in many cases, other internal factors – especially other R&D activities, new equipment, new innovation partnerships or collaborations and new business plans – were regarded as more or equally as important as the Catalyst in realising outcomes. However, crucially, ATC was commonly responsible for these other internal factors being introduced.

24. We therefore conclude that the ATC is an important – and can be a decisive – factor in realising the specific project-based outcomes described by those consulted, particularly intermediate outcomes. This said, we recognise that the large majority of beneficiaries (and unsuccessful applicants) consulted had already been active in collaborative R&D, most financed by other UK-based public funds or internal funds. This is likely to impact upon the businesses' R&D capacities and ability to bring forward positive outcomes from the ATC-funded project. Also, in most cases, beneficiaries acknowledged that the ATC project will rely on other investments and activity for the commercial and economic potential of these intermediate outcomes to be realised fully.

Learning

25. Phase one of this evaluation has identified a number of key factors that have enabled or hindered the progress of early and late stage ATC projects towards impacts. In doing so, we are testing whether the assumptions on how outcomes would be achieved (as set out in the ATC's original Theory of Change) were appropriate and whether mechanisms are in place to enable future anticipated outcomes and wider impacts. Key messages are summarised in the table below.

Table 1: Lessons to date – factors enabling and inhibiting routes to impact

Enabling factors	Inhibiting factors
• Broadly cast, challenge-based competition, attracting attract spill-ins and potential for technology convergence • Feeder programmes, as well as ATC, stimulating project ideas • High demand, with high-quality, innovative and high-risk projects selected, creating strong base for potential impact • Collaboration consistently identified as the critical factor in enabling pathways to impact – e.g. projects benefited from the technology convergence associated with complementary expertise, research could be undertaken at greater depth/quality and sufficient scale to validate results, industry provided commercial pull/expertise in commercialisation processes, and businesses/membership bodies provide potential routes to market • Within projects, clearly defined roles, collaboration agreements, strong project management and shared goals (that align with those of the participants' wider organisation) have enabled teams to work together effectively • The role of the Agri-Tech Strategy in raising the profile of the sector • Context is also important – previous experience of R&D of some/all partners has facilitated the delivery of some ATC projects	• Ensure the programme duration is sufficiently long to enable a seamless transition to the next of stage funding (as intended through ATC at the outset), accelerating technology progression further • Risk that viable technologies will stall due to lack of follow-on finance and/or lack of and high-risk projects selected, creating strong base for potential impact • Collaboration consistently identified as the critical factor in enabling pathways to impact – e.g. projects benefited from the technology convergence associated with complementary expertise, research could be undertaken at greater depth/quality and sufficient scale to validate results, industry provided commercial pull/expertise in commercialisation processes, and businesses/membership bodies provide potential routes to market • Within projects, clearly defined roles, collaboration agreements, strong project management and shared goals (that align with those of the participants' wider organisation) have enabled teams to work together effectively • The role of the Agri-Tech Strategy in raising the profile of the sector • Context is also important – previous experience of R&D of some/all partners has facilitated the delivery of some ATC projects awareness/ability to secure external finance amongst beneficiaries • Scope for greater integration with elements of the wider support landscape during and after ATC projects, particularly to assist in securing follow-on finance and accessing markets (including overseas) – support could include DIT, local networks and clusters, mentoring, signposting/brokerage with private investors, and the Agri-Tech Innovation Centres • The importance of knowledge exchange and exit (next stage development) strategies for each project, and developing these as early as possible • Effective programme and project dissemination is essential, including clear responsibilities for undertaking this after project completion, to ensure awareness and adoption across the wider agricultural sector • Missed opportunity in terms of knowledge exchange and synergies between projects in the ATC portfolio, where there may be potential for greater impacts on aggregate across the programme as a whole

Enabling factors	Inhibiting factors
	• Within some projects, challenges around feedback loops and other aspects of a product's ecosystem that require (often early stage) R&D in order for the whole product to progress to market

Source: SQW

Overall performance against objectives and rationale

26. The early evidence gathered for phase one of the evaluation suggests the programme – and specifically the early stage and late stage projects it has funded – is performing well against its aims to "accelerate translation of research into practical solutions, best practices" and encourage greater R&D in the sector, and is addressing many aspects of the original rationale, particularly relating to risk, uncertainty and co-ordination failures.

27. It has also delivered against the Agri-Tech Strategy's wider ambitions for the Catalyst which focused on supporting collaborative relationships between academics and industry and attracting co-investment from the private sector. It is too early to assess whether these intermediate outcomes are translating into final outcomes and broader sector impacts, such as "applications of new technologies in agriculture", improved agricultural productivity and reducing environmental impacts, and improved competitive position of the UK's agri-tech sector internationally.

28. The foundations appear to be in place to achieve these wider impacts – many of the projects expect to deliver against these – but the key question is whether the mechanisms are in place (and implemented) to ensure these wider impacts are realised. Enhanced mechanisms for dissemination, improved alignment with other elements of the innovation landscape – particularly the Agri-Tech Innovation Centres – and ensuring that linkages are made to support future financing (including from the private sector), will be important in realising this potential.

1. Introduction

1.1 The Agri-Tech Catalyst (ATC) is a flagship programme under the UK Strategy for Agricultural Technologies published in 2013. With £60m sourced from the Department for Business, Energy and Industrial Strategy (BEIS)/Innovate UK, the Biotechnology and Biological Sciences Research Council (BBSRC) and £10m from the Department for International Development (DFID), the ATC awarded funding to 127 projects between 2013 and 2017. Of these, 103 were UK-based projects which have involved over 80 lead organisations and nearly 230 organisations acting as collaborators.

1.2 The supported projects cover a wide range of R&D activity, ranging from the development of novel vaccines for livestock and anti-microbial technology to control disease in crops, through to optimising the use of big data in different agricultural contexts, testing innovative sensor technologies and building the UK's first aquaponics urban farm.

1.3 ATC offered three grant-types, reflecting different stages of the R&D process:

- early stage awards to test commercial potential of scientific ideas/feasibility of new technologies, with grants of £150k to £500k
- industrial research awards to develop innovative solutions through technology development, lab-based prototyping, pilots, and trials market testing, with grants of up to £3m
- late stage awards, to test/trial innovations in real-life context ahead of larger-scale deployment, including commercial assessments for technologies that are closer to commercialisation, with grants of up to £1m.

Introducing the evaluation

1.4 SQW, in partnership with Martin Collison and BMG Research, was commissioned by BEIS in December 2017 to undertake an interim impact evaluation of the ATC over 2018 and early 2019, and to develop an evaluation framework for longer-term impact evaluation of the Catalyst. This study follows (but is separate to) SQW's earlier work to develop a baseline and evaluation framework for the UK Agri-Tech Strategy in 2016[2] (that included the ATC), and more recently a process evaluation of the ATC (and Industrial Biotechnology and Energy Catalysts) for Innovate UK that reported in mid-2018.

1.5 The Steering Group for this project includes representatives from BEIS, Innovate UK (now UKRI), BBSRC (now also part of UKRI), DFID, the Department for Environment, Food and Rural Affairs (Defra), and the Department for International Trade (DIT).

1.6 The overarching aim for the evaluation, as set out in the Brief, was to:

[2] http://www.sqw.co.uk/insights-and-publications/agri-tech-industrial-strategy-evaluation-scoping-study-and-baseline/

“gauge early impact and to assess the extent to which the programme is making or has made an impact taking into consideration its original aims, the market failures it seeks to address, and the key strategic goals of the Agri-Tech Strategy more widely”.

1.7 During an initial scoping phase for the study, in discussion with the Steering Group and wider stakeholders and a review of programme documentation, a detailed set of research questions were identified for the evaluation. These are presented in Table 1-1 below.

Table 1-1: Key evaluation questions

Key Question Area	Key Issues to Consider
What has been delivered to date?	What is the spend-profile to date, compared to expectations, and how much private sector funding has been levered? What is the profile of activities and lead/collaborators supported? Are collaborations new? Are projects encouraging new actors/disciplines (including spill-ins) to engage in R&D in the agri-tech sector? Have the activities been delivered in partnership with other programmes (e.g. Agri-Tech Innovation Centres)? Are any other programmes acting as “feeders” for the Catalyst?
What outputs, outcomes and impacts have been achieved to date?	What is the nature, scale and reach of outputs, outcomes and impacts achieved by industry and academic partners, compared to expectations (set out in the logic chain – see Section 2)? How are outcomes distributed across portfolio/beneficiaries, including variation by type of grant (in a qualitative sense)? What are the wider indirect outcomes on innovation in the sector more widely, spillovers (e.g. knowledge transfer), unexpected and unintended effects, observed effects on the finance community (e.g. banks, VCs)? To what extent is the Catalyst portfolio being packaged and communicated to deliver more than the sum of its parts (e.g. in terms of spillovers, synergies between projects)? How sustainable are the outcomes achieved to date?
What is the added value of the collaborative approach?	What is the added value arising from the collaborative approach across supply chains, with academia/industry, with other programmes (including the Agri-tech Innovation Centres)? How sustainable are collaborative relationships with research partners, the supply chain and other programmes (such as the Centres)? Is the programme changing attitudes towards collaborative R&D and/or propensity to collaborate in future?
To what extent are outcomes and impacts additional?	To what extent would outcomes/impacts have been achieved anyway without the Catalyst?
How are outcomes/impacts delivered?	What are the pathways from inputs/activities to outcomes/impact for direct beneficiaries (leads and collaborators)? How are outcomes expected to impact on the wider agri-tech/agricultural sector (and achieve the Catalyst’s

	ultimate objectives)? Are mechanisms in place to enable this? How do routes to impact compare with the Theory of Change (and associated assumptions/risks)?
What is the contribution of the Catalyst relative to other internal/external factors identified?	To what extent can outcomes/impacts be attributed to the Catalyst? What has been the role of programme design and project-related factors, and influence and relative importance of other internal and external factors to achieving outcomes/impacts (e.g. role of the overarching Agri-Tech Strategy, wider policy, market, technological and people/skills drivers, consumer acceptability)?
What has supported or inhibited the progress, effectiveness/efficiency of the Catalyst?	What broader factors/processes have supported or inhibited performance? e.g. the context and system in which the programme operates, integration with other programmes (incl. Agri-tech Innovation Centres).
What are the anticipated outcomes/impacts of the Catalyst in future?	What is the nature and scale of outcomes expected in future (incl. environmental benefits)? How and when will these be achieved, and how do they compare with the logic chain(s) and Theory of Change? How these outcomes/impacts can be measured in future?
How is the Catalyst performing overall?	To what extent is the Catalyst on track to deliver against original aims/objectives (of the programme and wider Agri-Tech Strategy) and addressing the original rationale? Linked to this, to what extent have projects achieved their original objectives? What the remaining barriers to commercialisation?
What are the key lessons from the Catalyst?	At a programme level, what has worked well (or not) and why in delivering outcomes/impacts? Are there examples of transferable good practice from projects? What makes for a successful project? Which factors have been critical to success? Is the Catalyst a good model for encouraging greater public/private investment in R&D?

Source: SQW, drawing on original Specification for the study, SQW's proposal, discussions with the Steering Group, and feedback from the scoping consultations

1.8 **The overarching approach for this interim evaluation is theory-based**, which assesses and compares the evidence collected on what has actually happened as a result of an intervention, against its original Theory of Change of what was expected to happen (explained in more detail in Section 2).

1.9 The evaluation is being undertaken in two phases:

- **Phase 1** (the focus of this report) covers projects in receipt of **early and late stage** grants, on the basis that these projects were most likely be completed at the time of the evaluation given their relatively short timeframes for delivery. The research for this phase has taken place between February and June 2018.
- **Phase 2** will focus on projects in receipt of **industrial research** grants, which are longer in duration. Phase 2 will be undertaken between August 2018 and February

2019, by which stage a larger number of industrial stage projects are expected to be 'closed' in terms of their participation in the ATC programme.

1.10 Each phase adopts a similar **mixed-methods approach**, including a desk-based review of data and documentation (such as monitoring data and close-out report information), stakeholder consultations, surveys with project leads and collaborators and unsuccessful applicants, and a series of in-depth case studies with projects. The second phase of the evaluation will also include consultations with strategic, management and delivery staff and development of a framework to assess longer-term impacts in future. The final report in early 2019 will draw together the findings of both phases of work.

1.11 This interim evaluation for BEIS **excludes the 24 DFID-funded projects** under the Catalyst programme, which will be subject to a separate evaluation commissioned by DFID. Throughout this report, 'the programme' refers to the non-DFID aspects of the Catalyst.

Report structure

1.12 This report is structured as follows:

- Section 2 sets out the approach adopted for this first phase of the evaluation in more detail
- Section 3 provides a summary of the ATC model, and the associated logic models and Theory of Change
- Section 4 summarises the programme portfolio, inputs and an assessment of rationale and engagement
- Section 5 sets out the activities delivered to date
- Section 6 presents evidence on outputs, outcomes and impacts achieved to date, and expected in future
- Section 7 provides an assessment of additionality and the contribution of ATC
- Section 8 presents the conclusions, including the overall contribution story, performance against the programme's objectives to date, and key lessons learned.

1.13 The main report is supported by three annexes: Annex A provides further detail on the survey sample; Annex B provides more detailed data tables on the programme portfolio; and Annex C presents the individual case study reports.

2. Approach

2.1 This section describes the approach adopted for this evaluation and details the research tasks undertaken to gather evidence (and limitations). It also provides further detail on the survey response rates and profiles of respondents.

Key messages

• This phase of the evaluation has focused on early and late stage projects only. Industrial Research projects will be considered in Phase 2, taking place through to early 2019.

• A theory-based approach has been adopted for the evaluation, drawing upon 'contribution analysis', reflecting the 'small-n' but complex programme, the diversity of projects supported, and multiple routes to impact across a diverse sector.

• The evaluation has also sought to identify lessons to inform future policy, particularly in terms of what has supported or inhibited pathways to impact.

• The methodology encompasses mixed methods, including a review of monitoring and application data and close-out reports, consultations with 16 strategic and wider stakeholders, a survey of beneficiaries and unsuccessful applicants (57 and 29 respondents respectively), and seven indepth case studies.

• Where possible and appropriate, the analysis disaggregates findings between early and late stage projects, reflecting their different stages of technological development. The beneficiary survey results are also compared to those of unsuccessful applicants to provide some insight and qualitative evidence into the potential counterfactual position.

• The evaluation has involved an iterative process of evidence gathering and analysis to develop the 'contribution story'. A combined quantitative and qualitative assessment is provided, rather than a 'single figure' estimate which would be partial and omit changes and benefits brought about by the Catalyst.

Overarching approach

2.2 The overarching approach to this evaluation is **theory-based,** which has involved developing and then testing logic models and a Theory of Change for the programme, and drawing upon **'contribution analysis'**. Given the complexity of the programme in terms of three types of award, complex and multiple routes to impact and the very diverse nature of projects supported, combined with relatively small sample sizes (particularly when assessing outcomes for each type of award), empirical impact evaluation was not appropriate for the Catalyst. The overarching approach aligns with the recommendations for the evaluation of the ATC set out in SQW's evaluation framework for the Agri-Tech Strategy in 2016.

2.3 Theory-based evaluation, and specifically contribution analysis, is an approach to evaluation 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. The approach is based on the development of logic models and underlying theory as to how intended outcomes and impacts were to be brought about[3]. Evidence is used to evaluate the intervention's contribution to the observed outcomes and impacts (e.g. new products developed, employment and turnover generated) by constructing a "contribution story" on the extent to which the intervention was important in generating these observed outcomes and impacts relative to other factors[4], such as external market, policy or environmental conditions.

2.4 Following the collation and analysis of the evidence, a plausible association can be made (or attribution is demonstrated beyond reasonable doubt) if the following are satisfied[5]:

- a reasoned Theory of Change for the Catalyst is set out
- the activities of the Catalyst have been implemented as set out in the Theory of Change
- the chain of expected results, e.g. on individual businesses, academics, and the wider sector can be shown to have occurred
- other influencing factors have been shown not to have made a difference, or the decisive difference.

2.5 Alongside the contribution analysis that responds to the research questions related to the interim impacts of the Catalyst at this stage, the evaluation also focuses on **learning**, particularly in terms of what has supported or inhibited progress informing the outcomes and impacts that are realised, the added value of the collaborative approach, and what has worked well (or not) for whom and why, in progressing towards the ATC's intended impacts.

Research tasks

2.6 A **mixed-methods approach** has been adopted for this evaluation, combining a range of different methods within the theory-based framework. This includes a desk-based review of monitoring data, application baseline data, consultations with strategic and wider stakeholders active in the agriculture/tech field, a survey of beneficiaries and unsuccessful applicants, and in-depth case studies with seven early and late stage projects. In addition, SQW has met with the Steering Group on four occasions to (i) initiate the study, (ii) agree the evaluation's research questions, logic models and Theory of Change, following an initial review of documentation and scoping consultations, (iii) discuss interim findings and plan for the survey and case study work, and (iv) discuss and test emerging findings before the draft report was produced.

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

2.7 Given the nature of the programme, we have not included econometric techniques, but have employed basic statistical tests to supplement the analysis, including z-tests[6], to test the equality of distributions of characteristics and the outcomes between samples (e.g. successful and unsuccessful applicants, early stage or late stage respondents, or leads and collaborators, responding to the survey). Although this approach does not provide evidence of causation of the programme (as it does not control for any other factors), it highlights key differences that are statistically significant, e.g. where project leads are more likely to have experienced a particular outcome compared to collaborators.

2.8 In the paragraphs that follow, we outline in more detail the research tasks undertaken to inform this report, and, for the survey, present details on response rates and profiles.

Desk-review of documents and data

2.9 A review of programme documentation was undertaken to develop the logic models and Theory of Change for the programme[7]. In addition, we have reviewed monitoring data from Innovate UK (including application and project data, and expenditure[8]), baseline data set out in application forms on type of organisation, turnover, employment and sub-sector of those applying, funders panel data[9] on the assessor scores of each application, and close-out reports[10] that had been completed at the time of the evaluation.

2.10 Baseline data from applications was available for application leads, but not collaborators, with the collaborator survey (see below) used to gather relevant baseline data. This provided some (partial) evidence on collaborators before their involvement in ATC, but the lack of comprehensive data means it was not possible to compare the profile of collaborator survey respondents with the population to check the representativeness of the sample.

Stakeholder consultations

2.11 A total of **16 consultations were held with a range of strategic and wider stakeholders**, involving representatives from the organisations set out in Table 2-1.

[6] A two-sample z-test can be used to test the difference between two population proportions p1 and p2 when a sample is randomly selected from each population. In this case, we can apply the two-sample z-test to test for any statistically significant differences between two samples.
[7] Documentation included the Agri-Tech Strategy and Evaluation Framework, ATC Business Case, Competition Guidance and Briefings.
[8] Targets for spend to date are not available from Innovate UK – claim profiles are updated regularly and are therefore 'live'. Data on outputs achieved compared to target is not gathered and compiled by Innovate UK. On the advice of BBSRC, Research Council spend to date was calculated on a pro rata basis, using the lifetime budget, anticipated start and end dates for each projected, and expected spend to date.
[9] For each round of ATC competitions, applicant information and assessor scores and feedback were compiled and presented to the 'funders panel'. The 'funders panel' comprised Innovate UK, BBSRC, DFID and BEIS, and a selection of assessors.
[10] Once a project has been completed under the ATC programme, the project lead and collaborators complete a close-out report, which contains information on performance against project level objectives, outputs and outcomes, and wider spillovers, exploitation and dissemination plans, and lessons learned from the project.

Table 2-1: Organisations involved in strategic consultations

Agri-Food Tech Leadership Council Agriculture and Horticulture Development Board (AHDB) Individual agri-tech venture capital funder Innovate UK Defra (agricultural R&D and innovation Policy team) Department for International Trade (agri-tech team)	National Institute of Agricultural Botany (NIAB) Royal Agricultural Society of England (RASE) Knowledge Transfer Network Agri-Tech East Agri-EPI Innovation Centre John Innes Centre British Beet Research Organisation (BBRO

Source: SQW

2.12 The purpose of this consultation was to gather stakeholders' views on the activities delivered by the Catalyst to date, the programme's fit with the wider innovation support landscape, emerging outcomes and overall performance of the Catalyst, lessons learned about what works (or not) and why, and remaining barriers to commercialisation in the sector. Where possible, consultees were asked whether there were differences in progress between the early and late stage projects, but in reality, few were sufficiently familiar with the programme to comment at this level of detail.

Surveys with beneficiaries and unsuccessful applicants

Approach

2.13 **All of the project leads and collaborators of early and late stage projects** were included in the survey sample. The purpose of the survey was to gather evidence on their experience with collaborative R&D in agri-tech before ATC; their rationale for engaging with ATC; activities funded through the programme (and the extent to which they were additional) and technological progression; outcomes achieved so far and expected in future; key enablers or barriers to progress; progress since the ATC project; and the overall level of attribution to ATC, additionality and the contribution of ATC compared to other internal and external factors.

2.14 A similar approach was adopted for unsuccessful applicants, with the sample including **the leads of all unsuccessful applicants[11] scoring 70+ for early stage projects** (i.e. deemed fundable but not funded[12]), on the basis that this provides a well-matched group to the beneficiaries[13]. All but two unsuccessful applicants for late stage projects scored below 70. Therefore, due to the lack of a 'fundable but not funded' group for this award-type, the survey covered the leads of **all unsuccessful applicants[14] for late stage projects[15]**. The survey with unsuccessful lead applicants followed a similar structure to the beneficiary survey, but asked whether projects had proceeded without

[11] Excluding those who were subsequently successful in later rounds for ATC funding.
[12] They did not rank highly enough in the 'fundable' category in that funding round.
[13] For applicants who were unsuccessful in securing ATC funding, there were two groups: first, a group who did not meet the Innovate UK threshold of 70% (i.e. the average assessor score was below 70%); and second, a group who exceeded the 70% threshold (and therefore were deemed of sufficient quality to be funded) but, when applications in this group were ranked in order of score and projects were funded from the top, these applications did not rank sufficiently high to be awarded funding in that funding round.
[14] Excluding those who were subsequently successful in later rounds for ATC funding
[15] Eight scored between 60-70 and six scored below 60.

ATC funding, and if so, to what scale/timing/quality, how this has been achieved, the technological progress made anyway, and any outcomes/impacts observed from the activities undertaken.

2.15 The surveys were undertaken by BMG Research in May and June 2018. Each interview lasted up to 30 minutes for beneficiaries and 15 minutes for unsuccessful applicants.

2.16 The interview with each lead and collaborator in this survey focused on a single project in each case, and the effects of this project. This approach was adopted for two reasons: first, in some cases, organisations have been involved in multiple projects (and in different capacities, as lead and/or collaborator) and it would not have been possible to seek to cover all of these projects in a single survey; and second, seeking to attribute changes in overall organisational performance (for example, on turnover, employment of R&D expenditure) to the Catalyst alone was not likely to be possible, particularly for medium-sized and large businesses and for academic participants. A series of rules were applied, in agreement with the Steering Group, to identify the project to be the focus of the survey for each individual beneficiary. In summary, this meant that we prioritised an organisation's involvement as lead (rather than collaborator)[16], and the earliest completed project where a lead or collaborator was involved in multiple projects enabling outcomes to have been realised as far as possible[17][18]. For the survey with the leads of unsuccessful applications, a similar approach was adopted, whereby we focused on the most recent application if the organisation had applied multiple times for ATC funding.

2.17 Given the modest sample sizes, the diversity of projects covered and the small number of respondents observing quantifiable impacts (such as employment and turnover) to date and able to quantify these, it has not been considered appropriate to 'gross-up' the quantitative results of the surveys to the project population at the level of grant type[19], nor overall. The nature and scale of outcomes achieved and expected by different types of actors and the scale of collaborations involved in the early and late stage projects, and how these differ, has therefore been explored in a qualitative sense.

Survey response rates and bias

2.18 For the **beneficiary survey**, 57 completions were secured, out of 125 viable contacts[20] provided by Innovate UK for early and late stage projects, which gives a **response rate of 46%.** The 57 completions included 20 leads and 37 collaborators.

[16] Where a contact has been involved in both early and/or late stage projects and industrial stage projects, the early and/or late stage project was prioritised. This was based on (i) the larger population for the industrial stage projects, and (ii) the potential to re-contact the named contact later in the year for the Part 2 survey on the industrial stage grants. This will mean we may then need to re-contact some beneficiaries in late 2018 to discuss their industrial stage project.

[17] Given the timing of the projects – with the earliest project starting in 2014 – the risk of memory decay (which if evident would suggest the focus is on the later projects) is not considered to be a major issue, particularly given the potential long time-paths to impacts, meaning that the earlier the project was completed the greater potential for outcomes and impacts to have been generated.

[18] Note that we contacted all collaborators, including where there were multiple collaborators on an individual project.

[19] The sample sizes are too small to ensure that the findings are statistically robust. For example, for the late stage projects, with a population of 12, we would need responses from 11 leads to be confident that the findings are representative of the population with a 7.5% confidence interval, 95% confidence level.

[20] i.e. correct phone number etc

2.19 The 57 completions included leads/partners from **36 separate ATC projects**[21] (out of the 49 projects covered by this phase of the evaluation) spread across all five rounds of funding, of which 27 were early-stage projects[22] and nine were late stage projects[23]. There are 15 projects where the survey sample includes two or more completions for one project, allowing the analysis to provide a richer story for projects where we have multiple perspectives on the nature and routes to outcomes of these individual projects.

2.20 With a theory-based approach to the evaluation drawing principally on evidence and feedback from participants in the programme via the surveys and case studies, there is a risk of response bias, where those individuals that have had a more positive experience with the programme are more likely to engage in the research (e.g. by responding to the survey).

2.21 Quantifying the exact level of response bias is not possible: we do not know the experiences and perspectives of those participants (and their projects) that did not participate in the evaluation, and there are gaps in the coverage of close-out reports and monitoring data. However, we have sought to test for response bias and, given the following, **we are reasonably confident that the survey cohort is representative of the wider beneficiary population,** which means that the findings can be generalised for the population of ATC beneficiaries (although as noted above, given the variation in characteristics and outcomes, we are not seeking to quantitively 'gross-up' the findings):

- the composition of the sample was statistically equal to the programme population in terms of industry/academic representation, business size and sectors (see Annex A for further details)
- the beneficiary sample is representative of the population in terms of the average assessor scores on applications, i.e. the difference between the mean scores for the two samples is not statistically significant
- the majority of survey refusals from beneficiaries (that is, those beneficiaries that explicitly said they would not participate, excluding those where it was not possible to make contact) were due to key personnel moving on or time constraints, rather than issues with project failure, suggesting that a higher response rate from successful projects is not causing response bias
- a comparison of self-reported performance against project objectives in close-out reports between beneficiaries who did/did not take part in the survey (to see whether those responding to the survey appear to have performed better) identified no difference between the groups – most believed they had achieved their objectives, very few did not[24].

2.22 This said, we recognise that there remains some risk of response bias. For example, there are eight projects (the 49 projects covered by this phase of the evaluation) where we have no evidence from the survey or close-outs reports were not available at the time of the evaluation[25] on project progress and outcomes. Further, there may be other factors/variables that have influenced project success that are not captured fully by the

[21] Of the 49 early and late stage projects.
[22] Out of 37 projects.
[23] Out of 12 projects.
[24] The sample size here is small; 20 close-out reports were provided, of which four had no participants that were included in the survey.
[25] Monitoring data does not provide information on outcomes.

analysis above on characteristics, application scores and close out reports that may still mean there is some response bias in the survey sample. This should be taken into account when reviewing the findings and conclusion of the evaluation at this stage.

2.23 For the survey of **unsuccessful applicant leads, 29 completions were secured**, out of 99 viable contacts provided by Innovate UK for early and late stage unsuccessful applicants, which gives a **response rate of 29%**[26]. Of these, 27 were leads of early stage applications[27] and two of late stage applications[28].

2.24 The composition of the unsuccessful applicant sample was statistically equal to the population of unsuccessful applicants (in terms of industry/academic representation, business size and sectors, see Annex A for further details). In terms of comparing the beneficiary and unsuccessful applicant survey samples, to inform our assessment of the counterfactual:

- we have greater confidence in generalising findings for early stage unsuccessful applicants and beneficiaries, given the higher number and rate of responses for this type of award, similar scale of businesses responding to both surveys (in terms of turnover[29]), and similar quality of proposal (based on assessor scores of 70 or above[30])
- there is greater caution for the late stage respondents given low response numbers/rates and some differences in the 'quality' of applications[31].

2.25 As a result, any counterfactual analysis comparing beneficiaries and unsuccessful applicants is presented for the two groups combined, rather than for each type of grant.

Case studies

2.26 **Seven case studies** have been undertaken for this first phase of the evaluation: **five were focused on early stage projects, and two on late stage projects**. This split reflects broadly the distribution of award types across the programme as a whole. The case study projects were selected from those completing the survey and agreeing to follow-up research through a case study. The case studies are illustrative rather than representative and have sought to cover a range of policy interests, varying scales/types of collaboration, and types of technologies, applications and markets.

[26] This is a relatively good response rate for non-beneficiaries. It is similar to response rates for non-beneficiaries achieved in other similar evaluations – for example, 33% was achieved in SQW's evaluation of Innovate UK's Smart instrument (see https://www.gov.uk/government/publications/smart-funding-assessment-of-impact-and-evaluation-ofprocesses).
[27] Out of 84 contacts available.
[28] Out of 16 contacts available.
[29] Current employment is higher in beneficiary lead firms (median=20) compared to unsuccessful applicant firms (median=12), but turnover is similar for both groups (median=£750k for both). Beneficiary lead firms on average were slightly older than unsuccessful applicants, but there is significant diversity within each group.
[30] As expected, the difference in mean assessor scores between the beneficiary and unsuccessful applicants sample is statistically significant, because projects were funded in rank order of score. However, all of the early stage beneficiaries and unsuccessful applicants surveyed scored 70+ by Innovate UK's assessors in their application and therefore deemed of sufficiently high quality to be funded.
[31] Only two of the late stage unsuccessful applicants scored 70+, so we were unable to sample from a 'fundable but not funded' pool of applicants to ensure a similar quality of proposal. However, the late stage unsuccessful applicants surveyed scored 64 and 67, and so were not substantially different in terms of quality to those funded (compared, for example, to the unsuccessful late stage applicants towards the lower end of the scores, around 41).

They also include the only ATC project that has progressed from one type of grant to another within the programme. The case studies are presented in Table 2-2 below.

Table 2 - 2: Case Studies – *Source: SQW*

Project Title	Award Type	Funding Round	Lead Organisation	Lead Location (Region)	No. collaborators involved in project	No. partners consulted/surveyed for the case study	Collaboration Type
Maximising mycoprotein substrate utilisation and nutrition	Early	2	East Malling Research Limited	South East	2	2 organisations consulted (and surveyed)	Academic and Industry
WheatScan: Tractor-mount sensing for precision application of Nitrogen and control of milling wheat protein content	Early	1	Adas UK Limited	West Midlands	2	2 organisations consulted (and 1 of these also surveyed)	Academic and Industry
Evaluating a potential proxy test for Feed Conversion Efficiency in beef cattle.	Early	3	SRUC	Scotland	1	2 organisations consulted (and surveyed)	Academic and Industry
CAPSEED - A New Seed Conditioning Process for Arable and Horticultural Crops	Early	3	GnoSys Global Limited	South East	4	3 organisations consulted (and surveyed)	Academic and Industry
Lobster Grower - Develop the technology to fast track the aquaculture potential for the European Lobster	Early	1	The National Lobster Hatchery	South West	5	3 organisations consulted (and surveyed); 2 further collaborators surveyed	Academic and Industry
Harnessing Natural Fungi to Control Insect and Mite Pests in Grain Storage	Late	1	Exosect Limited	South East	2	1 organisation consulted (and surveyed); 2 further collaborators consulted; 1 further collaborator surveyed	Industry only
Rubber track undercarriage systems for controlled traffic farming	Late	5	Sly Agri Ltd	East Midlands	0	1 organisation consulted (and surveyed)	Research organisation and Industry

2.27 The case studies have provided in-depth evidence on the context before ATC (and spill-ins to agri-tech), the nature of outcomes observed to date (and whether these vary across the consortium), pathways to impact and factors enabling/hindering progress at each stage of the process, additionality and the contribution of internal/external factors in achieving these outcomes/impacts (and whether this varies across partners). The case studies have also provided an opportunity to focus on organisations that have been involved in multiple projects (ATC funded or not), to allow the evaluation to test interdependencies between projects, and the potential benefits and impact of this e.g. where there may be outcomes that are greater than the sum of their parts.

2.28 Each case study has involved a review of the project documentation and construction of a project-specific Theory of Change, a site visit and face-to-face consultations with the lead and follow-up consultations with two or three collaborators, and a short stand-alone report (which has been reviewed by consultees before sharing more widely[32]). Each case study report is presented in Annex B of this report.

Implementing the contribution analysis

2.29 For this evaluation of the ATC, we have adopted an iterative process of evidence gathering and analysis to develop the ‘contribution story’. This has involved developing a Theory of Change and risks to it[33], gathering evidence against this through the mixed methods approach described above, and assessing the contribution story (and challenges to it). This was then followed by further evidence gathering and testing (including via a steering group workshop), and finally the revised and strengthened contribution story (based on the quantitative and qualitative evidence available) is presented in this report.

2.30 For each of the outcomes assessed, we have sought to triangulate evidence from a range of different sources to corroborate the findings (or where appropriate, demonstrate the diversity in opinion). Where possible, we have distinguished between outcomes (and pathways to impact) achieved by early and late stage projects, reflecting their different stages of technological development. The additionality of activities undertaken and outcomes achieved has been assessed through self-reported evidence from beneficiaries (and what would have happened in the absence of ATC), compared to the experiences of unsuccessful applicants.

2.31 The combined quantitative and qualitative assessment adopted here, rather than a ‘single figure’ estimate, is important. Any single estimate of impact will be partial and focussed on the results of the most direct routes to impact that can be most easily measured. This approach would understate the impact of the Catalyst, and omit key aspects of how it may be bringing about change and benefits – including through changes in behaviours and attitudes, and indirect effects on the wider sector and across the industrial and academic base.

2.32 The contribution analysis presented in the remainder of this report, and structured around the four key lines of enquiry set out in paragraph 2.4:

[32] If the case study consultees provided feedback that they wished to be anonymous, this has been used to inform the overall analysis for the study (rather than included in the case study report).

[33] Which was discussed with the Steering Group and then signed off Group in a scoping report on 21 February 2018.

- whether a reasoned Theory of Change for the Catalyst was established (Section 3)
- whether the activities of the Catalyst have been implemented as set out in the Theory of Change (Sections 4 and 5)
- the outcomes observed and expected in future, how these have been/will be achieved (i.e. factors enabling or hindering pathways to impact), and the extent to which they align with the Theory of Change (Section 6)
- the extent to which outcomes are additional and whether other influencing factors have made a difference (Section 7).

2.33 The overall contribution story is then presented in Section 7. This also includes a summary of the key lessons in response to the evaluation questions focused on learning, at this stage of the evaluation.

3. Programme context and logic model

3.1 In this section, we present an overview of the Catalyst programme design, including the original rationale and strategic context, the programme's aims, inputs and activities, and intended outputs, outcomes and impacts. A logic chain and Theory of Change was developed at the outset of this study (presented below), which has been tested during the evaluation.

Key messages

• The Catalyst was a core part of HM Government's 2013 UK Strategy for Agricultural Technologies, it responded to a series of market and other failures facing those wishing to pursue R&D in the agri-tech sector (including information failures, risk and co-ordination failures) and global opportunities for growth.

•Its aim was to accelerate translation of research into new technologies in agriculture, leading to improved agricultural output and productivity, and reduced environmental impact. It also sought to provide an economic boost to UK agri-tech industry, encourage greater investment in R&D, increase turnover, employment, productivity within the sector, and improve the UK's competitive position internationally.

• The programme budget was £60m, which comprised £30m investment by BEIS/Innovate UK and £30m from BBSRC.

• Early, industrial and late stage grants were awarded through five competition rounds. All projects had to be collaborative in nature – early stage grants could be led by a business or academic, but industrial and late stage grants had to be industry-led. Any sector or discipline could apply, and funders were keen to see spill-in of typically non-agricultural partners to encourage technology convergence. Intervention rates were tailored according to type of award and size of business applying for support.

Programme design and delivery

3.2 HM Government's 2013 UK Strategy for Agricultural Technologies included the proposal for an Agri-Tech Catalyst to improve the translation of research into practice which would:

- "support collaborative partnerships between academics and industry that contribute to the challenge of sustainable intensification
- be designed to attract co-investment from the private sector
- support business, and particularly SMEs, to take part
- cater for a range of project types from quite large collaborative programmes of threeto-five years, to shorter feasibility studies and proof of concept

- develop, monitor and evaluate a portfolio of projects with clear outcomes"[34].

3.3 The specific aim for the Catalyst, as articulated in the Brief for this evaluation, was to "accelerate translation of research into practical solutions, best practices and applications of new technologies in agriculture[35] – ultimately to contribute to improvements in agricultural output and productivity, whilst reducing the environmental impact of agricultural production". The intervention should provide an economic boost to UK agri-tech industry, through greater investment in R&D in the sector, increased turnover (including exports), employment, productivity and an improved competitive position internationally.

3.4 The programme is designed to address a number of **market and other failures**. Like in many sectors, those from academia and industry working in agri-tech often struggle to find appropriate collaborators for early stage R&D activity (co-ordination/network failures). Involving industry partners in early stage R&D is particularly important to ensure there is an industry pull for innovative ideas. For agri-tech, this is particularly difficult in such a large, diverse and fragmented sector, where there is often a lack of awareness amongst nonagricultural disciplines of opportunities within agri-tech. The relative risk, long lead times, and (in some instances) high costs of R&D leads to underinvestment in innovation (this is particularly difficult for small farmers with limited financial capacity) and can result in problems in accessing external finance at reasonable costs[36]. Firms are also likely to underinvest in R&D from a societal perspective because they are unable to capture full returns on investment – for example, the knowledge and the technologies developed become part of global knowledge stock, leading to socially and environmentally desirable objectives.

3.5 In addition, the Catalyst provided the opportunity for positive externalities associated with spill-ins from other sectors and technology areas into agri-tech. There are substantial global opportunities in markets such as machinery, sensors and data, and taking advantage of these is dependent on spill-ins from sectors such as engineering, aerospace and computing[37]. However, encouraging spill-ins into agri-tech can be a challenge – given the diverse range of sub-sectors covered by agri-tech, other technology areas may not realise the opportunities in agriculture.

3.6 The ATC **programme budget was £60m**, which comprised £30m investment by BEIS/Innovate UK and £30m from BBSRC. In addition, the programme expected to secure £30m of industry match. Innovate UK is responsible for managing the delivery of the Catalyst, in partnership with BBSRC and DFID.

3.7 The Catalyst offered **three types of grant award**, reflecting different stages of the R&D process and the intention to accelerate and encourage collaborative R&D at each stage:

[34] HM Government (2013) UK Strategy for Agricultural Technologies.
[35] Other documentation also refers to application in related sectors.
[36] Compared to more established technologies
[37] A study by UKTI (now DIT) before the Agri-Tech Strategy was published and which looked at the global market conclude that the largest single sub-sector was for agricultural machinery, which together with the emerging sub-sector of sensor technologies already in 2012 accounted for approximately half the global market. In contrast other sub-sectors, such as plant breeding in which the UK had traditionally been a World leader, were much smaller at only 7% of the global market and seeing slow growth rates (expect for GM technology which was not allowed in most cases in the UK and EU).

- **early stage projects** to test commercial potential of scientific ideas/feasibility of new technologies (taking ideas up to Technology Readiness Level[38], TRL, 4), with grants of £150k to £500k delivered over an 18-month (maximum) period.

- **industrial research** awards to develop innovative solutions through technology development, lab-based prototyping, pilots, and trials market testing (to TRL 7), which provided grants of up to £3m[39] for up to three years.

- **late stage awards**, to test/trial innovations in real-life context ahead of larger-scale deployment, including commercial assessments for technologies that are closer to commercialisation (up to TRL 9), offering up to £1m[40] for up to 12 months[41].

3.8 The grants were offered through **six funding competitions** between October 2013 and February 2017. The sixth competition focused on DFID funding only, and so is not covered by this evaluation. Each competition set out broadly defined sector challenges, rather than having narrow or prescriptive thematic focus for each competition or proposing solutions, and asked for applications in the following areas:

- primary crop and livestock production, including aquaculture

- non-food uses of arable crops (for example, for biomass)

- food security and nutrition challenges in international development

- challenges in downstream food processing, provided the solution lies in primary production.

3.9 All projects had to be **collaborative in nature** – early stage grants could be led by a business or academic, but industrial and late stage grants had to be industry-led. The only exception was that mid-way through the programme (from Round 3), Innovate UK allowed individual businesses to apply for late stage grants only. Any sector or discipline could apply, and funders were keen to see spill-in of typically non-agricultural partners to encourage technology convergence.

3.10 All sizes of business were eligible for the programme, but **the intervention rates (i.e. the proportion of the project cost that was covered by the grant) were tailored** for SMEs and large firms. The intervention rate decreased from early to late awards reflecting the level of risk and time lag for returns on investment (i.e. the proportion of the cost covered by the grant decreased and the proportion covered by the applicant increased). From Round 3 onwards, the intervention rate for early stage projects was 55% for SMEs and 45% for large firms (and 100% for academics, capped at 50% of overall project cost); for industrial stage projects, the rate was 45% for SMEs and 35% for large firms applying for industrial stage, and 35% for SMEs and 25% for late stage[42].

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[38] TRLs are a described as a “technology management tool that provides a measurement to assess the maturity of evolving technology” by UK Government. For example, see https://publications.parliament.uk/pa/cm201011/cmselect/cmsctech/619/61913.htm
[39] Up to £3m in Rounds 1-5, and then up to £1.5m for Round 6 (DFID only)
[40] Up to £1m in Rounds 1-5, and then up to £800k for Round 6 (DFID only).
[41] Up to 18 months for Round 6 (DFID only).
[42] There were some changes to the intervention rate during the programme. In Round 3, funders believed that greater leverage could be achieved for early and industrial awards, partly given the higher-than-expected demand, so the intervention rate for SMEs changed from 75% to 55% for early stage grants and from 60% to 45% for mid-stage grants. For large companies, the rate changed from 65% to 45% for early stage grants, and 50% to

Logic model and Theory of Change

3.11 Figure 3-1 presents a **logic model for the Catalyst as a whole**. It sets out the rationale and strategic context, aims and objectives, inputs and intended outputs, outcomes and impacts for the Catalyst. The logic model excludes DFID related material, as the DFID-funded Catalyst projects are not within the scope of this evaluation. The programme level logic model is underpinned by '**nested' logic models for each grant type**, reflecting where we might expect variances in the emphasis of each grant's rationale, aims and intended outputs, outcomes and impacts (see Figure 3-2) for different stages of the commercialisation process. For example, we might expect outcomes around new collaborations and leverage of further R&D investment to be particularly relevant for early stage grants (at least in terms of the direct effect of the programme), whereas new products to market will be more appropriate for late stage grants.

3.12 In summary, the key blocks of the logic model are as follows:

- **Rationale**, i.e. the justification for public intervention, as outlined above
- **Aims and objectives**, including the overarching Agri-Tech Strategy aim (to support economic growth, employment and productivity by facilitating the development and uptake of world class UK based agri-science and associated technologies) and specific objectives for the Catalyst relating to: (i) accelerating the translation of research into practical solutions, best practices and applications of new technologies in agriculture (and related sectors); (ii) contributing to improvements in agricultural output and productivity, whilst improving animal welfare and reducing the environmental impact of agricultural production, and (iii) providing an economic boost to UK agritech industry
- **Inputs**, including the £60m funding for grants, operational management/delivery inputs (by Innovate UK, BEIS and BBSRC), and strategic oversight by the Agri-Tech Leadership Council.
- **Activities**, i.e. the three types of grant award described above
- **Intended outputs** (i.e. measures of the activities delivered), including investment in R&D (i.e. match funding), new collaborations, research outputs etc
- **Intended outcomes and impacts arising from the activities/outputs**, including intermediate outcomes for those directly involved in ATC projects (e.g. leverage of follow-on investment, new products/processes taken to market, business growth and exports, changes in university attitudes/behaviours) and ultimate impacts more widely (e.g. improved competitive position of UK agri-tech, additional inward investment, changed attitudes/behaviours of banks/VCs towards investing in agritech R&D, innovation adoption leading to wider productivity gains and environmental improvements in the agricultural sector).

3.13 In Figure 3-3, we then present SQW's interpretation of the **Theory of Change (ToC) for the programme**. This attempts to show how and why the Catalyst might be expected to bring about outcomes and impacts, by setting out causal links between activities,

35% for mid-stage grants. In Round 5, intervention rates for SME were divided into two different rates, one for Micro/Small companies, and another for Medium-size companies.

outputs, outcomes and impacts, and associated assumptions and risks or reasons why the logic might break down. As part of our theory-based approach to the evaluation, we have sought to test the extent to which the Catalyst is delivering against the intended outputs, outcomes and impacts set out below (and whether these vary by type of award), and the routes to impact, noting any differences in enablers or barriers at each stage of the process compared to original expectations. In doing so, has been important to recognise that **the Catalyst is a complex intervention**, for example:

- each grant type differs in terms of its scale of funding available, intervention rate and timeframe for delivery
- project topics are diverse, reflecting the nature of the agri-tech sector
- project start points vary (with implications for when outputs and outcomes are expected to be generated), and routes to impact are variable, iterative and, in many cases, long
- project outcomes are heterogeneous, with some being more/less relevant and important for different projects and different participants within projects (as illustrated by the nested logic chains); the outcomes cover both ‘market’ effects, and those related to behaviours and capacities, reflecting the focus on collaborative R&D activity, and also cover both ‘direct’ effects on those involved with the programme, and the ‘indirect’ effects on the wider agricultural sector and research base
- attribution is a challenge for some beneficiaries (especially where they are involved in more than one project, and/or the scale of intervention is relatively small).

3.14 Given the timing of this interim impact evaluation, SQW and the Steering Group thought it reasonable to expect that the Catalyst would be delivering against intermediate outcomes set out in the Theory of Change – and potentially also final outcomes/impacts for late stage projects (or industrial projects who have progressed technologies without moving on to late stage Catalyst grants) who were funded during the earlier rounds of the programme

Strategy & design | **Delivery** | **Benefits**

Context & rationale

Co-ordination failures/network externalities. Lack of infrastructure for collaboration. Public/private sector lacks opportunity to engage with/build on research, large number of actors involved, diversity of sector. Collaboration will enable industry "pull" for innovative ideas and transform into commercial products

Information failures: Absence of information about benefits of new technologies leads industry/farmers to perceive them as high risk investments; Uncertainty of research payoffs in agri-tech R&D – "valley of death" where government funding for basic research ends

Other challenges: Farmers, the majority being small businesses with limited financial capacity themselves, are unable to invest in R&D/take tech from lab to market; Long lead times for research payback, leading to under investment from private sector

Wider externalities and spillovers: Private firms likely to underinvest in R&D from a societal perspective because they are unable to capture full returns on investment – knowledge/technologies become part of global knowledge stock, leading to socially desirable objectives ("Innovation failures"). Agri-tech is an enabling sector supporting growth in other key sectors incl. healthcare, bioenergy and chemical industries, and plays important role in addressing societal challenges, climate change, environmental sustainability, food security. Knowledge exchange/spillovers and academic/industry people exchange.

UK Agri-tech Strategy 2013: Vision: *That the UK becomes a world leader in agricultural technology, innovation and sustainability; exploits opportunities to develop and adopt new and existing technologies, products and services to increase productivity; and thereby contributes to global food security and international development.*

Aims & Objectives

Overarching Agri-Tech Strategy aim:

- support economic growth, employment and productivity by facilitating the development and uptake of world class UK based agri-science and associated technologies.

For the Catalyst specifically:

- accelerate translation of research into practical solutions, best practices and applications of new technologies in agriculture [and related sectors]
- contribute to improvements in agricultural output and productivity, whilst improving animal welfare and reducing the environmental impact of agricultural production
- providing an economic boost to UK agri-tech industry

Inputs

£70m fund comprising:
£30m BEIS
£30m BBSRC
[Plus £10m DFID]
Plus £30m match

Operational management, delivery and monitoring by IUK (incl. inputs from KTN, monitoring officers and panel assessors)

Management and delivery inputs from BEIS, BBSRC,[and DFID]

AT Leadership Council strategic oversight role

Activities

Competitive fund process, single point of access, resulting in 100+ new / additional applied/translational research projects:

- early stage projects to test commercial potential of scientific ideas/feasibility of new technologies (taking ideas up to TRL 4)
- industrial research awards to develop innovative solutions through technology development, lab-based prototyping, pilots, trials market testing (to TRL 7)
- late stage awards, to test/trial innovations in real-life context ahead of larger-scale deployment, incl. commercial assessments for technologies that are closer to commercialisation (to TRL 9).

All projects involve collaboration between industry and research base. All business sizes eligible, with ATS emphasis on SMEs

Focus on pre-farm gate (excl. food processing)

Outputs

- Additional private sector investment in R&D (match funding)
- New patents filed
- Number/New collaborations between industry and research
- Research outputs
- Skills acquisition
- Commercial applications (including 'spill ins' of technology from other sectors and translating into agricultural applications) and technological progress/reduced risk of failure
- New data available to industry

Outcomes/impacts

<u>Intermediate outcomes</u>

- **Leverage of further investment**, where appropriate/required *after* ATC project
- New products/processes successfully **incorporating R&D results, and then taken to market** (in UK/exports)
- Business growth (**sales/market share) and/or productivity**
- More businesses engaged with research base and/or extent of **engagement** increases (sustainable collaboration)
- Greater **understanding/access** to innovative practices/techs across sector
- Changes university **attitudes, behaviour, knowledge** of commercialisation process, better understanding of business needs/expectations and propensity to collaborate, improved ability to lever R&D funding (e.g. H2020)
- **Take-up** of new techs/products/processes in market (UK/overseas)
- **Turnover** (incl. exports) and **employment** generated for UK agri-tech firms

<u>Final outcomes/impacts</u>

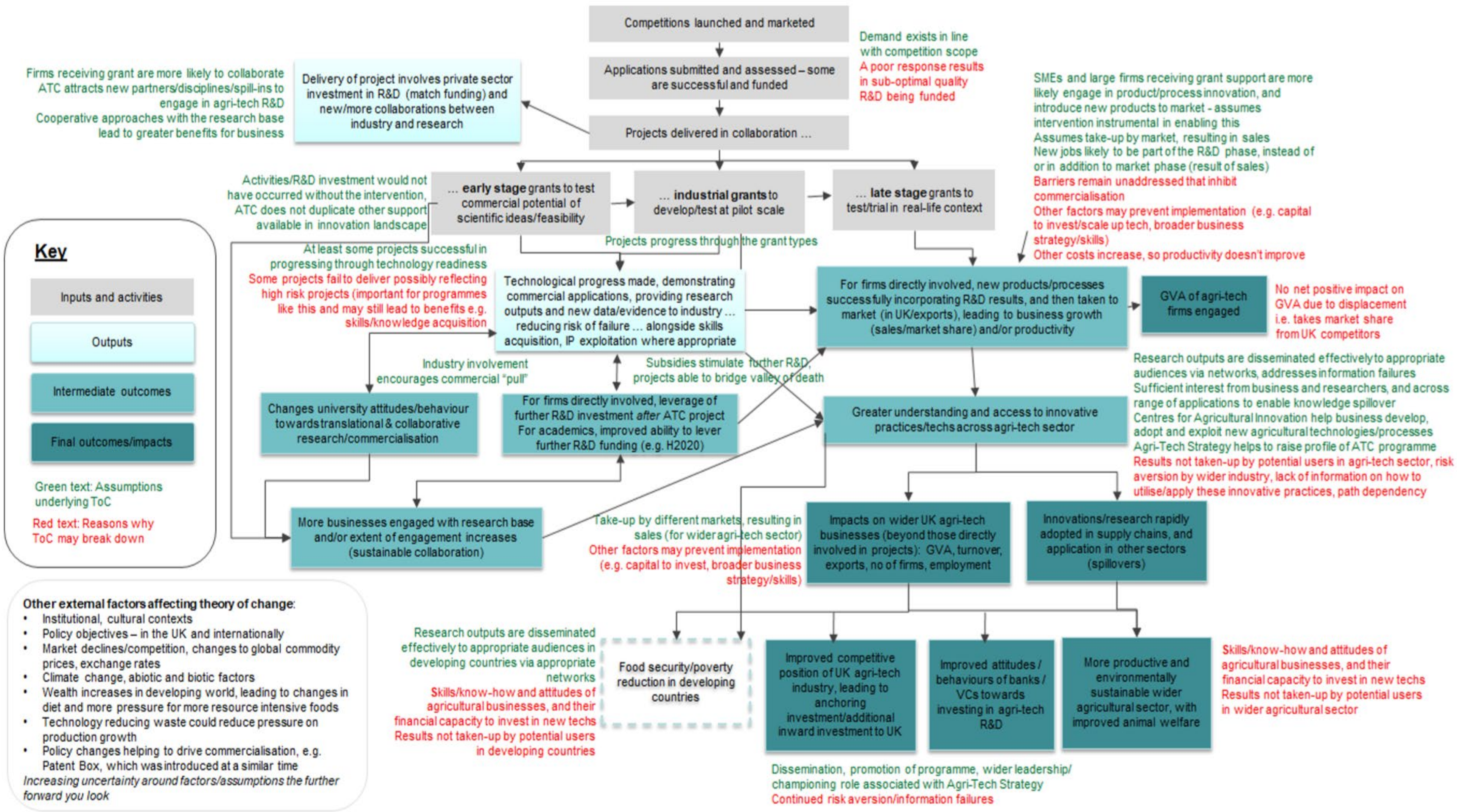
- **GVA** of agri-tech firms engaged
- Increased **GVA, turnover, no of firms, employment** in UK agri-tech sector, and increased exports (incl. to developing countries)
- Improve **competitive position of UK** agri-tech, leading to anchoring investment/additional **inward investment** (the UK becomes the 'go to' destination for international agri-tech investment)
- Improved attitudes/behaviours of banks/VCs towards investing in agri-tech R&D
- Innovations/research rapidly adopted in **supply chains,** and application in other sectors (spillovers)
- **Productivity gains** in agriculture sector UK: total factor productivity, labour productivity, yields
- Improved animal welfare and more **environmentally sustainable** agriculture in UK, e.g. energy use, GHG emissions, nitrogen inputs, nutrient balance

Timescales: Delivery (Inputs/Activities): 2014-17 | Outputs: 2015-2020 | Outcomes/impacts: 2016-2025

Figure 3-1: Programme-level logic model

Source: SQW

Figure 3-3: Theory of Change, assumptions and risks



Source: SQW

4. An overview of the project portfolio, rationale and engagement

4.1 This section provides an overview of the ATC project portfolio, and the evidence on the rationale for engagement with the programme and the characteristics of those applying for support.

Key messages

• Demand for the Catalyst was strong and the quality of applications was high.

• 103 projects were awarded ATC funding (excluding DFID funded projects), of which 37 were early stage projects, 54 were industrial stage, and 12 were late stage.

• These projects were allocated c. £51m of BEIS/Innovate UK and BBSRC funding.

• They involved 83 organisations leading one or more projects, and 229 organisations acting as collaborators

• At the time of the evaluation, the majority of early and late stage projects were either closed or at final claim

• The large majority of applicants to ATC were already active in collaborative R&D before they engaged with the programme, predominantly through the use of internal funds or UK-based public funds. However, ATC has been successful in attracting new organisations to public sector R&D programmes, particularly in a collaborative capacity.

• The evidence supports the original rationale for the programme set out in the Theory of Change, with applications driven by uncertainty and risk associated with the R&D activity, a lack of finance to fund the activity, and limited alternatives in the innovation support landscape at the time. The ATC, alongside other "feeder" programmes, also played an important role for early stage leads in stimulating R&D ideas.

• For collaborators surveyed, making new partnerships was the most common reason cited for involvement in their ATC project, followed by developing sector experience and understanding.

• The Catalyst has encouraged spill-in of non-agricultural disciplines and companies who are new to agri-tech, and enabled new collaborations to form.

Programme portfolio

Applications and projects funded

4.2 **Demand for the Catalyst was strong, and the number of applications increased** for all types of award as the programme progressed[43]. In total, 396 applications were submitted in the first five rounds of ATC competition[44], of which 55% were for early stage, 37% for industrial stage and 8% for late stage projects. **The quality of applications was also high**, reflected by the high proportion of applications scoring 70 or more[45]. Competitions were significantly oversubscribed, and demand from high quality applications exceeded the funds available for the programme (only a third of applications scoring 70+ were funded). Stakeholders consulted agreed that as a result, the Catalyst has funded very high-quality proposals. This supports assumptions made in the original Theory of Change around demand and the quality of applications, and (in theory) sets the programme up with a strong foundation for realising the delivery of the outcomes and impacts anticipated in the logic model (tested in Sections 5 and 6 of this report).

4.3 In total, **103 projects were awarded ATC funding** (excluding DFID funded projects), of which 36% were early stage projects, just over a half (52%) were industrial stage, and 12% were late stage (see Table 4-1). At the time of the evaluation, the **majority of early and late stage projects were either closed or at final claim** (51% of the early stage projects had closed and a further 22% were at final claim stage, and 83% of late stage projects were closed). The evaluation could therefore realistically expect (at least) intermediate outcomes to be evident for many projects at the time of the fieldwork.

Table 4-1: Number of projects by round and type of grant

Round	Early	Industrial	Late	Total
One	8	14	2	24
Two	9.	13	1	23
Three	9	9	4	22
Four	4	8	3	15
Five	7	10	2	19
Total	37	54	12	103

Source: IUK Monitoring Data

[43] The absolute number of applications for late stage awards was lower, which may reflect the lower intervention rate for this type of award (and therefore grant value compared to the resources that businesses would need to invest in the application process).
[44] This excludes applications for DFID funding.
[45] i.e. were deemed 'fundable' by Innovate UK's assessors.

Expenditure

4.4 **The total funding allocated to the 103 projects[46] by Innovate UK/BEIS in the first five rounds was £28.3m**, of which £5.8m was for early stage, £20.9m for industrial stage, and £1.6m for late stage projects. On average, early stage projects were larger than late stage projects, but the latter had a slightly wider range of grants made available, for example[47]: early stage awards were £144k on average (median), and ranged from £48k to £308k; and late stage awards were £87k, but ranged from £33k to £343k.

4.5 The programme has also **secured £35.8m in private sector match funding**, which is nearly 20% higher than the expectation of £30m[48][49]. However, it should be noted that this is principally owing to the level of match funding associated with the industrial research awards, which are not the subject of this phase of the evaluation. Of the £35.8m of matched funding, £7.4m was accounted for by early (£4.4m) and late stage (£3m) projects.

4.6 **Of the £28.3m Innovate UK monies allocated, 68% had been spent by February 2018 across the programme as a whole**. Reflecting the short duration of early and late stage projects, and the high proportion that were complete at the time of the evaluation, these projects had spent a greater share of their budget (86% of budget spent for early stage projects, and 94% for late stage projects), as shown below.

Table 4-2: ATC funding awarded by Innovate UK/BEIS

	Early	Industrial	Late	Grand Total
IUK grants offered (£m)	5.8	20.9	1.6	28.3
Actual Spend to Date (£m)	5.0	12.7	1.5	19.2
Proportion spent to date (%)	86%	60%	94%	68%
Private sector match (£m)	4.4	28.4	3.0	35.8

Source: IUK monitoring data

4.7 **In addition, BBSRC in total contributed £22.7m towards the ATC programme**, which funded academic partner inputs. Of this, 17% was allocated to early stage projects and 83% to industrial stage projects (to note, BBSRC did not fund any late stage projects). As of April 2018, **BBSRC had spent approximately £18.5m, around 82% of its total budget.**

[46] The 103 projects exclude projects that also received DFID funding. Since there are projects which received both IUK and DFID funding, actual IUK expenditure will be greater than £28.3m.
[47] The numbers exclude BBSRC funding – total grants awarded to each project will be higher. Project reference numbers in the BBSRC funding dataset did not match IUK data, to allow for disaggregation of total grants for each project.
[48] Private sector match is calculated by subtracting Innovate UK award from total cost. Actual private sector spend is not monitored in real time.
[49] Late stage projects achieved a relatively high level of match funding, which was a function of the lower intervention rate for late stage projects (reflecting the lower level of risk associated with technologies that were closer to market).

Table 4-3: Total spend by BBSRC

	Early	Industrial	Grand Total
Total number of grants awarded	32	54	88
Number of projects supported	28	44	72
Total amount awarded	£3,928,565	£18,758,212	£22,686,776
Total amount paid to date	£3,708,939	£14,824,363	£18,533,303
% spent to date	94%	79%	82%

Source: BBSRC spend data

Organisations involved

4.8 The 103 projects (non-DFID funded) ATC projects involved:

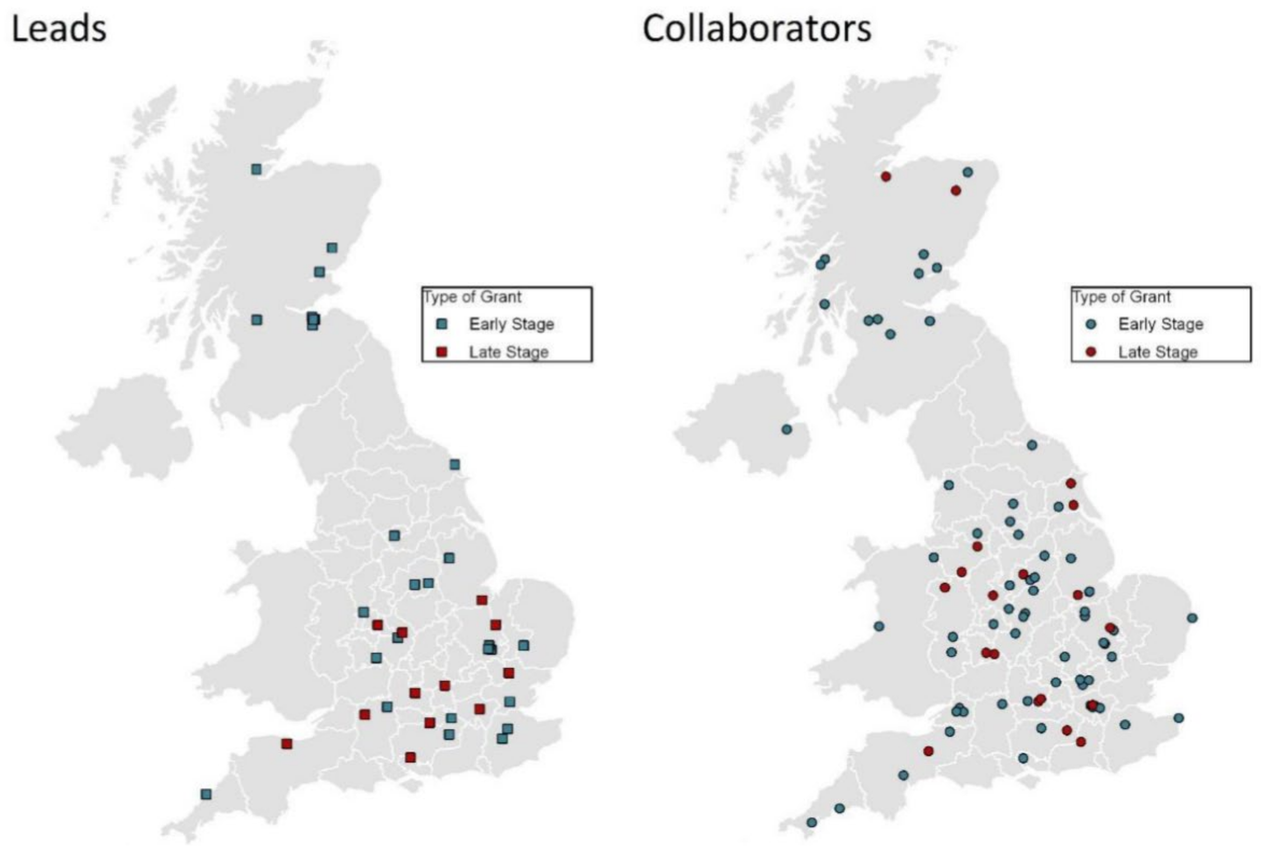
- **83 organisations leading projects**, of whom 15 were leading more than one project and 14 were also acting as collaborators on other projects. Around two thirds of leads of early stage projects were businesses (notably, nearly half of all leads, 46%, were micro or small businesses, reflecting the composition of the sector[50]) and the remainder were academic leads. All late stage projects were led by businesses (again, a high proportion – 58% of the total – were micro businesses, but late stage projects also attracted a higher proportion of medium and large firms[51]).
- **229 organisations acting as collaborators on projects**, of whom 44 collaborated on more than one project. As with the leads, just over two thirds of early stage collaborators were businesses and the remainder (31%) were academics, and none of the collaborators on late stage projects were academics.

4.9 The spatial distribution of project leads and collaborators for the early stage and large stage awards covered by this phase of the evaluation is set out in Figure 4-1. Three points are noted:

- beneficiaries are found in all regions across the UK, although the number of participants in Northern Ireland, Wales, and the North East is (relatively) low (in part reflecting the lower number of applications in these areas)
- there are particular concentrations of leads in Scotland, the East Midlands, east of England and South East; this reflects the spatial focus of much of the UK's agricultural sector, and where key research centres and assets are located.

[50] 30% micro-businesses, 16% small businesses and 14% large businesses
[51] 33% small, 25% micro, 17% medium sized, and 25% large

Figure 4-1: Geographical spread of ATC leads and collaborators



Source: IUK monitoring data. Note, UKRI assumes the postcodes provided are for the office of the participating organisation

Pre-programme R&D behaviours

4.10 The surveys of beneficiaries and unsuccessful applicants suggest **that the large majority of applicants to ATC were already active in collaborative R&D before they engaged with the programme**, predominantly through the use of internal funds or UK-based public funds. This was true for both beneficiaries and unsuccessful applicants surveyed. For example:

- 98% of beneficiaries and all unsuccessful applicants surveyed had engaged in some kind of R&D in the three years before their ATC application: around 90% of beneficiaries and unsuccessful applicants (with no significant variation) had engaged in internal R&D, and 70-80% had undertaken training for innovative activities (again, no significant variation between beneficiaries and unsuccessful applicants). Given that the ATC was a competitive funding stream, it might be expected to attract businesses that consider themselves to have a strong enough R&D capability to be competitive. The pattern was similar for leads/collaborators and early/late stage beneficiaries, and for both academic and industry participants. However, unsuccessful applicants are more likely to have invested in the market introduction of new innovations and machinery/equipment in the three years before their ATC application compared to successful applicants[52]. This may reflect the age and maturity of organisations involved – the baseline data suggests the unsuccessful applicants were slightly younger, and therefore we may reasonably expect these businesses to have purchased machinery more recently as part of business set-up.

- The most common source of funding for these R&D activities was the businesses' own funds (nearing 80% for beneficiaries and unsuccessful applicants, with no statistically significant difference between the groups), followed by UK public sector grant (around 40% for beneficiaries and unsuccessful applicants, with no significant difference), with a large proportion of these involved with Innovate UK programmes in the past. Customer or collaborator funding, European grants and Research Council funding were also evident for both beneficiaries and unsuccessful applicants. The proportion of respondents who had previously used loans and overdrafts or external equity finance to fund R&D was low for both beneficiaries and unsuccessful applicants – this is not unexpected and reflects the challenges associated with raising loan or equity finance for R&D activity across sectors and disciplines, given the level of risk and uncertainty to the funder/investor at this stage.
- Nearly all of those surveyed had undertaken this R&D collaboratively (95% of beneficiaries and 100% of unsuccessful applicants, with no significant difference). The most commonly-cited partners were universities or customers/clients from the private sector (for both beneficiaries and unsuccessful applicants). Also, at least half of respondents had collaborated with competitors, consultants, public or private R&D institutes, or suppliers. This significant experience in collaborative R&D amongst programme participants can be expected to de-risk significantly ATC project delivery and projects have been led by, and involve as partners, organisations with a track-record and experience in similar activities.

4.11 The leads of funded projects were more likely to have secured public funding for R&D activity in the three years prior to their ATC application than collaborators. This does suggest that **ATC has been successful in attracting some new organisations to engage in public sector R&D programmes, in a collaborative capacity**. The survey found 60% of project leads had used public sector R&D grants in the last three years, compared to 25% of collaborators (a highly significant difference at 1% level). This goes some way to allaying concerns from stakeholders that the programme may have provided funding to the 'usual suspects', at least in the case of collaborators. Prior experience of public funding was more prevalent for early stage beneficiaries compared to late stage across all types of collaboration (but the differences are not statistically significant).

Rationale for engaging in ATC

4.12 There is strong alignment between the reasons that organisations gave for why applied for ATC in the evaluation, and the original rationale of the programme set out in the Theory of Change. The reasons primarily centred around **uncertainty and risk**

[52] 79% of unsuccessful applicants had engaged in the acquisition of advanced machinery, equipment and software for innovation in the three years before they applied for a ATC grant, compared to 56% of beneficiaries (statistically significant at the 5% level). Also, 72% of unsuccessful applicants had been involved in the market introduction of innovations, compared to 46% of beneficiaries (again, statistically significant at the 5% level).

associated with the R&D activity, a lack of finance to fund the activity, and limited alternatives in the innovation support landscape at the time[53]. The ATC also played an important role for early stage leads in stimulating R&D ideas to address the challenges set out in the competition specification. For collaborators in particular, engagement in ATC stimulated collaboration, and enabled them to develop agri-tech experience and understanding. The evidence supporting these findings is presented below:

- For project leads surveyed, 85% cited **uncertainty in relation to the outcome and/or commercial return from the project** (including where others may benefit from the project i.e. an externality argument) and 80% cited **lack of internal finance** (100% of late stage projects) as challenges they were facing that prevented them from taking forward the project in advance of applying for (and therefore without) a Catalyst award. Also, 60% of beneficiaries felt that the **R&D costs were too high relative to other uses of finance within the organisation**, indicating that the relative costs of the project was a common issue for beneficiaries in advance of ATC support.
  - For unsuccessful applicants, the picture was slightly different: the most common reason cited by unsuccessful applicants was a lack of internal finance (66%), followed by an inability to secure external finance (62%)[54]. Uncertainty of outcomes was cited as a factor by 41% of unsuccessful lead applicants; despite the modest sample sizes (of 20 and 29 respectively), the difference in the proportions of respondents identifying this as a reason why the project could not progress without ATC support (85% for beneficiary leads, and 41% for unsuccessful lead applicants) is statistically significant (at 10% level)[55]. The explanation for this is not clear; successful applicants may have been more aware of the wider challenges faced in the implementation of R&D projects.
- Half of the beneficiary leads stated that the **availability of Catalyst funding stimulated the project idea**, this level was consistent with unsuccessful applicant leads. As may be expected, this catalytic effect of the programme in stimulating new ideas was particularly prevalent for early stage leads; of the 15 early stage leads surveyed, nine (60%) indicated that the availability of Catalyst funding stimulated development of project idea. The case studies also supported the survey findings (see example box below).
- A number of stakeholders consulted for the evaluation also commended ATC for supporting some **very risky/innovative projects**, again suggesting that the projects funded were well-aligned with the original rationale. In this context, some consultees noted this may have implications for the scale/distribution of impact, as some projects are likely to be very successful and others will inevitably fail (tested further in Section 5).
- Half of the leads surveyed had **considered alternative sources** of funding when applying for ATC (with a similar pattern for early and late stage projects), which

[53] Both SME and large companies surveyed reported uncertainty and lack of internal finance as reasons for seeking ATC funding. A higher proposition of large companies surveyed (75%) reported being unable to secure external finance compared to SMEs (50%); the pattern was similar for “R&D costs too high relative to other uses for finance”.
[54] Within the scope of the work we were not able to probe this in detail, but this is consistent with the challenges in securing finance in terms of loans/equity for early stage R&D activity discussed above.
[55] Z-test.

focused on businesses' own funds, public sector grants or customer/collaborator funding – some of the late stage leads had also considered bank loans or overdrafts but few of either award type had considered external equity funding. The main reasons for not using these alternative sources align closely with issues set out in the rationale – the focus on product development not appropriate for Research Council funding (basic science) and too risky and expensive to secure internal or external funding from elsewhere. ATC enabled some to share the risk with commercial partners in the consortium. The remaining half of leads were not aware of other funding or did not know how to apply for it.

- **For collaborators surveyed, making new partnerships (89%) and developing sector experience/understanding (81%) were the most common reason for involvement**, followed by accessing external knowledge and identifying new market opportunities (both 73%).

Case study example: Lobster Grower 1: The project lead had been involved in two 'feeder' projects: the first, a Coastal Communities Fund project, helped to develop IP relating to the container; and a second, a small TSB Innovation Voucher[56] project supported an initial redesign of existing oyster containers, to enable their use with lobsters. Following the completion of the latter, the (then) TSB signposted the National Lobster Hatchery to the ATC programme as a potential source of follow-on funding to progress the innovation project.

Case study example: Evaluating a potential proxy test for Feed Conversion Efficiency in beef cattle: prior to the early stage ATC grant, the project lead had received a £1.5m grant from Defra to develop testing infrastructure for the process in question. This study identified the need for a proxy that could be sampled and measured on-farm – the use of hair/blood sampling then became the focus of the ATC project.

4.13 **The findings above raise some questions around the validity of the underpinning rationale on lack of finance**, especially given that most applicants were active in R&D before ATC, and many had a track-record of investing their own finance in R&D activity pre-ATC. The evidence suggests that for some of the larger firms in particular, the issue may be more one of internal resource allocation, rather than the ability to access external funding. That said, there are multiple issues at play in terms of access to finance in the agri-tech sector. The picture is complicated and varies across different types of participant, sub-sector and stage of R&D. On the supply side, stakeholders commented on the limited supply of private equity/investment funds specifically for agri-tech (at least, until very recently) reflecting the relatively immature nature of agri-tech as a sector, and the challenges faced by agri-tech innovators in securing public funding in very widely defined competitions (such as health and life sciences). On the demand side, the lack of awareness of private investor opportunities/requirements amongst businesses remains an issue (discussed in more detail below). These issues will be explored in more detail in Phase 2 of the evaluation.

4.14 Overall, **the evaluation at this stage suggests that the case for the rationale remains sound in terms of addressing risk/uncertainty of outcomes from R&D and collaboration failures, at a programme level (that is, for early stage and late stage projects). However, the findings are less conclusive – and more variable,**

[56] The Technology Strategy Board Innovation Voucher programme was designed to encourage businesses to work with external bodies to develop innovative ideas.

depending on a businesses' track record and scale – in terms of lack of finance. The evidence demonstrates how (i) the Catalyst stimulated the project idea for half of project leads, suggesting the idea was inherently new and risky, with a legitimate case that this is likely to limit funding with internal resource (particularly relative to other uses of this finance) – put simply, the grant de-risks the project, (ii) a large proportion of leads (42%[57]) were working with some/all new collaborators (as discussed in more detail below), again enhancing the level of risk associated with the project, and (iii) the programme enabled risk to be shared, and without being able to do this, in many cases the projects would not have been taken forward. We return to this issue in Section 7 when we consider 'activity additionality' (i.e. whether project activity would have been taken forward without ATC).

Feeder schemes

4.15 **'Feeder' schemes were also important in generating ideas for early stage projects** (in addition to ATC itself) for beneficiaries and unsuccessful applicants. Over one third (35%[58]) of lead beneficiaries surveyed – all of whom were early stage projects – had received other public funding that led to the ATC application. This included other Innovate UK programmes (e.g. Collaborative R&D and Smart), BBSRC funding, and European programmes (e.g. H2020). The case studies also demonstrate how beneficiaries used feeder projects to inform their ATC ideas (see box above), and almost half of unsuccessful applicants surveyed have benefited from 'feeder' programmes (again, these included Smart, BBSRC, H2020).

4.16 On the whole, stakeholders consulted for the evaluation corroborated the evidence above. Many felt the Catalyst **aligned well with the wider agri-tech innovation landscape**. With its focus on the translation of research, it filled a "huge gap" between academic and private research in the agri-tech sector, and it complemented and built upon support available through BBSRC and the Sustainable Agriculture and Food Innovation Platform (SAF-IP, which helped to stimulate demand for the Catalyst).

Encouraging spill-ins and new collaborations

4.17 **The Catalyst has encouraged spill-in of non-agricultural disciplines and companies who are new to agri-tech**. From the baseline application data, we can see that just over half (54%) of leads providing sectoral codes[59] were in agricultural sectors (such as crop production, livestock and plant propagation, or the manufacture of agricultural and forestry machinery or agrochemical products). This is to be expected and demonstrates that the programme has supported innovation activity for existing sector actors, which is important given the founding rationale and objectives of the programme.

4.18 However, a large proportion (46%) were in non-agricultural sectors such as computer programming, defence and engineering. A very similar pattern is also evident from the

[57] 8 out of 19 leads responding to the question
[58] 7 out of 20 leads responding to the question
[59] 28 of the 49 early and late stage projects provided Standard Industrial Classification (SIC) codes as part of their application.

survey with collaborators, where just over half of those providing details on their sector[60] were operating in typically agriculture-related activities, and the remainder were in a diverse range of sectors, including unmanned ground vehicle design and manufacture, refrigeration, the manufacturing of chemicals/public health products/vitamins, heat exchange systems, specialist light sources, and connectivity services related to the internet of things. As noted in the earlier section, the survey also found that the need for greater agri-tech experience and understanding prompted many collaborators to apply for ATC funding.

4.19 Some care is needed in interpretation based on SIC code data as firms that may appear to be in non-agri-tech sectors may in fact be operating in this space, whilst reporting a SIC code that covers their wider business activity. However, as illustrated in the box below, the case study evidence shows how the ATC has encouraged – and in some cases accelerated – entry into agritech for both leads and collaborators for organisations that were explicitly not previously involved in the sector. The mycoprotein case study also demonstrates how ATC has encouraged a **producer who already operates in the agricultural sector to engage in R&D for the first time.**

Case study example: CAPSEED A New Seed Conditioning Process for Arable and Horticultural Crops: The project lead had 20 years' experience of developing controlled atmospheric plasma for the utilities and health and beauty sectors, but had not previously worked in the agri-tech sector. Whilst exploring new opportunities to apply their technology, they identified a research organisation as a potential collaborator, who in turn connected the lead with two major agricultural end-users (who had engaged with the research organisation previously in collaborative R&D), who joined the consortium, and the ATC as a source of funding. For all of those involved, working with known partners helped to reduce risk and leverage existing learning and knowledge sharing.

Case study example: Lobster Grower 1: ATC encouraged spill-ins of nonagricultural technologies/expertise into aquaculture for the first time through collaboration on the project. For example, Falmouth University's engineering design team had not worked in aquaculture before – whilst food security was becoming more prominent on the University's agenda, taking part in ATC accelerated their involvement in the sector (probably by five-to-six years). For the University of Exeter, applying offshore renewable energy expertise to aquaculture was a new area of research, and ATC enabled the University to undertake R&D in this field on a much larger scale.

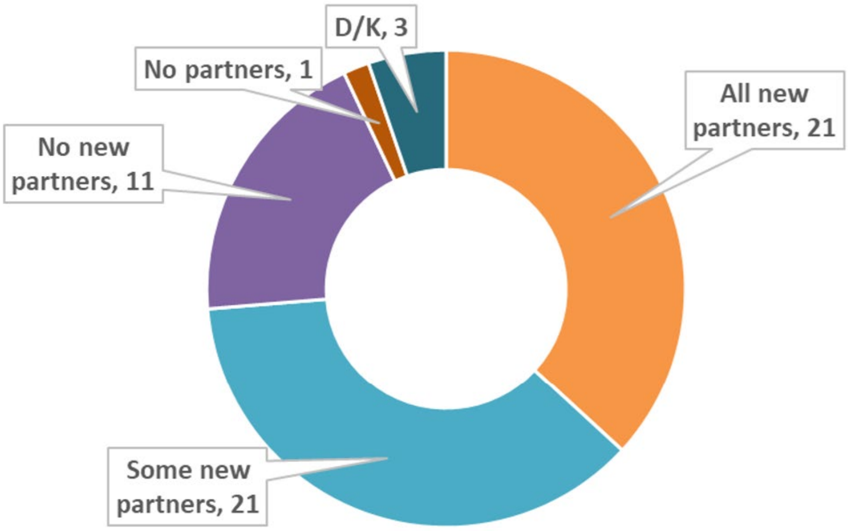
Case study example: Mycoprotein substrate utilisation and nutrition. The lead organisation (a research organisation) managed to secure the engagement of an industrial food producer who was a world-leader in mycoprotein production, but now had not engaged in R&D for over 20 years and had not work

4.20 Of the 13 academic respondents to the beneficiary survey, nearly all indicated they focused on 'core' agri-tech disciplines, including crop and environmental science, aquaculture, and genetics. Few specialised in non-agricultural disciplines (examples included computer science informatics). This is not unsurprising, with academic partners often playing a key role in undertaking the lab-based research activity as part of ATC projects, where the focus is likely to be on 'core' agri-tech issues.

[60] 29 out of 37 collaborators, 78%

4.21 **The programme has also stimulated new collaborations, where some or all of the partners had not worked together previously.** According to the beneficiary survey, over a third (38%[61]) of respondents had not worked with any of their ATC partners before, and this was up to half of late stage beneficiaries. Furthermore, three-quarters (74%[62]) of beneficiaries surveyed had worked with at least one new partner through the ATC project (see Figure 4-2). When considering leads only, beneficiaries were slightly more likely to not have worked with any of their ATC partners before (42%[63]), compared to unsuccessful applicant leads (24%[64]) but the difference is not statistically significant, potentially due to sample size.

Figure 4-2: For beneficiaries (n=57), Catalyst project activity involved working with …



Source: SQW. Note: number of responses in brackets. D/K = don't know

4.22 The case study evidence suggests that **new collaborations are often formed via bilateral and personal relationships, rather than formal mechanisms.** Where this is the case, consultees commented that it often helps smooth project delivery, especially where collaborator expertise and capacities are already known – but it raises the question around whether opportunities for other collaborations and technology convergence are missed because partners are not already known to each other. In SQW's process evaluation of the Catalyst, the evidence suggested that the Knowledge Transfer Partnership (KTN) played a role in consortia building, and there was some (limited) evidence from stakeholders to suggest that local networks (for example in the East of England) had played a role in enabling collaborations to come together. Elsewhere, teams have been set up specifically to do this, such as the Lincoln Institute for AgriFood Technology, which creates networks of expertise between the University of Lincoln's academic teams and potential end users in industry. However, none of these local or national networking mechanisms featured in any of the case studies undertaken for this evaluation.

4.23 The case studies also highlighted the different ways in which collaboration can be developed. For example, in one case, the project lead pro-actively sought to identify and target a collaborator with a specific commercial opportunity that was core to the project

[61] 21 out of 57 beneficiaries
[62] 42 out of 57 beneficiaries
[63] 8 out of 19 leads responding to the question
[64] 7 out of 29

focus (e.g Mycoprotein case study). By contrast, in a second case, the project lead had identified the commercial opportunity, and then undertook a search to seek to identify a relevant collaborator in the sector that could be a source of both information and wider contacts to enable the delivery of the proposed idea (e.g. the CAPSEED case study). In both cases (and more broadly across the case study evidence), the ATC funding provided the financial mechanism and incentive to make this approach attractive to the planned collaborator.

4.24 In this context, it is also important to recognise the potential benefits – both in terms of de-risking project activity, and in embedding and deepening relationships – in ATC projects supporting the continuation of existing collaborations, either in full or part. The case studies provided a number of examples where the ATC project had helped both to develop further existing bilateral relationships and to bring some new partners together to deliver collaborative R&D activity, providing a mix of new and existing relationships.

4.25 In summary, **the evidence above suggests ATC has been successful in attracting new actors to the agri-tech sector and stimulating new collaborations.** The programme's role in **enabling technologies to converge** is particularly encouraging, creating opportunities for new and interesting technologies, products and services to be developed in the context of agriculture. Whilst the potential for innovation is substantial where technologies (and partners) come together in new and different ways, this is inherently risky, both in terms of project delivery (where partner capabilities are somewhat unknown and may not deliver as expected, or it takes longer for partners to operate efficiently together) and technological success – in Sections 5 and 6, we discuss whether this has affected progress and outcomes achieved so far.

5. Activities and technology progress in projects

5.1 This section sets out the evidence on the activities undertaken (via ATC and since), and technological progress made so far, drawing on findings from the surveys, consultations and case studies.

Key messages

• The activities of the Catalyst have been implemented as set out in the Theory of Change, as evidenced by the close fit between the activities delivered and the intentions of early and late stage awards, including by TRL level before ATC support.

• In delivering the projects, partners have collaborated in different ways (from genuinely collaborative working, through to more sub-contractual relationships). The R&D process has been non-linear in many cases – some activities have varied from their initial plans and others very iterative in nature.

• ATC projects have integrated with wider innovation support landscape during the delivery, including (to a limited extent) the Agri-Tech Innovation Centres, although looking forward closer partnership working with DIT would be helpful to strengthen the pathway to export impacts.

• There has been limited progression through the ATC grant types, mainly because of the limited lifespan of the programme. In the one instance this has occurred, the seamless transition has enabled more effective delivery of the R&D process as a whole; there is some concern for projects who have not been able to progress (and unable to secure funding from elsewhere) and the potential impact of the programme in the longer term (explored in Section 6).

• Dissemination has taken place at both a project and programme level, although the former appears to be focused on very niche sub-sectors, and there is limited awareness of the latter amongst external stakeholders. Projects' concerns around IP protection and risk aversion have been a barrier, but ultimately effective dissemination is a critical factor in enabling wider impacts of the programme. There also appears to be a missed opportunity in terms of synergies between projects, where there may be potential for greater impacts on aggregate across the programme as a whole.

• The ATC has performed well in terms of encouraging technology progression, and enabling this to be realised more quickly that might otherwise have been the case without ATC support.

Activities delivered, including dissemination

Nature of project activity

5.2 A key question in the theory-based approach to the evaluation is whether the activities of the Catalyst have been implemented as set out in the Theory of Change. We can see from the data in Section 4 that the programme has funded early, industrial and late stage projects as planned. The question that follows is whether the projects funded are undertaking activities aligned with the scope of their award. Drawing primarily on survey evidence, the evaluation indicates that there is a **close fit between the activities delivered and the intentions of early and late stage awards.** For example, according to the beneficiary survey results:

- early stage projects have focused on early stage prototyping (13 of the 15 early stage leads surveyed), assessment of business opportunities or commercial potential (11), and the application of research in agri-food production (10)
- late stage projects have undertaken demonstration work to validate the technology's application (four of the five late stage leads surveyed), reviewed the commercial value of application in agri-food production (four of the five), developed commercially usable prototypes (all five), or developed new and/or improved services and processes (three and four respectively).

5.3 Project leads were also asked to identify the Technology Readiness Level (TRL) of their idea/innovation before the start of the ATC project. 16 of the 20 project leads provided a response on the TRL level, and the data suggests that the stage of supported projects was broadly consistent with the expectation that early stage grants will support projects at TRLs 1-4, and late stage projects would support project up to TRL 9.

Table 5-1: TRL before the start of the ATC project (✓ = single project)

	Early Stage (n=13)	Late Stage (n=3)
TRL 1: Basic principles observed and reported	✓✓✓✓✓✓✓	
TRL 2: Technology concept and/or application formulated	✓✓✓	
TRL 3: Proof of concept	✓✓	✓*
TRL 4: Basic technological components integrated to establish that they will work together	✓	
TRL 5: Testing technology in a simulated environment		
TRL 6: Testing prototype in a simulated operational environment		✓
TRL 7: Prototype demonstration in an operational environment		
TRL 8: Technology proven to work under expected conditions, further developmental testing/evaluation		✓
TRL 9: Technology proven		

Source: SQW. *As noted in Section 3, early stage projects focused on activities up to TRL 4, and late stage projects focused on up to TRL 9. One of the late stage survey respondents in the table above thought their project was at TRL 3 when it began – this may have been misclassification, but may also have been permitted within the late stage competition if the project's goal was to reach late stage TRLs.

5.4 It is notable that the **early stage projects were particularly concentrated at TRL 1 and TRL 2** (10 of the 13 that provided data), suggesting that ATC is supporting new ideas very early on in their development, at the stage where scientific research first begins to be translated into applied R&D, or where invention begins, and practical application start to be developed. This in part reflects academic leadership of early stage project (5 of the 20 were led by academics, with four of the five indicating TRL 1 or 2 before the ATC project). However, this has potential implications for the time-paths to commercialisation and impacts, with projects starting 'earlier' on the TRL scale most likely to require longer to reach this point; this context needs to be taken into account at this interim evaluation stage.

5.5 For late stage projects, there appears to be some inconsistency with the intended focus of late stage projects, with one at TRL 3 at the outset of the ATC project. However, this may in part be owing to the challenges in accurately identifying TRL stages particularly as ideas move into the applied R&D and implementation stages given the iterative nature of innovation and product/process development. The progress made by projects through the ATC activity – and subsequently – is discussed in more detail in Section 5.

Project roles

5.6 According to the survey, the role of the collaborator across the projects has tended to focus on providing technical expertise and knowledge (81%[65] of collaborators surveyed), analysis or evaluation (68%[66]) or testing in an operational environment (59%, and up to 66% for early stage collaborators compared to 38% for late stage collaborators[67]).

5.7 The case study evidence corroborates these findings and provides further details on the nature of activities delivered and the different ways in which partners work together (from genuinely collaborative working, through to more sub-contractual relationships). The case studies illustrate how projects can vary from their initial plan once they begin practical delivery, often for good or unforeseen reasons, and the implications for progress. They also demonstrate how projects are often iterative in nature, both in terms of refining the technology in question and how progress in one area raises new research questions that need to be addressed to ensure the wider 'supporting ecosystem' for a new technology is in place. Four examples are presented in some detail below.

Case study example: Harnessing Natural Fungi to Control Insect and Mite Pests in Grain Storage. The project is partly motivated by changes in legislation that have led to a decline in pesticides available to protect stored food. A business led this late stage project in collaboration with a pest controller and two research institutions. The project built on substantial previous research, including from work carried out by members of the collaboration, initially stemming from a 2003 project involving the two research organisations, as well as further follow-on work (including three of the partners involved in this ATC project). The project was technically successful, building on the complementary expertise and effective working of the collaboration.

Case study example: Maximising mycoprotein substrate utilisation and nutrition. This early stage feasibility study aimed to test the potential for the development of new and enhanced ways of producing mycoprotein from new sources of sugar, and thereby provide a substitute for meat-derived protein and alleviate global challenges linked to the

[65] 30 out of 37
[66] 25 out of 37
[67] 15 out of 37 for all collaborators, and 13 out of 29 for early stage collaborators compared to 2 out of 8 for late stage collaborators

meat industry, including land use pressures and CO2 production. East Malling Research (now NIAB-EMR) initiated the project and managed the overall delivery. Marlow Foods – the only producer of mycoprotein for human consumption globally – were the collaborator. Overall the project progressed smoothly and successfully. However, due to a lack of in-house R&D capabilities, it did take some time for Marlow Foods get up to speed, and also resulted in some changes to planned activities. For example, as Marlow Foods were using their main production facilities to conduct the R&D, as their understanding of this risks and costs involved increased, the testing of a new sugar source at production-scale was instead carried out at lab-scale. Post project completion, this influence the company's commitment to invest in their in-house R&D capabilities. This included the recruitment of an R&D specialist and over £2m of investment in a new pilot testing facility. The project also highlighted wider opportunities beyond the initial scope to test the feasibility of alternative sources of sugar in production. Marlow Foods are now working to identify and test new strains of fungus with improved characteristics. This is being carried out internally, as well as through PhD studentships (one in collaboration with NIAB EMR).

Case study example: CAPSEED A New Seed Conditioning Process for Arable and Horticultural Crops. This early stage feasibility study sought to test the viability of a novel technology for treating seeds to improve their economic and agronomic potential. The project was initiated and led by a contract R&D organisation and experts in the proposed technology, who were completely new to the AT sector. The lead identified and contacted an agri-tech research organisation, who facilitated the development of the collaboration to include two industrial partners, and the industrial collaborators had collaborated extensively previously in other areas. The lead led on the optimisation of the technology, while the partners focussed on testing treatments on a range of seed varieties (including oilseed rape and onion seeds, among others) at lab-scale as well as full-scale field testing. The collaborators worked relatively independently on defined work packages, but in a highly complementary way by building on the distinctive capabilities of each member. The feasibility study concluded by finding that the development of a commercial treatment for seeds would require taking a step back and conducting further fundamental, scientific research. The treatment proved complex and highly unpredictable. Nevertheless, the research did reveal promising avenues for future research, including the identification of anti-fungal and antibacterial benefits to treatment. The lead is currently seeking to progress with new work in this area, with new partners, but also with the project collaborators.

Engagement with the wider innovation landscape

5.8 **There is some evidence of integration with wider innovation support landscape during the delivery of ATC activities.** Eight of the 20 leads surveyed (40%) had received other forms of support to develop the idea during delivery of the ATC project. Support has been provided by other HEIs not already part of the ATC collaboration, consultants, commercial labs or private sector R&D institutes, and Research and Technology Organisations (RTOs).

5.9 The eight leads included both business and academic leads, early stage and late stage projects, led projects involving no collaborators and a mix of both academic and industrial partners, were at different stages of technology development at the project outset (as discussed in more detail below). As such, there is no evidence from the beneficiary survey that any particular project type or model is associated with seeking further external support from the innovation landscape alongside the ATC funding.

5.10 Approaching half of the project leads surveyed indicated that they had received other forms of support to develop the idea during delivery of the ATC project may appear to be relatively high given the diversity of partners already involved as part of the ATC collaboration. However, this may reflect the iterative nature of innovation, which might identify expertise/capabilities that were not expected at the outset that need to be included in the project as it evolves (as per the example above on Lobster Grower 1 with a new sub-contractor). However, this level of engagement with other sources of innovation support during delivery, reinforces the point that a range of factors, including external support, will influence outcomes from Catalyst funding (discussed in Section 7 as part of the detailed contribution analysis).

5.11 There are a small number of examples where projects have **engaged with DIT**, but this is perhaps not as widespread as might be expected given the programme's aim to encourage exports and inward investment. The DIT, in collaboration with Innovate UK, has developed a booklet to showcase ATC projects internationally (for example, this was circulated at a US event by DIT, and the global Artificial Intelligence Investment Summit in London), and the Catalyst projects are reported to have been an important part of DIT's offer to prospective investors (along with AgriTech Innovation Centres) because of the variety of innovations and collaborative network created by the programme. We found one example where a case study had engaged with DIT, as illustrated in the box below.

Case study example: Rubber track undercarriage systems for controlled traffic farming. This late stage project sought to develop new products that would allow the business involved to become a worldwide supplier of rubber track systems. As a result of the project, the company has been able to launch new products into the international market. In doing so, the company had some very small-scale support from DIT to help with overseas development, but other factors played a key role in their ability to export, including the recruitment of an additional sales person. The lead is keen to explore the potential for more support from DIT, as the overseas market is where the greatest potential lies for this product.

5.12 There was some concern amongst stakeholders consulted that ATC had not worked in partnership with the **Centres for Agricultural Innovation** as effectively as originally intended (for example, to assist in sharing research and scaling up implementation), due to both the delays in setting up the Centres and constructing the facilities combined with the short lifespan of the ATC. This was viewed by some as a missed opportunity for synergies under the Agri-Tech Strategy as a whole. The beneficiary survey found that three of the 20 lead respondents had engaged with Agri Innovation Centres as part of their projects – suggesting they have worked in partnership, even if not at the scale intended. One of these was followed up in a case study – evaluating a potential proxy test for Feed Conversion Efficiency in beef cattle – where one of the Agri-Tech Innovation Centres was engaged to test whether the proxies in question could predict the intended outcome, in addition to collecting samples across one of the project partner's network of farms. The level of engagement by industrial stage projects (which have continued to be delivered as the Centres have ramped-up their own activity), will be considered in the next phase of the evaluation.

Progression through grant types

5.13 It was originally envisaged that projects could move through the different grant types within the Catalyst, with the programme acting as a "seamless conveyor/escalator" through the commercialisation process. However, given the short lifetime of the programme, the scope for achieving this was limited – only one project successfully moved through two grants (from an early stage grant in Round 1 to an industrial grant in Round 5). This project was one of the case studies for the evaluation, and feedback from those involved suggested that the smooth transition from early to industrial stage ATC project was a key factor to the success of the project to date.

Case study example: Lobster Grower 1: The smooth and seamless transition from the early to industrial stage ATC projects was key – it enabled the project to maintain momentum and kept most partners on board. There is some concern that the potential gap whilst the project sources late stage funding from elsewhere will result in a loss of staff currently funded by the industrial stage grant and pause technological progress being made.

5.14 Stakeholders consulted for this evaluation were concerned that this limitation of the programme could have inhibited project progression, particularly where projects were unable to secure funding from elsewhere, and ultimately reduced the potential impact of the programme in the longer term – we return to assess this issue on outcomes/impacts to date in Section 6.

Dissemination

5.15 One of the critical assumptions under the ATC Theory of Change was that the learning and results of the ATC projects would be disseminated effectively, both by the projects themselves and Innovate UK (and other funding partners), to ensure that wider knock-on impacts are delivered, such as knowledge spillovers and uptake of new technologies across the wider agritech/agricultural sector.

5.16 There was **widespread frustration amongst stakeholders consulted with the lack of dissemination** from projects themselves and Innovate UK to date, even from stakeholders who are very active in the Agri-Tech R&D space. Strategic consultees argued that, whilst dissemination is required by projects for the full benefits of the programme to be realised, limited dissemination takes place because of IP concerns, an unwillingness to share project-related issues or failures, the timing of projects (it may be less appropriate for early stage projects), and the fact that dissemination take place after Catalyst funding has ended (so there is no incentive, funding to deliver it, or assessment to check it occurs). Consultees did note that this issue is not unique to the Catalyst and is a problem with R&D support programmes more generally.

5.17 The survey evidence suggests that leads and collaborators have undertaken dissemination activities (78% of closed projects surveyed[68]), including both early and late stage projects, but most of this has been “to some extent” or “to a limited extent”. The survey findings are corroborated by the close out reports, where 18 of 20 projects responding to this question stated they planned to disseminate findings, and of these, six had already undertaken some dissemination through conferences, events, academic/trade publications and press releases. The case study evidence illustrates how this has tended to be very niche and targeted towards specific sub-sectors, which means that high-level stakeholders may not be aware. Concerns around IP protection and risk aversion have also been a barrier to dissemination. Project descriptions and academic outputs are available publicly on Gateway to Research, but this requires third

[68] 25 out of 32

parties to actively search for the project online rather than the information being promoted proactively by projects themselves.

5.18 Many of the stakeholders consulted also commented on the lack of dissemination by Innovate UK (or others), and raised the concern that benefits would largely accrue to those directly involved rather than the wider sector as a result. However, they did not appear to be aware of **efforts by DIT and Innovate UK to showcase Catalyst innovations** on a global scale noted above, nor **Innovate UK's work with a new agri-tech venture capitalist (VC) fund manager** to connect 'high-quality' investment propositions arising from ATC with VCs interested in this sector. Consultees involved in these dissemination activities could not point to benefits arising (such as ATC projects securing follow-on investment), but the activities have been undertaken nonetheless. Furthermore, there was no evidence to suggest that Innovate UK had shared learning/findings from ATC projects *within* the programme portfolio.

5.19 Looking forward, effective dissemination will be critical, particularly in the context of driving demand and exports – this is where there is huge scope for impact, but something SMEs typically struggle with. Dissemination as a route to impact is explored in more detail in Sections 6 and 7 below.

Technology progression

5.20 **The ATC has performed well in terms of encouraging technology progression, and enabling this to be realised more quickly than might otherwise have been the case without ATC support.** The beneficiary survey found that 60%[69] of respondents reported that the ATC project had progressed a technology towards market readiness, and this rose to 93%[70] when those that expect to experience this in the future are included. Moreover, the majority of those observing technological progress said it was accelerated "to a significant extent" (79%[71]) and a further 18%[72] "to a limited extent" due to ATC. Two points are noted here:

- First, as we would expect given the time-paths of R&D activity, the balance of progression to market readiness varied between participants of completed and on-going projects. As set out in Table 5-2, with participants in on-going projects more likely to report that they expected this in the future relative to participants in completed projects (with the difference statistically significant at a 5% level).

[69] 34 out of 57
[70] 53 out of 57
[71] 27 out of 34
[72] 6 out of 34

Table 5-2: Survey evidence on progression of technology towards market readiness by project status at the time of the survey

	Completed projects (n=32)	On-going projects (n=25)
Experienced already	69%	48%
Expect to experience in future	22%	48%
Have not and will not experience	9%	4%

Source: SQW

- Second, the 60% of respondents reported that the ATC project had progressed a technology towards market readiness may underplay the level of progress at this stage, as this includes the perspectives of project collaborators who may have a less detailed understanding of the progress of the project as a whole (given they can be focused on a specific element). **When considering project leads only, 16 of the 20 (80%) indicated that the ATC project had progressed a technology towards market readiness at the point of the survey,** and a further three that this was expected in the future (with just one indicating this had not and would not happen). This is a positive finding, indicating that in nearly all cases, those leading ATC early stage and late stage projects believe that the funding has, or will, progress a technology towards market readiness. Notably, all five projects led by academics indicated that progress of technology towards market readiness, demonstrating the role of the ATC programme in supporting academic-led commercialisation of research.

5.21 As part of the survey, project leads were also asked to provide more detail on what Technology Readiness Level (TRL) their project concept/idea was at the time of the ATC application, when the project closed, and at the time of the survey[73]. The results are shown in Figure 5-1, first for early stage project leads (ES 1-12) and then for late stage leads (LS 1-4).

5.22 The key points are:

- For **early stage leads**, six of the 12 responding thought their idea had progressed from the experimental research stage (TRL 1-3) to the applied research stage (TRL 4-7) project during the ATC project – which aligns with the objective of early stage projects - and all but one had proven technologies (TRL 9) at the time of the survey (although this does not necessarily mean that technology had been taken to market). Two of the 12 early stage leads reported they had progressed within the experimental research stage (i.e. TRL 1 to TRL 3, and TRL 2 to TRL 3) between project start and completions, and had since moved on to the applied research stage (TRL 4-7) post-project completion.

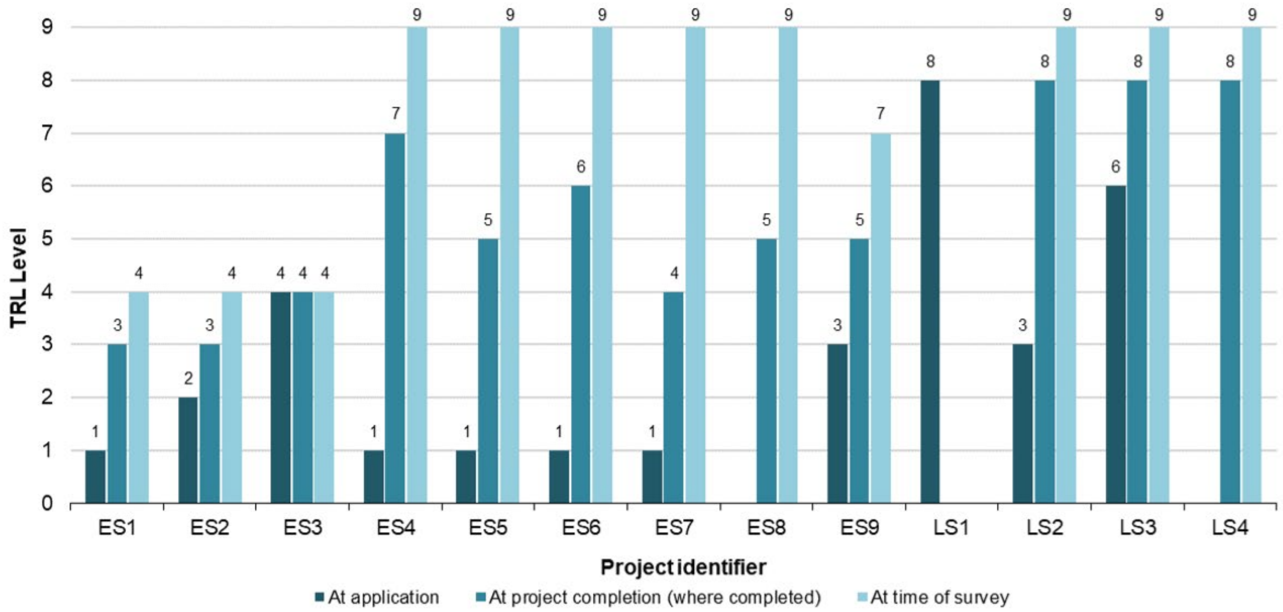
- For the **late stage leads**, a range of starting-point TRLs were identified, but three of the four respondents had progressed to TRL 8 by the time the project close, and all three of these had proven technologies (TRL 9) at the time of the survey.

5.23 For projects that have progressed since the ATC project closed, five (of eight responding to the question**) required additional investment post-ATC to reach the**

[73] Note: descriptions of each stage and level were used to ascertain levels with respondents, rather than TRL numbers.

current position. Sources of funding varied (including combinations of customer or collaborator funding, EU and UK public sector grants[74]), as did the scale of funding required (from up to £100k through to over £1m).

Figure 5-1: Technology Readiness Level (TRL) progress for projects, showing TRL position at application, at project close, and at the time of the survey (n=16 leads)



Source: SQW. ES = early stage; LS = late stage.

5.24 The speed at which many projects claim to have moved through the TRLs is perhaps surprising, particularly for the early stage projects and the limited time since their completion. It appears that several projects have gone further than originally intended during the project and/or made rapid progress after the project ended. However, it is important to note that TRL 9 equates to a "proven technology" that has not necessarily entered the market. This was demonstrated in some of the close-out reports, where routes to market were being 'finalised' or products were 'ready for market' at the time of project closure. A number of factors have enabled this rapid progression (see Section 6) and more widely it demonstrates the strong market pull from the sector, and in many cases as soon as a technology is developed there is keen interest from the sector to test it in practice.

5.25 The positive findings above on technology progression are supported by the case study evidence, where there are examples of **technological progress being made more quickly** that would otherwise have been the case (see box below).

[74] None of the beneficiaries surveyed had used VC funds.

Case study example: Mycoprotein substrate utilisation and nutrition: This early stage project proved the feasibility of using alternative sources of sugar for the production of mycoprotein, advancing the technology in this respect from TRL 3 to approximately TRL 5. It successfully developed a fully sequenced genome to pave the way for future R&D activity, and identified two alternative sources of sugar for further exploration.

Case study example: Lobster Grower 1: Before the project, the idea was at TRL 1 and by the time the project closed it had reached TRL 4 in the form of a prototype for a novel container suitable for the European Lobster. Subsequently – through an industrial award from ATC – the project has progressed to TRL 6, where it is testing the prototype in a simulated operational environment. The lead and all collaborators consulted/surveyed felt that technological progress has been "significantly quicker" than would have been the case without the early stage ATC grant, and the idea would still be at TRL 1 or 2.

5.26 As we explore in Section 7, even though some of the unsuccessful applicants had taken their idea forward without ATC funding, the majority have not been able to progress technologies.

6. Outputs, outcomes and impacts

6.1 This section presents findings on the outputs, outcomes and impacts achieved to date and expected in future for those engaged in the programme, key factors that have enabled or hindered pathways to impact, and comments on performance against project-level objectives. It draws on evidence from the survey with beneficiaries, case studies and consultations with stakeholders. It is important to note that whilst the outcomes and impacts discussed below have been attributed to ATC by those consulted, they are gross results, and do not take into account additionality (i.e. what would have happened without the programme) nor the contribution of other factors that might have influenced performance – these issues are covered in Section 7.

Key messages

• The effects of ATC on behaviour and capacities of participants can be significant, even in cases where the commercial application of the idea is not realised.

• The most common benefits of ATC include improved R&D and commercialisation capacity, profile, credibility and reputation, staff skills and knowledge, and understanding of market position and opportunities. The majority have also developed new and/or strengthened collaborations with industry and academia. There is little difference between the nature and extent of these outcomes between early and late stage projects, nor leads and collaborators.

• There is evidence of new products or services reaching the market already – and to a lesser extent, new processes being introduced – following Catalyst activity.

• Significant follow-on investment in R&D (post-ATC) is often required to bring a new product/service to market. ATC has helped to de-risk projects sufficiently to secure some follow-on public sector investment and/or encourage greater investment in R&D by the participants themselves. However, partners' awareness of and ability to secure private sector finance (at an appropriate stage of the commercialisation process) remains a concern.

• ATC has led to modest impacts on employment and/or turnover of those involved to date, but there are a small number of strongly performing projects (both early and late stage) who have generated substantial levels of revenue, including through exports. Most employment generated so far is associated with R&D activity, but growth in staff has provided businesses with greater capacity to explore new markets and undertake further R&D.

• In addition to the outcomes described above, ATC is leading to sustained changes in the attitudes and behaviours of those involved, which provides evidence to suggest that R&D activity in the sector is likely to continue. For example:

➢ collaborative relationships are sustainable – beneficiaries have continued to work with some or all of their ATC collaborators (or if not, they are more likely to collaborate with other partners in future)

➢ the majority are more likely to invest internal funds in other R&D and more likely to bid for Government funding to support other R&D activity in future

➢ for some organisations, ATC has led to more commercially focused business plans.

• Wider impacts on organisations involved in projects have focused (and are likely to in future) on reducing environmental impacts or improving sustainability, improved yields/productivity (especially collaborators), and produce quality. Similar benefits are expected for the wider agricultural sector in future. Other benefits for those involved include spillover of technologies to non-agri-tech applications, networking benefits and (small-scale) supply chain benefits.

• More broadly, the Catalyst has demonstrated a clear UK commitment to Agri-Tech innovation and generated a "buzz and energy" across the sector – and both are powerful tools in attracting industry investment.

• The majority of projects have fully or partially achieved their objectives, according to partners involved.

Outputs and outcomes observed to date

6.2 The sub-sections below review the evidence on the outputs and outcomes (as described in the logic model) drawing on the evidence from the survey and case-studies. The following outcome-types are discussed in turn:

- innovation behaviours, capacity and performance
- new products, services and processes
- employment and turnover
- follow-on investment
- legacy effects
- wider agricultural sector outcomes.

Innovation behaviours, capacity and performance

6.3 There is **strong evidence that the outputs and outcomes identified in the logic model associated with innovation behaviours, capacity and performance have been realised in practice at this interim evaluation stage**. As shown in Table 6-1, there is widespread evidence of positive effects on beneficiaries in terms of:

- **R&D and commercialisation capacity**, with 84%[75] of those surveyed observing this already. This included "learning more about project management for R&D".
- **Profile, credibility and reputation**, again 84%[76] have achieved to date, and up to 96%[77] if we include those expecting these impacts in future.

[75] 48 out of 57
[76] 48 out of 57
[77] 55 out of 57

- **Improved staff skills and knowledge**, 84%[78] have observed to date, and up to 88%[79] if future expected impacts are included. This aligns with close-out reports, where partners involved in both early and late stage projects had developed their skills and knowledge as a result of the programme, in project-related skills and knowledge, such as design, data analysis, technical skills and (for late stage projects) global market opportunities, as well as broader business/project management skills, including project management, financial modelling, problem solving and strategic thinking.

- **Improved understanding of market position and opportunities**, which had been observed by 79%[80] of beneficiaries to date, and up to 89%[81] if we include those expecting these impacts in future.

6.4 These outcomes were the most prevalent for both early and late stage projects surveyed.

6.5 The majority of respondents had also developed new and/or strengthened collaborations with industry and academia as a result of ATC (88%[82] and 86%[83] respectively, if future impacts are included). Again, this aligns with the close-out reports, where collaboration benefits were referenced. Even though the majority had worked together before, many noted in their close-out reports that relationships had been strengthened (leading to future collaborations). Within this data it worth noting that:

- 73% of *industry* respondents (n=44) reported they had already experienced new or improved collaborations established with academia/research base, which is higher (at a 10% level of significance) than academic respondents where 46% (n=13) indicated they had experienced this benefits; however, this still demonstrates that many (around half) academic participants in ATC projects are benefits from new/enhanced collaborations with other academics

- 11 of the 13 *academics* surveyed (85%) indicated they had experienced new or improved collaborations established with industry.

6.6 It is also worth noting that **around one-fifth of beneficiaries reported that the ATC project had led them to apply for/secure IP or patents**, and a further third expect this to occur in the future. The survey therefore suggests that the ATC programme is supporting the filing of new patents (as anticipated in the logic model), and if projects progress as expected, around half of participants consider that the ATC project will have led to a patent or other forms of IP. As discussed later, in some cases agreeing an approach to IP can be a challenge for collaborative projects, so this is an encouraging finding, and validates the expectation set out in the logic model, particularly as patents/other forms of IP may not be appropriate, relevant, or timely in all cases.

[78] 48 out of 57
[79] 50 out of 57
[80] 45 out of 57
[81] 51 out of 57
[82] 50 out of 47
[83] 49 out of 57

Table 6-1: Effects of the project on beneficiary leads & collaborators (n=57)

	Experienced already	Expect to experience in future	Have not and will not experience	Don't know/not applicable
Improved understanding of R&D and commercialisation processes	84%	7%	9%	0%
Improved profile, reputation, credibility	84%	12%	4%	0%
Improved staff skills/knowledge	84%	4%	11%	2%
Improved understanding of market position and opportunities	79%	11%	11%	0%
New or improved collaborations established with industry	72%	16%	12%	0%
New or improved collaborations established with academia/research base	67%	19%	11%	4%
Progress in moving a technology towards market readiness	60%	33%	7%	0%
Improved understanding of private sector investor opportunities and expectations	53%	7%	39%	2%
Patents or IP applied for and/or secured	21%	32%	39%	9%

Source: SQW

6.7 There was limited statistical difference between the nature and extent of these outcomes shown above between early and late stages survey respondents. There is only one outcome where the variation between the groups was statistically significant – progress in moving a technology towards market readiness, where 100%[84] of early stage respondents had observed an impact to date or expect to in future, compared to 69%[85] of late stage respondents (statistically significant, <1%). This may be a reflection of late stage projects already being relatively high on the TRL scale, so progression is less substantial than early stage projects that appear to have moved through a greater number of TRL stages.

6.8 There was also limited statistical **difference in outcomes observed between leads and collaborators**, with the exception of progress in moving a technology towards market readiness, where 80%[86] of leads responding to the survey compared to 49%[87] of collaborators have observed the outcome to date (statistically significant at <5%). We have also analysed survey results in more detail where two or more partners were interviewed (15 of the 36 early and late stage projects) to see if there are any patterns in

[84] 44 out of 44 early stage respondents
[85] 9 out of 13
[86] 16 out of 20
[87] 18 out of 37

which type of actor has observed each type of outcome. However, there is no clear pattern – for some projects, both leads and collaborators have observed the same types of outcomes; for others, the lead has observed more outcomes than collaborators, and vice-versa; and for others, the lead appears to have observed outcomes to date, but collaborators expect outcomes in future. This likely reflects the varied benefits of ATC projects and how these are realised for and experienced by participants.

6.9 The case studies provide illustrations of many of the outcomes noted above – particularly in terms of R&D capacity (both to manage the R&D process effectively, and in terms of knowledge and experience that will be of value in future R&D. Importantly, **these benefits have emerged in some cases even where the specific technology in question was unsuccessful.** Other benefits including enhanced profile and credibility of the partners involved (which has improved partners position in the R&D field and/or market place), skills and knowledge, and strengthened collaborative relationships were also identified, as summarised below.

Table 6-2: Case study evidence on outcomes

Outcomes	Case study examples
R&D and commercialisation capacity	**Lobster Grower 1 (early stage):** As a result of taking part in the project, the lead has improved their R&D process skills, which has enabled them to deliver subsequent R&D activities more efficiently and effectively, and broadened their knowledge of IP and regulation. The lead and academics involved have also learned about the other disciplines involved (e.g. materials, techniques, holistic design, real world application), including how to apply spill-in technologies to aquaculture in the R&D context. **Harnessing Natural Fungi (late stage):** the lead has gained further experience in the application of its technology which could be useful in other fields and, during the laboratory efficacy testing for the project, made an important discovery that should make it possible to control the full range of grain pests with the one formulation. The process of delivering the project also helped to develop a new trial protocol for biological assessments in grain silo. **Feed Conversion Efficiency in Cattle (early stage):** Both partners have increased their skills and R&D capabilities as the scope of project was outside the organisations core activity. This included improved understanding of developing protocols for testing activity and new sampling processes. **WheatScan in-field sensing for precision application of nitrogen (early stage):** the partners learnt practical lessons in how to develop a WheatScan sensor (e.g. the resolution of shadow problems), and this knowledge is considered to be invaluable for future development of these units. **CAPSEED (early stage):** Project partners have identified new avenues for further industrial research in related areas relevant to the agricultural sector, even though the technology treatment was not proven across different seed varieties. Another unanticipated outcome of the project was the development of technology-treated water with antibacterial properties through further R&D.

	Close out reports also referenced R&D capacity benefits – for example, for one business, the project helped to develop R&D methodologies which provided a 'blueprint' for further R&D activity
Improved staff skills and knowledge	**WheatScan in-field sensing for precision application of nitrogen (early stage).** ATC enabled ADAS to improve its skills and capabilities in handling large datasets, as well as project management skills. For UoM, the project enhanced existing knowledge of sensors. **CAPSEED (early stage):** Two partners involved were introduced to the potential of technology treatments, which they are interested in, and may engage in future R&D activities (potentially with the lead business and the wider project team) to explore opportunities identified.
Profile, credibility and reputation,	**Rubber track undercarriage systems (late stage):** The project has helped the lead company to project itself as a progressive, innovative company, which has in turn helped grow sales by improving the company's credibility in new markets (and increased sales volumes has enabled unit costs to be reduced, opening up further new markets overseas). This is also important for the future positioning of the company as a specialist supplier who delivers a high-quality track/track system rather than competing at the cheaper end of the market. **Lobster Grower 1 (early stage):** The ATC project has played an important role in improving the profile, reputation, credibility of partners involved, internally within their own organisations (for example, at Falmouth University, it was reported that senior management now recognise the value in applying engineering design technology in the agri-tech context) and externally (for example, the lead believes that ATC has raised the NLH's profile as a respected research charity). **Feed Conversion Efficiency in cattle (early stage):** Both partners have improved their profile, reputation and credibility, and key to this was the ability to have R&D evidence (from ATC) to present at a global livestock forum.
Improved understanding of market position and opportunities	**Harnessing Natural Fungi (late stage):** The research partner has gained further insights into industry requirements as a result of working with a lead partner from industry. **CAPSEED (early stage):** The project lead has developed a much wider awareness of the agri-tech landscape, and has identified a range of opportunities in new areas to progress in the future.
New and/or strengthened collaborations with industry and academia	**Lobster Grower 1 (early stage):** Collaborative relations have developed and strengthened through the project, between business, academic and charity partners, leading to subsequent collaborative R&D activity and a joint funded PhD student between CEFAS, the University of Exeter and NLH. **CAPSEED (early stage):** The lead business has established relationships with three previously unknown organisations, and together they are actively exploring future collaborative R&D projects. The three partners – each with a history of collaboration with each other - have strengthened their relationships

New products, services and processes

6.10 There is evidence of **new products or services reaching the market** – and to a lesser extent, new processes being introduced – following ATC project activity.

6.11 At the time of the survey, **30%[88] of all respondents reported that a new or significantly improved product or service had been introduced to the market as a result of the project, and 56%[89] expected this would happen in the future.** Of these, 65%[90] said the products/services were new to market, and nearly half (49%[91]) said the product/service was reaching a new market. As demonstrated in the close-out documentation, for some, ATC had allowed beneficiaries to access the agriculture or agri-tech market itself, which they had limited knowledge of before; others were able to access wider markets in sectors such as pest control and animal health; and for some of the late stage projects, partners were able to improve their technical advantage over European competitors, and expand the geographical reach internationally. The case studies also provided examples of new products in the market (see below).

Case study example: Rubber track undercarriage systems.

As a result of the late stage ATC project, the company has successfully launched new products into the market. These have been sold to manufacturers in Canada, France, Austria, Belgium, Hungary and Australia. The company has had some links with DIT (formerly UKTI) to help with overseas development, but the recruitment of an additional salesman (a direct outcome of the ATC project and the associated business growth) has played a key role in enabling the company to explore new international markets.

6.12 As we might expect, there is a significant difference in the reported market-entry at this point of new products/services between early stage and late stage awards: 25% of early stage participants that were aware (n=44) stated that their project had led to the introduction of new or significantly improved products or services to the market by the point of the survey, compared to 55% of late stage participants (significant at 10% level)[92]. Although not significant owing to sample size, this trend holds true when only leads are included (to address any bias from collaborators that are not fully aware of project progress), with three of the five late stage leads indicating market-entry by the point of the survey, compared to just two of the 15 early stage leads.

6.13 Encouragingly, early stage respondents showed strong confidence in their projects reaching market in future (64%[93]), and over half (58%[94]) those expect to introduce the new product/service within three years.

6.14 In terms of those expecting to introduce a new product or service in future, nearly two thirds of beneficiaries across both types of award responding to the survey (62%[95]) expect that this will occur within the next three years. When looking at the survey

[88] 17 out of 57
[89] 32 out of 57
[90] 11 out of 17
[91] 8 out of 17
[92] 11 out of 44 early stage respondents, and 6 out of 11 late stage respondents who were able to answer the question
[93] 28 out of 44
[94] 15 out of 26 who were able to answer the question
[95] 19 out of 30

results as a whole, the leads were slightly more optimistic about this (69%) than collaborators (59%) but the difference is not statistically significant[96]. Indeed, our analysis of multiple survey responses for individual projects shows differences in opinion within the team on when new products/services will be brought to market for many of these projects, but no consistent message on whether leads or collaborators are most optimistic. As we might anticipate, all of the late stage respondents expected introduce a new product or service within two years (compared to around half of early stage projects, a statistical difference at 5%). For other beneficiaries, the process will take longer – four out of 30 respondents (all early stage) expected it to take over five years.

6.15 These findings align with the evidence from some case studies, where two early stage projects believed they were two/three years from commercialisation, compared to one early stage project that thought the product was at least three years away from reaching the market (and would be five-to-ten years before it generated turnover and job impacts).

6.16 The case studies also indicate that in most cases**, the ATC project is focused on the development of a single product between all partners** – this is an important caveat, as it means (for example) that whilst 17 of the 57 respondents to the survey reported that the ATC project had led to a new product/service reach the market at this point, there are not 17 individual products are in the market (with the 17 based on five leads, and 12 collaborators). This said, the case studies did provide some examples of 'spin-off' commercial opportunities that have been realised through the project, for example around the commercialisation of the knowledge that has been generated through the R&D process; an example is presented in the box below. These wider effects are hard to track as they do not represent the full commercialisation of the specific project that was the focus of the ATC funding, but they are important in recognising the full market (and in time economic) impact of the programme.

Case study example: Lobster Grower 1:

The focus of the project was to develop a new product, and it is anticipated that this will be taken to market in three or more years in the future. However, through the delivery of the project, partners developed a wide range of knowledge on the specific technical challenges and research issues that may be applicable in wider contexts. There is the potential for this knowledge to be commercialised through the delivery of consultancy services to other parties involved in the similar activities, which may generate revenues sooner than the principal product focus of the ATC project.

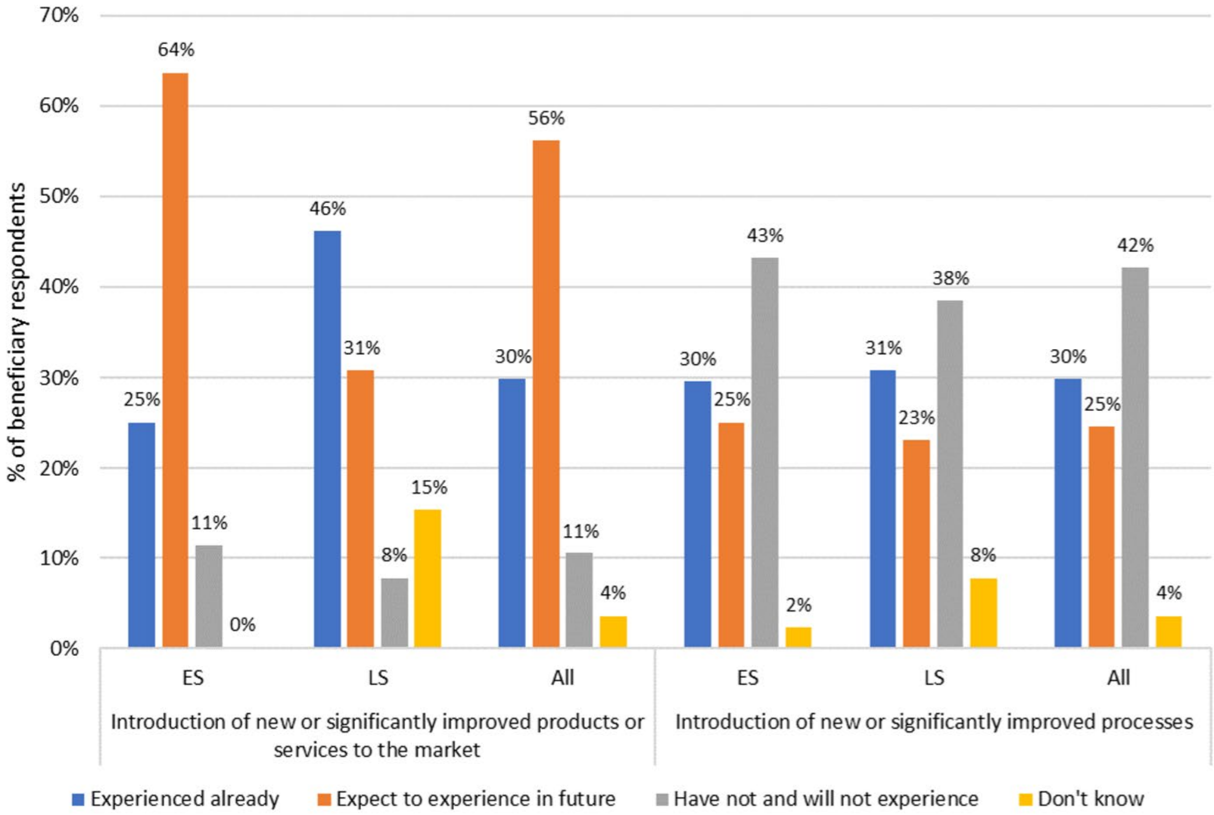
6.17 In addition, 30%[97] of survey respondents had **introduced new processes** as a result of ATC, and a further 25%[98] expect to do so in future. The majority of these (87%[99]) said the process will be new to industry (i.e. not currently undertaken by any other market participant, as far as they were aware). There is very little difference between early and late stage respondents on this outcome measure. Collaborators were slightly more likely to have introduced new processes already (32%) compared to leads (25%), but

[96] 9 out of 13 leads and 10 out of 17 collaborators
[97] 17 out of 57
[98] 14 out of 57
[99] 27 out of 31

leads were more optimistic about introducing new processes in future (35%) than collaborators (19%) – due to sample sizes, the differences are not statistically significant[100]. For those expecting to introduce new processes in future, the timetable was similar to that for new products/services above.

6.18 The summary data for the introduction of new products/services and process from the survey is set out in Figure 6-1.

Figure 6-1: Evidence on introduction of new products/services, and processes (n=57)



Source: SQW

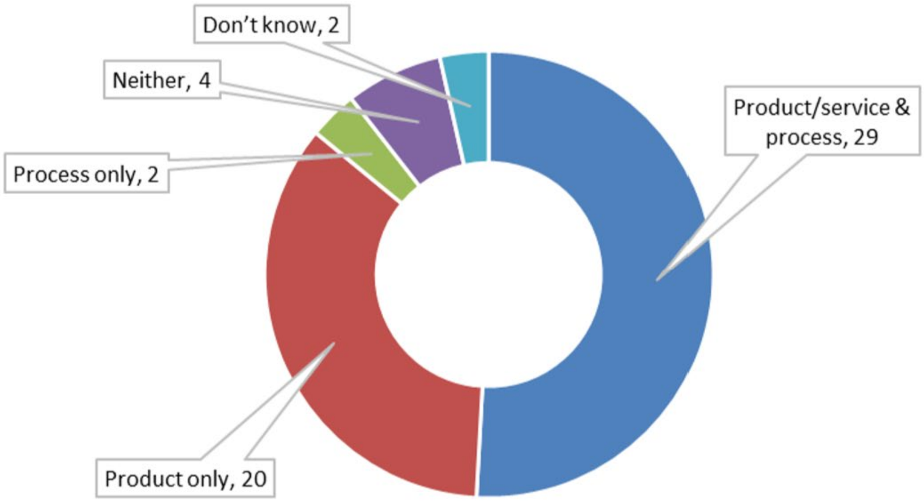
6.19 Importantly, and reflecting both the relationship between new products and processes, and the learning benefits from ATC activity discussed above, **many participants identified achieved/expected effects for both new products/services entering the market, and new processes as a result of the ATC project**. As shown in Figure 6-2, half of survey respondents reported they had experienced or expected to experience both types of effect. This trend is consistent when looking at leads only, where 11 of the 20 reported both types of effect, and seven new products/service only.

6.20 Interestingly, 'process only' effects were very limited (identified by just 2 of the 57 respondents), reflecting the focus of the programme on the development of new technologies and solutions for the market, rather than internal process improvements for participants. However, the high level of both product/service and process outcomes suggests that these latter benefits have been realised through the product development

[100] Observed already – 12 out of 37 collaborators vs 5 out of 20 leads; expect in future – 7 out of 20 leads vs 7 out of 37 collaborators

activity, which may lead to performance and productivity benefits over the longer-term for participant organisations.

Figure 6-2: Nature of effects experienced / expect to experience across new/significantly improved products/services and new/ significantly improved processes (n=57)



Source: SQW

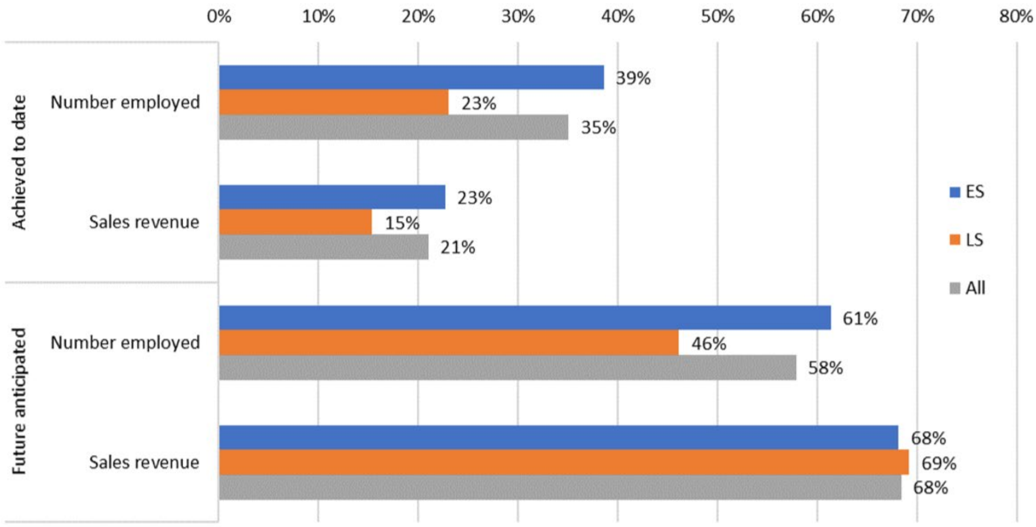
Employment and turnover outcomes

6.21 ATC has led to **modest impacts on employment and/or turnover of those involved to date**, which is unsurprising given the bulk of the projects covered by this first phase of the evaluation are early stage and the lag time to impact. Slightly more beneficiaries have observed employment impacts, rather than sales, predominantly through creating or safeguarding jobs to deliver the R&D activity (and in a small number of cases, raising capacity to deliver new market offer). Moreover, leads are more likely to have observed employment and turnover impacts to date, compared to collaborators (and the difference is statistically significant).

6.22 That said, there are a **small number of strongly performing outliers** (both early and late stage projects) that are already generating substantial levels of revenue from the technologies developed (£250k or more), including through exports.

6.23 The summary data is set out in Figure 6-3, and discussed in more detail below.

Figure 6-3: Evidence on effects on employment and turnover (n=57)



Source: SQW

6.24 Overall, 35%[101] of beneficiaries surveyed had observed an increase in employment to date due to ATC, and 58%[102] expected employment to increase in future.

- Of those, 19 respondents were able to estimate the number of jobs created/safeguarded: most stated one to three FTEs, reflecting the fact that the majority of respondents were micro/small firms before ATC support; there was also one firm that reported an increase of 20 FTE jobs due to ATC, which is a substantial uplift for what was a small firm before ATC support. Again, for those expecting employment growth in future, most estimated this to be 1-5 FTE by 2021, but four outliers estimated 10-35 FTEs.
- Early stage respondents were more likely to have observed employment increases to date (39%) compared to late stage respondents (23%), but the difference was not statistically significant[103].
- Leads were more likely to observe employment impacts to date (55%) compared to collaborators (24%), and this was a significant difference at 5%[104].

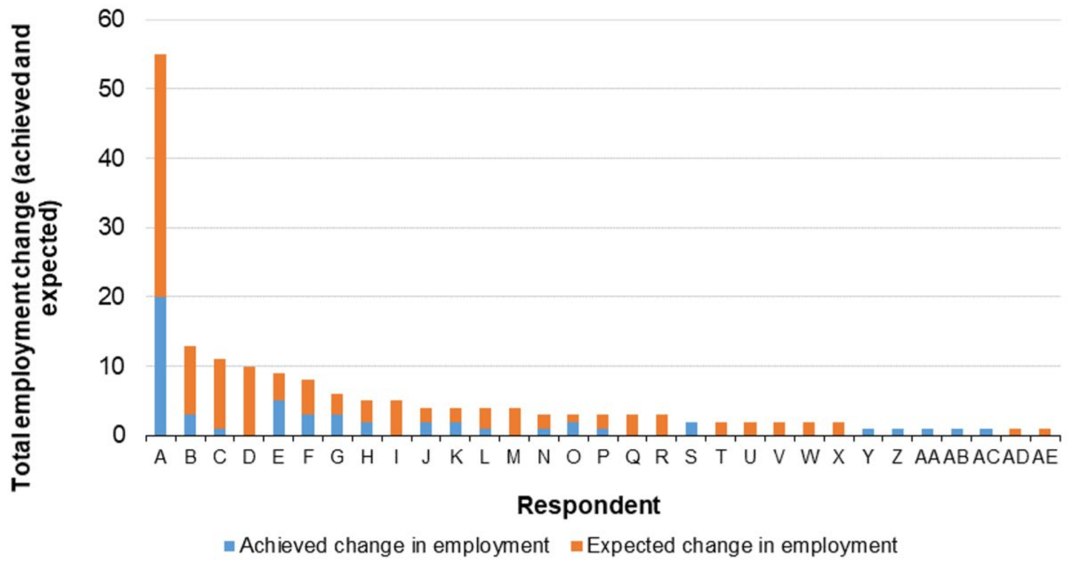
6.25 The **total increased employment to date from the survey group (n=57) was 53 FTEs, and total increased employment expected by 2021 was 119 FTEs, providing a total anticipated (gross) employment effect from the beneficiaries surveyed of 172 FTEs.** The average effect per participant (if the future expected employment effects are realised) is almost three FTEs, although this is higher for leads (5.3 FTEs) than collaborators (1.8 FTEs).

6.26 However, the variation between achieved and expected effects was very significant (with expected effects accounting for around 70% of the total), and the data should therefore be treated with some caution as there may be some optimism bias in play, whereby participants over estimate the potential effects in the future. It is not possible to

[101] 20 out of 57
[102] 33 out of 37
[103] 17 out of 44 early stage respondents, and 3 out of 13 late stage respondents
[104] 11 out of 20 leads, and 9 out of 37 collaborators

quantify with any precision the scale of this optimism bias at this stage, and this may vary across the survey cohort.

Figure 6-4: Evidence on effects on employment (n=31)



Source: SQW. Note: Respondent ID's (A-Z) do not correspond to respondent ID's in other figures.

6.27 The case studies and close-out reports corroborate this evidence, and provides further information on the types of jobs created/safeguarded. For example, close-out reports documented how projects had created positions for highly skilled post-doctorates, technicians and research assistants. In some cases, growth in staff (and the skills sets they bring) has provided companies with greater capacity to explore new markets and undertake further R&D, which in turn is creating further collaboration opportunities and fuelling further growth (see case study box and quote from survey respondent below):

"A general benefit to having a larger team, exclusively employed to deliver this stage and future stages. Enabled us to take on more side projects which in turn has opened up further partnerships."

Case study example: Rubber track undercarriage systems.

Following the successful launch of the new product and exports overseas, the lead company is likely to see a further 15-20% increase from a baseline of £1.4m per annum turnover before the project began. Within three years the company expects turnover to have doubled compared to the position before the project commenced.

Case study example: mycoprotein substrate utilisation and nutrition:

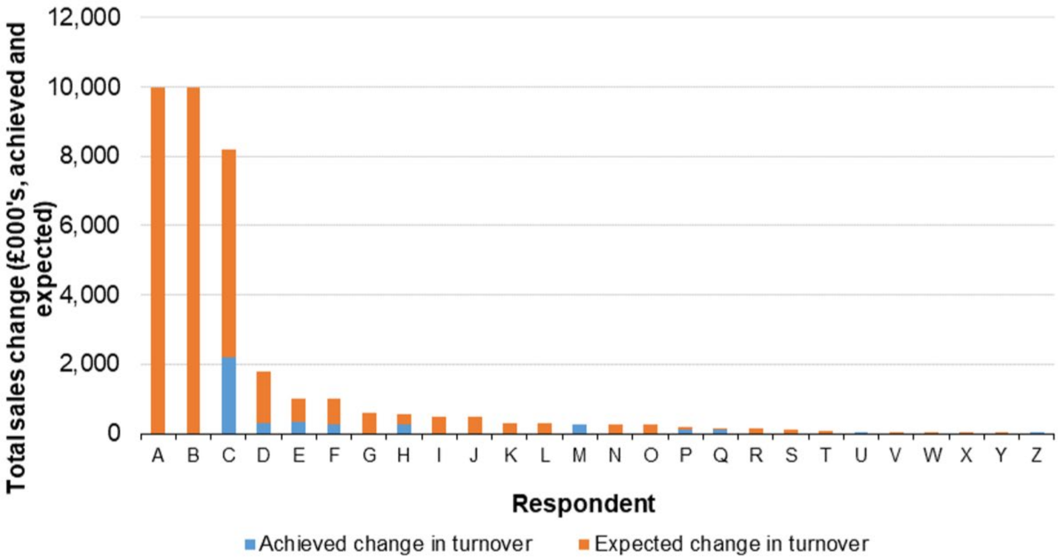
The potential commercial outcomes to result from this work are subject to further R&D and may take a number of years to be realised. However, some economic returns may be realised within the next 12 months – for example, the collaborator has progressed their understanding of c-variant occurrence and control in their production and, subject to some final R&D, lead to cost savings of around £150k.

6.28 Just over one fifth (21%[105]) of beneficiaries have observed an increase in turnover due to ATC do date, and 68%[106] expect to generate higher turnover in future[107] (and, as noted in the close-out reports, ATC has played an important role in increasingly the likelihood of this revenue being generated at a later date).

- Of these 12 reporting changes to T/O due to ATC to date, nine were able to quantify the impact. This showed a wide range from £15k to £250k for early stage projects, and from £350k to £2.2m for late stage projects. With such small numbers able to quantify impacts, there was no clear pattern in terms of the increases compared to baseline turnover – for example, one respondent had a pre-ATC turnover of “up to £100,000” and ATC led to an increase of £50,000; whereas another respondent had a turnover in excess of £50m before ATC, and the project increased turnover by £250,000.
    - Five of these nine projects have also been successful in exporting their products/services, with 50-100% of their turnover generated by overseas demand.
    - Looking forward, expected turnover benefits by 2021 also varied substantially – 23 respondents provided estimates for future turnover income, which ranged from “up to £100k” for eight respondents to “up to £10m” (and greater than £5m) for three respondents.
- As with employment impacts, early stage respondents were more likely to have observed turnover increases to date (albeit a lower proportion, at 23%) compared to late stage respondents (15%), but the difference was not statistically significant[108].
- Leads were more likely to observe employment impacts to date (again, a lower proportion, at 35%) compared to collaborators (14%), and this difference was ‘weakly’ significant (at 10%)[109].

[105] 12 out of 57
[106] 39 out of 57
[107] This evidence is based on the business questionnaire, where businesses were explicitly asked whether their turnover had or would in future due to the ATC support.
[108] 10 out of 44 early stage respondents, and 2 out of 13 late stage
[109] 7 out of 20 leads, and 5 out of 37 collaborators

Figure 6-5: Evidence on effects on turnover (n=26)



Source: SQW. Note: Respondent ID's (A-Z) do not correspond to respondent ID's in other figures.

6.29 **The total increased turnover to date from the survey group (n=57) was £3.9m, and total increased turnover expected by 2021 was £32.3m, providing a total anticipated (gross) turnover effect from the beneficiaries surveyed of £36.2m.** The average effect per participant (if the future expected turnover effects are realised) is £630k, at a similar level for or leads (£660k) and collaborators (£620k.) Again, this data is heavily reliant on the expected future effects, which account for 90% of the total.

6.30 All of these data are 'gross', and it is important to recognise the high level of skew across the survey sample; for most participants of the early stage and late stage projects captured in the survey, no quantitative effects have yet to flow through. This said, the data highlights the potential effects that individual ATC project can have on participant performance, which can be significant in individual cases. See Annex D for further details on each 'case' that has observed employment and/or turnover impacts, which demonstrates the variability in TRL progression, experiences of new products/processes reaching the market, and employment/turnover impacts.

Follow-on investment

6.31 For those who have not yet reached the market, a key issue in the pathway to commercialisation is the ability of projects to secure follow-on investment after their ATC, if required. Despite earlier findings around technology progression, and some beneficiaries having "proven technologies", the majority (85%[110]) of beneficiaries surveyed that expected to introduce new products/services/processes in future said they **would require further R&D investment to achieve this.** The proportion was similar for early and late stage projects.

6.32 **The survey provides some – albeit limited – evidence that follow-on investment has been secured in some cases after ATC support ends, meeting the expectation that ATC will lead to leverage of further investment in R&D.** Of the 20 project leads interviewed, 12 had completed their ATC project, and of this group eight indicated that

[110] 29 out of 34 (comprising 32 who said they would introduce in future and 2 who were unsure)

the project had been continued post-ATC either through further R&D or rolling-out the product/service commercially (four had halted the project at this point). For five of the eight that had continued the project, additional investment post-Catalyst was required to progress the project, sourced either from public sector sources or customers/collaborators. The scale (by band) and source of this investment is summarised below in Table 6-3 (where the specific amount was provided this is noted). Note all five were early stage ATC projects.

Table 6-3: Scale and source of post-ATC investment to enable project continuation

Example	Scale of post-ATC investment	Source of investment
Example 1	Up to £100,000 (£80k)	• UK public sector (AHDB) • UK public sector (unspecified*)
Example 2	Over £1 million (£3.3m)	• EU grant • Customer/collaborator funding
Example 3	Up to £250,000	• Customer/collaborator funding
Example 4	Up to £100,000	• Customer/collaborator funding
Example 5	Up to £500,000 (£500k)	• EU grant

Source: SQW. * the source was not specified by the respondent

6.33 Given the limited sample, these data should not be taken too far, however the following points are noted:

- the scale of investment secured ranges substantially, from around £80k up to £3.3m, demonstrating the significant investment that can still be required at the close of early stage projects to progress ideas/innovation to market
- the scale of investment does appear to be linked to the TRL stage at project closure: the project that secured £80k post-ATC investment had reached the 'technology implementation' stage (specifically TRL 7[111]) by the point of ATC project closure (the investment supported a PhD student to continue the research); by contrast, the three projects that secured up to £250k, up to £500k and over £1m (£3.3m) remained at the 'applied R&D' stage (specifically TRL 4 or 5[112]) at project close, suggesting that further investment was required to progress the project along the TRLs[113]
- the investment secured came from a mix of public (UK and EU), and private sector sources, including from customers and/or collaborators – none of the three businesses leads (the other two were academics) reported they had invested their own funds to progress the project post-ATC.

[111] 'Prototype demonstration in an operational environment'.
[112] 'Basic technological components integrated to establish that they will work together', and 'Testing technology in a simulated environment'.
[113] Examples 4 where the exact value is not known was at TRL 4 at the close of the project; it is not known if this investment was more or less than the £80k.

6.34 The case studies also provide evidence on how ATC has helped to de-risk projects sufficiently to secure follow-on public sector investment and further investment in R&D by the participants themselves, as illustrated in the box below.

Case study example: Mycoprotein substrate utilisation and nutrition:

ATC has successfully de-risked several avenues of research, making it likely that further R&D will be funded by the business. It triggered a change in strategy at the collaborator organisation to develop their in-house R&D capabilities and invest £3m in a pilot production facility.

6.35 **There is some encouraging evidence of benefits relating to participants understanding of private sector financing options (even though this was not an explicit objective of ATC).** Around half (53%[114]) have improved understanding of private sector investor opportunities and expectations as a result of the ATC project (up to 60%[115] if we include future expected impacts), although almost 40%[116] did not expect this outcome. Leads were more likely than collaborators to improve in this area – 80% of leads and 38% of collaborators have observed this outcome to date, which is statistically significant (at <1%)[117]. That said, only one survey respondent (a business collaborator on an early stage project) mentioned VC finance as a potential source of future funding to enable commercialisation. Whilst this does not account for beneficiaries' baseline position (i.e. the knowledge they already had about private sector investment, before ATC), it does raise **some concerns about beneficiaries' ability to raise the follow-on finance required to take a product/service to market and grow their business** – it cannot be assumed that those involved will gain a better understanding of private investors solely by having business involvement in projects. The importance of aftercare in this respect, and links to other programmes that provide access to finance support, was raised in the Catalyst process evaluation.

6.36 Also in the case studies, there was limited evidence to suggest that projects have improved their understanding of private sector investor opportunities – this tended to be more common for leads, who were more likely to lead on securing any future investment, but there was still a sense that further support would be needed to raise project partners' awareness and their ability to secure private investment. This was particularly important where projects had not yet begun to generate revenue from their new technology/product, either due to the early stage of development or concerns about sharing their knowledge (for example, via consultancy) before IP was fully protected. Whilst this is not directly a goal of ATC (and nor is private investment the only option), it raises a question around whether projects requiring follow-on investment postATC will be capable of realising outcomes if they are not better equipped to secure private sector at an appropriate point.

6.37 In terms of the supply-side of private finance, there were **mixed views amongst stakeholders consulted on the programme's influence on the wider investment community**, in terms of changing perceptions of the commercial viability of funding R&D in agri-tech. It was reported that there is growing willingness by private sector investors to invest in agri-tech (especially in relation to global food security and climate

[114] 30 out of 57
[115] 34 out of 57
[116] 22 out of 57
[117] 16 out of 20 leads, and 14 out of 37 collaborators

change), but consultees struggled to attribute this to the Catalyst. That said, the programme has played an important role in creating and de-risking a pipeline of investment opportunities. Having been through a robust Innovate UK assessment and monitoring process, Catalyst projects are reported to be viewed more credibly by the VC community – and the UK Government's Agri-Tech Strategy has given investors more confidence that the sector has a long-term future. This has helped to "stoke investor appetite". One consultee is currently setting up a VC fund, and has found that sharing examples of ATC projects is attracting VCs to the fund.

Legacy effects

6.38 In addition to the outcomes described above, ATC is leading to sustained changes in the attitudes and behaviours of those involved after the project itself, which are crucial for further collaborative R&D activity in agri-tech in future. For example:

- 84%[118] of beneficiaries surveyed have continued to work with all or some of their ATC collaborators after the project completed (the level was similarly high for leads and collaborators, early and late stage projects)
- for those who haven't continued to work with their ATC partners, all were more likely to collaborate with other partners in R&D in future
- 75%[119] are much more/more likely to invest internal funds in other R&D in future (again, the level was similarly high for leads and collaborators, early and late stage projects). For example, one survey respondent felt that:

*"It helped us to create a culture change within the organisation so as to be **more receptive to longer-term R&D and more investment in a new pilot plant**. We needed to test the scalability, and getting time was difficult, so building the pilot plant means we can test without impacting on productivity" (emphasis added)*

- 81%[120] are much more likely to bid for Government funding to support other R&D activity in future. There was no statistical variation between early and late stage project participants or by leads and collaborators.

6.39 There is also evidence from the case studies to demonstrate how the ATC experience has led to **changes in beneficiaries' business plans**, encouraging them to be more commercially focused than in the past. This should create a stronger "commercial pull" for R&D activity in future. The close out reports for early and late stage projects also documented (largely unexpected) benefits around improved business planning, in part through developing/improving their business plan during project delivery.

Case study example: Wheatscan:

For the lead, the combination of several IUK projects (including this ATC project) has led to a change in business strategy and approach. Moreover, the consultee noted an increase in consciousness amongst senior management to exploit opportunities where there is potential to create IP and generate future revenues.

[118] 27 out of 32 responding to the question
[119] 43 out of 57
[120] 46 out of 57

Case study example: Evaluating a potential proxy test for Feed Conversion Efficiency in beef cattle: The ATC project, together with other IUK projects, has changed the lead institution's behaviour towards innovation and applied R&D and played a role in encouraging management to come more commercially focused. They also now see greater potential, opportunities and benefits of developing an IP from its research to generate revenue.

6.40 Specifically, for academics, participation in ATC is leading to legacy effects, as they become more willing and able to engage in collaboration with industry and use the knowledge gained to inform their wider research activity, more committed to continued research in agri-tech, and are able to lever further R&D funding. A total of 13 academics responded to survey (out of a population of 33 involved in early and late stage projects). Of these:

- 11 (85%) agreed/strongly agreed that ATC had improved their ability to engage in collaborations with industry
- nine (69%) agreed/strongly agreed that ATC had improved their knowledge which would be of value to wider research activity
- eight (62%) agreed/strongly agreed that ATC had changed their attitude, so they were more likely to collaborate with industry in R&D activity in future
- eight (62%) believed that ATC had enabled them to lever further research funding from public and/or private sources (equally split between public and private)
- seven (54%) agreed/strongly agreed that ATC had changed their attitude towards commercialisation of research, so they are more likely to engage in future.

Wider agricultural sector outcomes

Effects on participants

6.41 For the organisations involved in ATC projects, the survey results suggest that wider impacts have focused on **reducing environmental impacts or improving environmental sustainability** so far, with some experiencing **improved yields/productivity, produce quality and animal health.** A wider cohort of beneficiaries expect these environmental, productivity and quality benefits to materialise in future, although future impacts on animal health/welfare is limited (possibly reflecting the nature of projects covered by the survey).

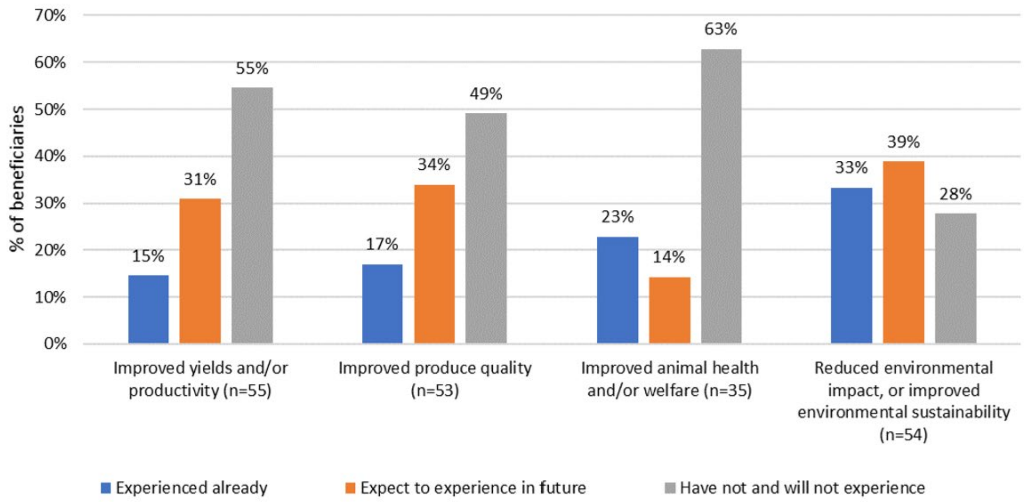
6.42 The data are set out in Figure 6-6; note that this excludes those respondents that responded 'not applicable' (or don't know) to the survey, in order to remove those respondents where these specific outcome types are not relevant to their project, which would present a potentially misleading picture.

6.43 Both early and late stage survey respondents demonstrated a similar pattern. The only significant difference was between leads and collaborators**, where a greater proportion of collaborators have/are expecting impacts on yields/productivity (54%) compared to leads (25%)[121].** This may reflect the different roles of collaborators

[121] 20 out of 37 collaborators, and 5 out of 20 leads. Statistically significant at 5% level.

– for example, as noted above, nearly 60% of collaborators surveyed were "testing in an operational environment" and around 40% were testing in laboratories or demonstrators.

Figure 6-6: Wider effects of the project on organisations involved



Source: SQW

6.44 Beneficiaries have also observed some wider unexpected or unintended outcomes from their ATC experience, notably in relation to spillovers from ATC to other sectors, media coverage and networking benefits, and (albeit limited) supply chain benefits. For example:

- A small number of surveyed beneficiaries and close-out reports noted how ATC has enabled them to expand into new areas of development (e.g. robotics) and benefit from spillovers where their agri-tech products/technologies have found application in other non-agricultural sectors. This was supported by one of the case studies, where the track systems developed potentially have a market in the industrial and construction sectors.
- One survey respondent has benefitted unexpected from media coverage (exhibiting at Innovate 2017 and Innovate 2018), and two of the case studies have gained networking benefits by disseminating their project findings (as illustrated in the box).
- There is also (limited) evidence of supply chain impacts arising from the delivery of ATC projects. For example, the delivery of Lobster Grower 1 generated small-scale supply chain impacts (c. £65k) through sub-contracting a UK-based manufacturer to produce the prototype.

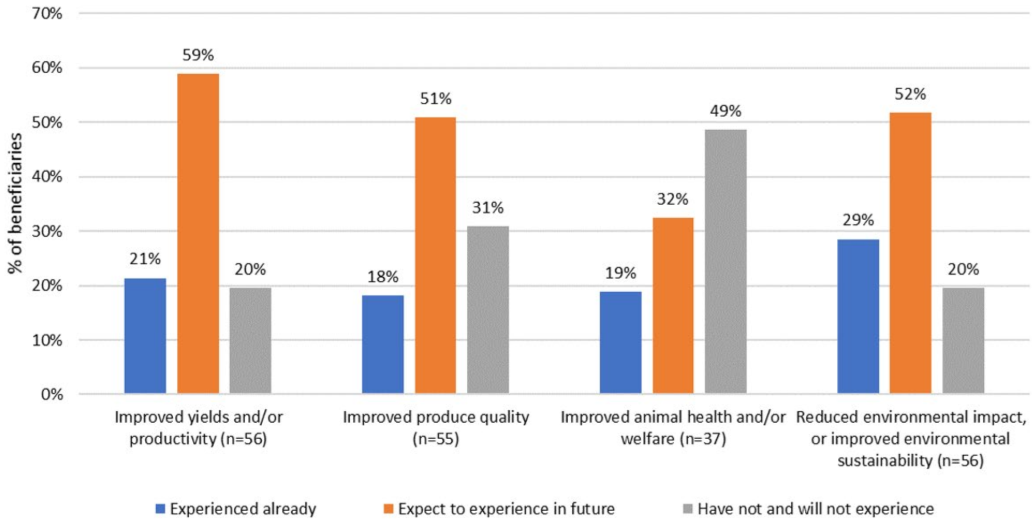
Case study example: Lobster Grower 1:

The lead has observed networking benefits as a result of disseminating the learning from Lobster Grower at national and international conferences. This has led to early discussions on potential collaboration opportunities abroad (applying the Lobster Grower technology in new contexts or for different species) and developing potential routes to market in future.

Effects on the wider agricultural sector

6.45 As part of the beneficiary survey, respondents were asked whether their ATC projects had impacted on the wider agricultural sector, or were expected to in future (see Figure 6-7; again this excludes those responding “not applicable/don’t know”). The results follow a similar pattern to observed/expected impacts on the organisations involved in the ATC projects, reflecting the nature of their activities. However, **there is greater confidence in future impacts on productivity, produce quality and environmental sustainability (and more limited effects on animal welfare).** In order to achieve this, the key test will be whether the new/improved technologies deliver improved financial performance – if they do, and if this message is effectively disseminated to the relevant audiences, the technologies are more likely to be adopted. We explore the intended routes to wider impacts and potential risks to achieving these in the subsection below.

Figure 6-7: Observed effects of the project on wider agricultural sector



Source: SQW

6.46 More broadly, some of the stakeholders consulted felt that the Catalyst has demonstrated a **clear UK commitment** to Agri-Tech innovation, and generated a **“buzz and energy”** across the sector – and both are powerful tools in attracting industry investment. These wider benefits are a key part of the original rationale for the intervention. Beyond the examples here and above, the stakeholders consulted struggled to comment on wider outcomes and impacts of the Catalyst – in part because the projects are not (to date) very visible, but also because it is too early to comment, and/or the scale of Catalyst investment is relatively small compared to the wider sector.

Case study example: WheatScan:

The collection of data, enabled by this project, is expected to create potentially significant opportunities for the reduction in nitrogen waste on farms, aiding farmers in management decisions to improve efficiency, reduce costs and generate higher yields.

Performance against project-level objectives

6.47 There has been **mixed performance of projects against their own stated objectives**, according to survey evidence. Of the 32 projects that had completed at the time of the survey, 17 respondents believed they had "fully achieved" the project's objectives, nine had "partially" achieved objectives, and four had not[122]. The picture was similar for early and late stage projects surveyed, and leads were slightly more optimistic on performance compared to collaborators (but the difference was not statistically significant). Notably, the data from on-gong projects and whether they expected to meet their objectives was similar, with around half (14 of 25) believing that objectives would be achieved in full, with 10 of the 24 believing that objectives would be achieved in part.

6.48 In part, this reflects the non-linear process of innovation noted above, which was illustrated in our case studies where early stage prototypes required more rounds of iteration than expected, and where progress with one aspect of the innovation raises research questions for other parts of the product ecosystem that then need testing. The four projects that had not achieved objectives reported this was due to unexpected/unfavourable research results, technology failure or an inability to prove commercial viability – all reasonable outcomes of high-risk R&D. Again, factors that have enabled or hindered progress are covered in more detail below.

6.49 There appears to be a **relatively consistent message on the extent to which projects achieved their objectives from different partners involved.** As noted above, as part of the beneficiary survey two or more partners were interviewed for 15 of the 36 early and late stage projects. Only four of these demonstrated differences in opinion on performance – in two cases the lead was more optimistic, in two it was the collaborators.

6.50 Evidence gathered from the close-out reports suggested that a higher proportion of projects had achieved their original goals (17 out of 20 close out reports available at the time, or 85%), suggesting there may be some optimism bias in the close-out evidence. The close-out reports suggested that most progress had been made against activity-related measures (such as developing commercial feasibility and improved knowledge for early stage projects, and patenting or new/increased availability of products for late stage projects), whereas goals where projects fell short related to market entry, increasing sales to planned levels, profitability and animal welfare. This is consistent with evidence of limited revenue generation to date (see above), suggesting that, despite strong technological progression, projects may have been overly ambitious in their original applications.

6.51 Further, it should be recognised that **some project failure in R&D programmes is to be expected, and arguably is desirable;** zero or no failures would imply that the programme was insufficiently risk averse – or supporting only low-risk projects. By targeting higher-risk projects, the programme has arguably delivered against the original rationale (around risk) and increased the level of additionality (i.e. projects were too risky to be taken forward anyway).

Factors enabling or hindering pathways to impact

6.52 Through the survey, case studies and stakeholder consultations, we have gathered evidence on the key factors that have enabled or hindered the progress of ATC projects towards impact. In doing so, we are testing the added value of a collaborative approach

[122] Two survey respondents did not know how the project had performed against objectives.

in delivering projects, other factors that have supported or inhibited the progress and effectiveness of the programme in delivering activities and outcomes set out in the logic model (both project-related and the wider system in which the programme operates), and whether mechanisms are in place to enable future anticipated outcomes for those involved and impacts on the wider agri-tech/agricultural sector (and any risks/barriers to this).

Enabling factors

6.53 **The collaborative approach of ATC has added significant value to the effectiveness of the programme**. Just over 80%[123] of beneficiaries surveyed agreed, and project leads were more likely to value the collaboration (95% of leads felt this approach had added value, compared to 73% of collaborators, which was a statistically significant difference at 5%). Throughout survey, case studies and stakeholder consultations, collaboration was consistently identified as the critical to success throughout a project's journey, particularly in terms of:

- Enabling partners to **share the risk** of inherently high-risk projects – funding has also been an important factor here.
- The **multi-disciplinary** nature of collaboration, which has meant that projects have benefitted from synergies arising from complementary expertise, skills and practical experience. For many beneficiaries surveyed, the partnership of academia and industry has been particularly important. This multi-disciplinary approach has led to **greater depth and quality of research, accelerated progress towards outcomes, and brought about new examples of technology convergence** in the agri-tech context – and for those involved, it led to the development of new knowledge and skills.
- **Scale,** whereby involving multiple partners allows data gathering at a sufficient scale to ensure robustness and validity, and, as one stakeholder argued, it creates projects of "sufficient critical mass to make a difference".
- **Network opportunities,** whereby partners have provided access to a network of end-users to test new technologies/products.
- **Industry involvement,** which provides a commercial pull, understanding and experience of commercialisation processes, and a potential route to market (in addition to market testing and feedback). Stakeholders argued that involving large corporates in ATC projects provides routes to much larger markets and the mainstream agricultural sector, and so are an important mechanism to ensure wider impacts are achieved.
- Linked to the point above, **collaboration has provided gravitas to some projects**. It has enabled SMEs to collaborate with leading Universities and large companies, and stakeholders argued the latter is particularly important to a project's credibility when seeking follow-on Venture Capital investment.
- Providing a **legacy in terms of sustained partner relationships** – as we note above, many participants have continued to work with some or all of their partners after the ATC project was completed. By creating and/or strengthening partner relationships, the projects have been able to progress their technology toward

[123] 46 out of 57

market after ATC than might otherwise have been the case. Moreover, there is evidence to demonstrate how partners have continued to work together on other R&D projects.

Case study example: CAPSEED A New Seed Conditioning Process for Arable and Horticultural Crops:

The partner's large membership network and expertise across agri-tech were instrumental in establishing the collaboration, drawing in major distribution and producer partners. This partner is also seen as critical for the exploitation of any future opportunities that arise in related areas. In addition, the multidisciplinary expertise, knowledge and skills of the collaboration added considerable value, each working towards a common goal for which capabilities of each partner were essential to achieving results.

Case study example: WheatScan:

For this project, data has been gathered from the lead's field trial sites and a collaborator's grower membership co-operative. Collaboration allowed the project to calibrate a large enough dataset (of over 120 samples) to establish proof of concept. As a result, the collaboration led to better quality results, at lower cost (due to economies of scale), alongside the skills development benefits for those involved.

Case study example: Evaluating a potential proxy test for Feed Conversion Efficiency in beef cattle:

Collecting a large, comprehensive sample (of 1000) has been critical to the success of this project, enabling a greater level of robustness to the research. This would not have been possible without collaboration. The collaborating partner (a membership organisation) has provided access to a large number of member farms to achieve this.

Case study example: Lobster Grower 1:

Delivering the early stage project through a multi-disciplinary collaboration has been the overriding critical factor influencing the success of this project, and has accelerated technology progression, led to a better-quality output (which has influenced networking benefits, profile/reputation/credibility, attitudes towards R&D in agri-tech, and the ability to secure follow-on finance) and benefits for those involved (such as knowledge development).

6.54 These collaboration factors come into play at different stages of a project's journey. For example, the ability to share risk is important in initiating the project, multi-disciplinary inputs are critical to the quality, scale and speed of outcomes achieved, which in turn matters when it comes to derisking follow-on investment, and industry involvement is essential not only in the design and testing of new products, but also in providing a potential route to market once new products are launched.

6.55 In order to ensure a collaboration works effectively together, **clearly defined roles** and **collaboration agreements** from the outset have been important. Moreover, effective partnership working inevitably depends on the **personalities** of those involved – teams have worked best where partners are committed, enthusiastic, motivated and open. For example, one beneficiary argued *"the project was extremely ambitious. I would say the key factor with the success we had was the enthusiasm and commitment from the* *team members".* It also helped where they **share common goals**, and these need to be closely aligned with those of their wider organisations.

6.56 Whilst the evidence on the benefits of collaboration are clear, one of the late stage case studies was a single business project, and in this instance the lack of collaborators was not detrimental to the success of the project. From the lead's perspective, the business could provide many of the capabilities listed above – prior experience in agri-tech R&D, established expertise in the technology area, a keen interest in developing in-house capabilities further, good knowledge of market demand, and pre-existing routes to market. The key motivation for seeking ATC support here was the lack of cash resources to accelerate the development of their product, and the lead felt that acceleration could be best achieved (and impacts for the business could be maximised) by working independently. This suggests that single business projects are not necessary disadvantaged, if the business involved can provide the necessary capabilities.

6.57 **Context is also important. The evidence suggests that previous experience in R&D of some or all of the partners involved has facilitated effective delivery of ATC projects in some instances.** For some of the case studies, such as one of the late stage projects, partners drew on their long track record of successful R&D to deliver their ATC projects effectively. Also, where (at least some of the) partners have pre-existing relationships stakeholders and beneficiaries argued projects were operational more quickly, compared to new partnerships where the first few months were spent in start-up mode. Furthermore, partner capabilities and strengths were known from the outset – this helped to ensure roles were clear and realistic from the outset. However, this is not to say that projects that involved new collaborations or partners who were new to R&D were necessarily less effective – ultimately many, including the mycoprotein case study, progressed their technologies successfully through ATC and achieved their project's objectives.

6.58 As will all R&D projects of this nature, strong and committed **project management** by the project lead has been important. In addition, a number of the beneficiaries and stakeholders interviewed highlighted the role that Innovate UK's monitoring processes have played in providing structure and momentum for the projects. For example, one of the survey respondents argued that *"having a structure to work within, time constraints meant we had to push on and do it"*. As noted in the Catalyst Process Evaluation, often the Monitoring Officers have provided a helpful check/challenge function, ensuring that partners continually focused on routes to exploitation throughout the R&D process. Some also allowed projects the flexibility to adapt to changing contexts, and as a result, consultees felt this enabled them to maximise its potential impact, rather than rigidly sticking to the original plan which – for various reasons – was not likely to deliver against intended impacts.

6.59 A **smooth and seamless transition to follow-on funding** has also been a key factor in enabling projects' pathways to outcomes and impacts. This was clearly evident in the one ATC project that managed to progress from early to industrial stage grant (Lobster Grower 1), where it helped to maintain momentum and commitment from partners, retain staff involved who have the in-depth knowledge of the technology, and continued to accelerate the pace of technological progress.

6.60 Where projects have been more outward facing and undertaken **dissemination activities**, these are beginning to open-up routes to market and further R&D

collaboration opportunities. Whilst it is still early days for many projects, as noted above, this will be increasingly important looking forward.

Barriers and risks

6.61 There have been a number of factors that have inhibited progress to date and risks that may hinder pathways to future outcomes and wider impacts of the programme.

6.62 There were some issues with programme design which has meant that outcomes have been suboptimal – for example, beneficiaries argued that the **length of early and late stage projects** (and the timing of grant approval) were not always compatible with the growing season for the sub-sector in question, particularly where the projects need to gather more than one growing season's data to test a new technology[124].

6.63 As expected in the original Theory of Change and legitimate for R&D programmes which are based on part on uncertainty of effects and risk, **some projects have failed due to unforeseen technical reasons**, which halted the R&D process, **and others have been more complicated than expected**, leading to delays. For example, survey respondents commented that:

"The project did not prove to be commercially viable"

"Discovered a flaw during the testing stage"

"Looking at new techniques as treatments to improve […], unfortunately it had the adverse effect, so we couldn't take it any further in terms of its application"

6.64 During project delivery, **some SMEs involved have found the R&D process difficult to manage.** For example, the view of SME collaborators towards the risk, cost and reward balance of the project changed once two of the case study projects began, as they became more aware of the demands of the project, resulting in scaled back involvement in the project. For example, as noted in Section 5, the SME partner on the mycoprotein substrate project had limited recent experience of R&D – as the project began, they reassessed the risks and costs involved, and due to the perceived negative impacts on existing production, decided to scale back ATC activities.

6.65 According to beneficiaries and stakeholders, there have been a number of other issues that have hindered the progress of projects to date, including:

- Limited **integration with Agri-Tech Innovation Centres** in terms of helping businesses to exploit new technologies, partly due to misaligned timings of the two interventions.
- **Wider challenges associated with a technology/product's ecosystem** that require further R&D (tracking back to earlier TRLs) before a product can be brought to market.
- **IP, licencing and royalty issues** that have hindered project progression.
- **Limited dissemination and "socialisation" of project findings**, with a lack of a clear knowledge exchange strategy/mechanisms (for projects and the programme as a whole) or clarity on dissemination responsibilities post-project. Despite many

[124] See SQW's Process Evaluation of the Catalyst Programmes for UKRI.

of the stakeholders consulted being very active in the agri-tech R&D space, few were aware of projects and their achievements. Linked to this, there is little evidence to suggest that local networks/clusters are playing a role in dissemination, nor does there appear to be dissemination between the ATC project portfolio (perhaps missing opportunities for synergies).

Case study example: WheatScan:

This early stage project successfully developed a hand-held sensor prototype, but for the sensors to be reliable and commercially viable, a much larger and robust calibration to predict nitrogen content is needed. The academic collaborator is funding a PhD student to develop the technology further (albeit covering a wider scope than the ATC project) via a spin-out company, but the industrial lead on the ATC project lacks internal finance and has been unable to secure further public funding to continue their involvement with the technology.

6.66 Despite efforts to maintain a strong focus on exploitation in ATC projects, there was considerable concern across beneficiaries and stakeholders about **“what next” after the ATC project** and the implications this might have for achieving ultimate impacts. As discussed above, **few early stage projects have progressed to next stage ATC grants,** creating risk in relation to project continuation, momentum, loss of partners and expertise. As noted above, some have successfully secured funding from elsewhere, but others have **struggled to secure follow-on finance**. Competing with other sectors (such as health and life sciences) in open competition has been difficult, and many are not in a position to seek/secure private sector investment. Moreover, a number of beneficiaries and stakeholders felt that wider support is/will still be needed to enable their products to reach the market, including for late stage projects. Examples of support need include: signposting/brokerage with private investors; mentoring; exporting advice; and access to networks.

6.67 Finally, looking forward, a number of stakeholders were concerned that the programme has not placed sufficient emphasis on *how* **spillover benefits will be achieved**, which are critical to achieve the Catalyst’s ultimate goals for the wider agricultural sector. When probed in detail, case study consultees could describe the potential impacts of their new technologies/products on the wider sector, but few could articulate how this would happen (beyond their own involvement in taking the product to market) and the mechanisms in place/planned to enable this. Furthermore, a number of beneficiaries highlighted potential challenges in influencing the wider sector, including the skills and financial capacity of industry to invest in the new technology (and supporting infrastructures required to operate the technology), the need to change cultures and attitudes towards new products/processes, and external factors such as rural broadband/digital access, securing food safety standard approval and regulation.

7. Additionality and contribution

7.1 This section presents evidence on additionality of ATC, and explores the contribution and relative importance of ATC to achieving the outcomes and impacts described above compared to wider internal and external factors.

7.2 The analysis of additionality covers two perspectives: 'activity' additionality (i.e. R&D activities that would not have been progressed without ATC) and 'outcome' additionality (i.e. outcomes that have been realised, that would not have been possible without ATC support). The two forms of additionality are related but focus on different aspects of the logic model.

7.3 In each case, additionality has been assessed using self-reported evidence, drawing on beneficiary feedback in the survey and case studies, which has been calibrated with the evidence from those who were unsuccessful in applying for ATC support. There are issues in relying on self-reported information as a core source of evidence on additionality. However, other methods (such the use of econometric or statistical techniques) were not considered viable for the evaluation, as discussed in the earlier Evaluation Framework[125]. The relatively small number of programme participants and unsuccessful applicants means that quantitative analysis on a comparison/control group is not possible; the evidence from the survey of unsuccessful applicants has therefore been used to calibrate the self-reported evidence from a qualitative perspective.

Key messages

- ATC is catalysing new activity in the sector, and encouraging high levels of 'activity additionality' that might not otherwise have occurred in both early and late stage projects. The programme has also brought about a considerable level of additionality in terms of timing and quality of activities, even where the activity progressed without ATC.

- The self-reported evidence suggests the programme has achieved high levels of outcome additionality. Over half would probably or definitely not have achieved the same outcomes in the absence of ATC, and others have been able to generate outcomes more quickly, on a larger scale and to a higher quality with ATC support. Substitution is very low from the evidence we have to date.

- The case study evidence suggests that the collaborative element of the ATC funding is important in realising outcome additionality – outcomes often require complementary expertise, which no single partner could bring to the project. Supporting and enabling this collaboration appears to be an important part of the ATC 'added value'.

- Across the unsuccessful applicant cohort as a whole, fewer have made technological progression without ATC support. However, those progressing their idea anyway have performed relatively well, but for some, ATC stimulated the idea in the first place (even though the activities were not ultimately funded by the programme).

[125] Agri-Tech Industrial Strategy: Evaluation Scoping Study and Baseline, see https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/536388/bis-16-18agri-tech-industrial-strategy-evaluation-and-baseline.pdf

• The evidence indicates that a range of other factors have also contributed to the outcomes achieved, including other R&D activity (as may be expected given pre-ATC levels of R&D) and the development of other partnerships. Further, in most cases, additional investment will be needed in the future for outcomes to be realised

• The relationship of the ATC to these other factors is complex – whilst other factors were commonly seen as equally or more important than the ATC (including wider business plans and strategies) in realising outcomes, the ATC activity often caused these other factors in the first place

• The evidence indicates there are often a number of mutually reinforcing factors that are required to realise outcomes, of which the ATC is an important – and can be a decisive – one.

Activity additionality

7.4 **The ATC is catalysing new R&D activity in the sector, delivering a suggested high level of 'activity additionality' that might not otherwise have occurred at all, as soon, or to the same quality.** Importantly, the survey evidence indicates strong alignment between what beneficiaries *said* they would have *done* in the absence of ATC funding, and what unsuccessful applicants have done without Catalyst funding. Given that the unsuccessful applicants had in most cases similar quality project ideas to the beneficiary leads (as reflected in the assessment score of 70+ in 27 of the 29 cases surveyed), this does help to provide confidence in the self-reported perspectives from beneficiary leads of what they would have done without ATC support.

7.5 Specifically, some **60% of beneficiary leads (12 of 20) responding to the survey reported that they would probably or definitely not have progressed their activities without ATC funding** (and the reasons given for this align with the rationale for ATC, focusing on lack of finance and risk). The level of self-reported activity additionality was broadly similar for early and late stage beneficiaries. Although some care is needed given the modest sample sizes, it is notable that the perspectives from beneficiary leads and collaborators of what they believed would have happened without the ATC support was consistent between early and late stage leads. Given that late stage projects are closer to market and are likely to have already required significant investment (particularly by leads), we may have expected there to be greater confidence amongst late stage leads that they would have progressed their project without ATC funding i.e. to avoid 'wasted' costs previously incurred, and the shorter time-scale to potential returns.

7.6 In turn, two fifths (40%, 8 out of 20) of lead beneficiaries stated that they probably/definitely would have progressed anyway using internal or public funds. **A similar proportion of unsuccessful applicants (12 of the 29, 41%) did in practice progress their project without ATC funding**, mostly using internal funds or (in a small number of cases) other public funds.

7.7 Further, all of the unsuccessful applicants who progressed their idea were affected adversely in terms of timing (mostly by up to two years), and five of the 12 delivered projects that were either smaller and/or of a lower quality without ATC. Four of the 12 that did progress also undertook the project in-house with no collaborators. This **suggests the programme has brought about a considerable level of activity**

additionality in terms of the timing and quality of project activity, even where the activity may have been progressed without ATC.

Table 7-1 Activity additionality – survey results from project/application leads

Beneficiary survey respondents (n=20 leads)	Unsuccessful applicants survey respondents (n=29 leads)
Of the 20 beneficiary leads: • 4 would definitely not have taken forward their projects without ATC (20%) • 8 would probably not have taken forward their projects without ATC (40%) • 5 would probably have taken forward their projects without ATC (25%) • 3 would definitely have taken forward their projects without ATC (15%) • Most of those who would have taken forward activities would have done so with internal funds or other grants • No statistical variation between early and late stage leads.	Of the 29 unsuccessful applicant leads: • 16 had not progressed their proposed ATC project due to lack of finance and high risk (55%) – all of these were early stage applicants • 11 intend to progress in future (most within 3 years), most still reliant on public funding • 12 progressed without ATC funding (41%) ➢ 10 were early stage, and two were late stage applicants ➢ Mostly with internal funding, small number secured other public funding ➢ 12 were delayed (most by 2 years) ➢ 5 smaller scale ➢ 5 lower quality ➢ 8 in collaboration (but only 4 with same partners as ATC proposal)

Source: SQW

7.8 It is also notable that over half (57%) of collaborators surveyed (n=37) indicated they would not have engaged in *similar* collaborative R&D without the ATC support (with no statistical variation between collaborators on early stage and late stage projects). This data demonstrates **the role of the programme in helping to 'capture' and/or 'lock in' a wide range of organisations to engage in collaborative R&D in the agri-tech sector**, with a focus on new product/process development and innovation. This includes academics: of the eight academic collaborators surveyed, five (around two-thirds) stated that they definitely/probably would not have engaged in similar collaborative R&D without ATC.

7.9 The case study findings support the evidence above, and provide further details on why the programme has brought about additional activities – such as how the collaborative approach accelerates the R&D process, broadened the scope and increased the scale compared to what could be funded in-house by small companies (see below).

Case study example: Lobster Grower 1:

In addition to the funding to stimulate the project and engage partners at the outset, there was consensus amongst all partners that the multi-disciplinary collaboration enabled by the ATC funding has been critical to accelerating progression, by enabling simultaneous inputs and feedback loops, rather than bilateral engagement between the NLH and each partner separately, and has led to a better-quality output owing to the complementary strengths and synergies of partners working together. Further, it has enabled the NLH to undertake R&D activity on a far larger scale than would otherwise have been the case without ATC due to lack of internal resources.

Case study example: Rubber track undercarriage systems for controlled traffic farming:

Even though the project lead had prior experience in R&D involving the design and build of new agricultural machinery and components, the ATC grant allowed the development of track systems to be accelerated and the scope of the track development programme broadened compared to what a small and rapidly growing SME could have delivered using in house resources only. Before applying for the grant, the company had already built a similar system, but this was over engineered and thus very expensive. There was strong potential demand from the market for such a product, but the company struggled to finance R&D to develop a more cost effective and flexible system.

Outcome Additionality

7.10 The overarching message is that **'outcome' additionality of early and late stage projects does appear to be high, based on evidence from beneficiaries and stakeholders consulted.** However, the **evidence from the unsuccessful applicants suggests that the level of 'deadweight' in outcomes may be higher than the self-reported evidence alone suggests.**

Self-reported outcome additionality

7.11 The key data on self-reported additionality are set out in Figure 7-1, with the responses from beneficiaries when asked whether the outcomes attributed to the ATC project (as reported in the previous section) would have been achieved if they had not been supported by the programme. It is important to note that given the breadth of outcomes, and the need to ensure that the survey did not place undue burden on respondents, the question covered all of the outcomes that the organisation had identified as being realised or expected (i.e. it was not asked on an outcome-by-outcome basis). Note that the scale, quality and timing effects were not mutually exclusive.

7.12 The key points are as follows:

- Across all beneficiaries surveyed, nearly three quarters (74%[126]) reported that they probably or definitely would not have achieved the same outcomes in the absence of ATC – these outcomes are therefore considered to be "fully additional"; as a high-level comparator for contextual purposes (recognising the important differences in the intervention focus and beneficiary cohort, but using a consistent question), SQW's earlier evaluation of the Smart instrument for Innovate UK found that 51% of beneficiaries surveyed probably or definitely would not have achieved the same outcomes without support[127].
- Only one (out of 57) respondents reported they would have achieved the outcomes anyway without ATC, at the same speed, scale and quality; this suggests a very low level of 'deadweight' across early stage and late stage projects.

[126] 42 out of 57
[127] SQW (2013) Process and Impact evaluation of SMART. See: https://www.gov.uk/government/publications/smartfunding-assessment-of-impact-and-evaluation-of-processes. The programme offered funding SMEs across the UK to engage in R&D projects, which may lead to the development of new products, processes and services. Beneficiary survey n=293.

- For the remainder of respondents (around a quarter of the survey sample), partial additionality was evident, with speed effects the most common, identified by 13 (23%) of all survey respondents.

7.13 This partial additionality evidence reinforces the findings elsewhere in this report that ATC is accelerating the commercialisation process, and where speed effects were identified in most cases the outcomes were brought forward by two-to-three years. This can be an important effect, enabling organisations to undertake R&D more promptly, and develop new products/services/processes and access markets in the UK and internationally more quickly as a result.

Figure 7-1: Self-reported additionality for beneficiary survey respondents, for all, early and late stage respondents

	All (n=57)	Early stage (n=44)	Late stage (n=13)
Full deadweight			
Would have achieved the outcomes anyway, at the same speed, scale and quality	2%	0%	8%
Partial Additionality			
Would have achieved the same outcomes, but not as quickly	23%	20%	31%
Would have achieved the same outcomes, but not at the same scale	12%	9%	15%
Would have achieved the same outcomes, but at a lower quality	7%	5%	15%
Full additionality			
Probably would not have achieved the same outcomes	28%	27%	31%
Definitely would not have achieved the same outcomes	48%	52%	23%

Source: SQW

7.14 According to survey evidence, the level of (self-reported) additionality varies between the type of grant and partner role. The following points are highlighted:

- reported “full” additionality was more common for participants in early stage projects (80%, 35), compared to participants in late stage projects (54%, 7) of late stage respondents (with this difference significant at the 10% level); this may reflect the higher level of risks associated with early stage R&D, the uncertainty and long lead-time to impact, and the lack of alternative funding options, and the closeness to market for late stage projects, as set out in the original rationale for the programme
- reported “full” additionality was more common for collaborators compared to leads (81%/30 and 60%/12 respectively, which is significant at the 10% level), and in

turn, "partial additionality" was more common for project leads – particularly in terms of project scale and quality, where leads were significantly more likely than collaborators to say the outcomes have been brought about on a larger scale and to a higher quality (statistically significant at 1%); the data underpinning these findings are set out in Table 7-2.

Table 7-2: Self-reported additionality for beneficiary survey respondents, by lead and collaborator

Nature of Effect	Leads (n=20)	Collaborators (n=37)	Difference
Partial Additionality			
Speed effects	35%	16%	Not sig
Scale effects	30%	3%	Sig at 1% (z-test)
Quality effects	20%	0%	Sig at 1% (z-test)
Full Additionality			
Probably/definitely would not have achieved outcomes	60%	81%	Sig at 10% (z-test)

Source: SQW

7.15 The explanation for the variation in the findings between leads and collaborators is not evident from the survey data. One possible hypothesis is that project leads were often the main instigator of projects, and may have been more likely to have pursued the idea in some capacity without ATC support, so they were more likely to have "achieved something" (i.e. observed partial additionality) even without the ATC.

7.16 However, the case studies do not support this hypothesis fully – across most of these projects, the perspectives on additionality were similar between leads and collaborators. This said, the case studies do support the overall findings from the survey, with positive evidence on additionality. The summary evidence on self-reported additionality from the case studies, how this may have varied across partners (where relevant), and the key factors (where identified) that informed this feedback are set out in Table 7-3 (with further details in the full write-up in Annex C).

Table 7-3: Case study evidence on additionality

Case study	Additionality	Key points
Maximising mycoprotein substrate utilisation and nutrition	Full	• Consistent level across leads and collaborators • Key collaborator was not involved in R&D and without ATC outcomes would not have been realised
WheatScan: Tractor-mount sensing for precision application of Nitrogen and control of milling wheat protein content.	Full	• Consistent level across leads and collaborators • Added value of the collaboration key to realising outcomes, which would not have been realised without ATC
Evaluating a potential proxy test for Feed Conversion Efficiency in beef cattle.	Full	• Consistent level across leads and collaborators • Added value of the collaboration key to realising outcomes, which would not have been realised without ATC
CAPSEED - A New Seed Conditioning Process for Arable and Horticultural Crops	Full	• Consistent level across leads and collaborators • High risk projects, and without knowledge sharing through collaboration outcomes would not have been realised
Lobster Grower - Develop the technology to fast track the aquaculture potential for the European Lobster	Full	• Some slight variation between partners, but all reported high levels of additionality • Outcomes being taken forward via industrial stage ATC project
Harnessing Natural Fungi to Control Insect and Mite Pests in Grain Storage	Full	• Consistent level across leads and collaborators • Added value of the collaboration key to realising outcomes, which would not have been realised without ATC
Rubber track undercarriage systems for controlled traffic farming	Partial	• Product would have been developed without ATC but would have been delayed • Scale and quality effects also evidence

7.17 As set out in the table above, in six of the seven cases, the evidence suggested that the additionality of the ATC programme was high, where it was reported to be unlikely that outcomes would have been delivered via other means if the ATC project had not been funded. A key theme that emerged here was the importance of the collaboration (enabled by ATC) - this sharing of knowledge and expertise was essential to delivering outcomes. For one case study, partial additionality was evident; this exemplifies well the way in which the programme can support accelerated R&D activity, and deliver wider effects in terms of scale and quality of outcomes.

Case study example: Rubber track undercarriage systems for controlled traffic farming:

The project was led and delivered in full by a single company who reported that they would have still tried to develop the new track system without ATC support, but it would have taken “many years” compared to the very rapid progress made in one year with the ATC support. They also reported that a lack of funding would have meant that the range of systems developed would have been smaller, meaning that the company would have been unable to develop a product which is now in the market internationally having been supported through the ATC project.

Case study example: Harnessing Natural Fungi to Control Insect and Mite Pests in Grain Storage:

The additionality of the project outcomes was reported to be high. Technical success required complementary expertise which no single partner could bring to the project. The lead partner was an SME which could not have borne the risk of funding the research institutes which were essential to the project, especially given the relatively modest returns expected. ATC support was instrumental in bringing the partners together and building on prior research.

7.18 There also appears to be very limited substitution, whereby engagement in ATC projects has diverted participants efforts away from other business development activities, based on the evidence gathered to date. Only three of the 57 beneficiaries responding to the survey reported that the Catalyst had prevented them “a little” from engaging in other business development activities, and issues of substitution were not identified in the case studies.

Unsuccessful applicant experiences

7.19 As discussed earlier in this section, unsuccessful applicant survey respondents were asked whether they had progressed their idea without ATC support, and if so, the nature and scale of outcomes generated by these activities.

7.20 Above, we reported that 41% of unsuccessful applicants had progressed their idea to some degree without ATC funding – and all at a later date. Despite this, only 31%[128] of all unsuccessful applicants have been able to progress their technology towards the market without ATC (compared to 80% of lead beneficiaries who observed this outcome, which is a statistically significant difference at 1%).

7.21 However, the unsuccessful applicants who progressed their idea anyway (12 of the 29 unsuccessful applicants survey respondents, 41%) have performed relatively well. Whilst caution is needed with such a small sample size, we can see that:

- capacity and partnership development outcomes have been observed similar to beneficiaries, such as skills and knowledge development, improved understanding of R&D and commercialisation processes, improved reputation and profile, understanding of market position, and new/improved collaborations

[128] 9 out of 29

- eight of the 12 had introduced new products/services at the time of the survey, with a further three expected to do so in future
- six had introduced new or significantly processes, with a further two expecting to do so in future
- outcomes for employment and turnover are similar to those observed by beneficiaries; the data available on scale is very limited, but job impacts to date are up to five FTE per business (four responses), and under £100k for one and up to £500k for two respondents.

7.22 This evidence for the small group of unsuccessful applicants who have progressed their idea without ATC support (to recap, around one in three of the survey sample), does indicate that they appear to have performed equally as well as ATC projects in terms of product development, initial quantitative outcomes, and wider outcomes from R&D activity related to skills and capacities. This is perhaps not unexpected, and may reflect that many of the unsuccessful applicants will be under increased pressure to commercialise and generate a return on investment when they are self-financed, and potentially more willing to commercialise before the product is "fully" developed.

7.23 Based on the evidence throughout this report on the quality and innovativeness of projects funded by ATC, one hypothesis is that ATC activities have the potential to have greater, more sustainable impacts in future. However, given the low number of unsuccessful applicants providing quantitative estimates of future employment and turnover impact, it is impossible to assess robustly whether future impacts are likely to be different between the beneficiary and unsuccessful applicant cohorts. This will be a key issue to consider in the next wave of the research on the industrial stage awards.

7.24 Interestingly, four of the 12 unsuccessful applicants who progressed their idea anyway stated that the availability of ATC funding stimulated the development of their project idea in the first place. It is plausible that **ATC has played a role in delivering some of the outcomes above, even if the programme did not fund the activities directly.**

Contribution evidence

Context

7.25 A related issue to additionality is the relative contribution of the programme to the outcomes observed, that is, whether the outcomes that appear to have been generated by the support from the ATC have been influenced – to a greater or lesser extent – by other factors, whether this was alongside, or after the ATC project.

7.26 In this context, it is important to reflect on the evidence set out in Sections 4 and 5 regarding the innovation and collaborative behaviours of participants, both before and during their ATC-funded activity. To recap: nearly all beneficiaries surveyed had engaged in R&D activities in the three years prior to their application to ATC, and in nearly all cases this R&D was collaborative, most regularly with universities or customers/clients from the private sector; and eight of the 20 leads surveyed (40%) had received other forms of support to develop the specific idea during delivery of the ATC project.

7.27 This level of collaborative R&D activity and engagement with wider sources of innovation advice/support was also demonstrated by the case studies: in most cases, the project leads had been involved in previous R&D projects and collaborations, including with the research base, and collaborators were drawn from organisations involved in a range of R&D and innovation projects and processes.

7.28 This context matters as it indicates that the organisations supported by ATC have been exposed to a wide range of support and engagement that may have influenced – either directly or indirectly – the activity, and subsequent outcomes that appear to have been generated by the ATC project.

Findings on relative contribution

7.29 Consistent with this context, the survey suggests that the ATC is nearly always one of a number of internal factors, which, taken together, may be contributing to outcomes for programme participants. As shown in Table 7-4, most participants reported that alongside or after the ATC project, other R&D activities had been implemented (including all leads), and three quarters indicated that new innovation partnerships or collaborations (excluding partners on the ATC project) had been established. Other changes or developments were also common, including the purchase of new equipment and new business plans/strategies.

7.30 It is notable that the establishment of new innovation partnerships or collaborations outside of the ATC partnership was more common for participants in early stage projects than late stage projects[129]. This may reflect the development of new relationships associated with innovations/ideas that are at an earlier stage and further from the market where a range of expertise and perspectives are required.

Table 7-4: Other changes or developments at the same time or after Catalyst project (significant difference between Early Stage and Late Stage data in bold)

Change/development	Total (n=57)	Early Stage participants (n=44)	Late Stage participants (n=13)
Other R&D activities implemented	81%	84%	69%
New innovation partnerships / collaborations established	74%	82%	46%
New equipment purchased	54%	57%	46%
New business plan/strategy implemented	49%	50%	46%
Change of leadership or management in R&D team	39%	55%	30%
Other changes in senior management	35%	55%	24%

Source: SQW

7.31 These other changes/developments could, in principle, be fully separate and unrelated to ATC activities and outcomes, with participant organisations regularly involved in a wide range of R&D and other business development activities. However, the survey

[129] The difference between 82% (n=44) and 46% (n=13) is significant at the 1% level (z-test).

indicates that **these other factors were in practice often regarded as more, or equally, as important as the ATC in realising the outcomes identified** by beneficiaries that were associated with the project (as discussed in the previous section).

7.32 The relative contribution of other changes/developments in relation to the ATC was mixed, as may be expected reflecting the different relationship to ATC activities across projects and participants. The changes most commonly identified ("Other R&D activities" and "New innovation partnerships/collaborations") were identified as being of "equal" importance to the ATC in realising the outcomes in around half of cases where these changes/developments were identified. Notably, where a new business plan/strategy has been implemented (n=28), over a third of beneficiaries (36%) indicated this change was "more important" that the ATC project in realising the outcomes associated with the project.

Table 7-5: Response to "Reflecting on the outcomes discussed earlier, how important were these changes to achieving these outcomes compared to receipt of the Catalyst award? Were they more important than the support from the Catalyst, equally as important, or less important.

	…less important	… equally important	… more important	… don't know
Other R&D activities implemented (n=46)	15%	54%	26%	4%
New innovation partnerships / collaborations established (n=41)	17%	49%	29%	5%
New equipment purchased (n=31)	26%	45%	26%	3%
New business plan/strategy implemented (n=28)	18%	36%	36%	11%
Change of leadership or management in R&D team (n=22)	50%	27%	14%	9%
Other changes in senior management (n=20)	40%	20%	20%	20%

Source: SQW

7.33 Looking across the data, over a third of all beneficiaries surveyed identified at least one change/development that was more important than the ATC in achieving the outcomes identified in the survey (37%, n=57). Further, approaching two thirds identified at least one change/development that was regarded as equally as important as the ATC (63%, n=57)[130]. By contrast, one quarter of beneficiaries identified no other changes/developments that were more or equally as important as the ATC, suggesting in these cases that the relative contribution of the ATC project was high.

[130] Note, this does not mean that all beneficiaries identified one or the other as the data are based on whether one of six factors were identified as more or equally as important, and a single beneficiary can therefore be found in both groups.

7.34 The data from the survey split by lead and collaborators, and early stage and late stage beneficiaries are set out below. The differences between the groups are not statistically significant, although this may be owing to the modest sample sizes.

Table 7-6: Beneficiaries identifying at least one change/development more or equally as important at the ATC in realising outcomes

	Proportion with at least one more important	Proportion with at least one equally as important	Proportion with none more/equally as important
Lead (n=20)	50%	70%	15%
Collaborator (n=37)	30%	59%	30%
Early Stage (n=44)	41%	66%	23%
Late Stage (n=13)	23%	54%	31%
Total (n=57)	37%	63%	25%

Source: SQW

7.35 This analysis may suggest that in a majority of cases the relative contribution of the ATC to the outcomes identified has been modest, therefore calling into question the Theory of Change that the programme is enabling these outcomes to be realised. However, the picture is more complex, as the survey evidence also indicated that **the ATC support regularly led – directly or indirectly – to the implementation of these changes/developments.**

7.36 As shown in Table 7-7, half of the organisations with a new business plan/strategy, and around 40% of those identifying other R&D activities and/or the establishment of new innovation partnerships/collaborations indicated this was owing (directly or indirectly) to the ATC project. The survey evidence also demonstrates that the ATC has influenced investment in new equipment by those involved in projects (with the potential to support longer-term efficiency and productivity benefits), with half of those where purchases had been evident alongside/after the project indicating this was directly or indirectly as a result of ATC. This may include equipment that was purchased in order to deliver the project and/or enable the commercialising of the product/service developed.

Table 7-7: Were these changes implemented because of the Agri-Tech Catalyst award?

	A: Number reporting factor evident	B: No. reporting ATC led to other factor directly or indirectly	C: % where ATC led to other factor directly or indirectly (B/A)
Other R&D activities implemented	46	18	39%
New innovation partnerships / collaborations established	42	17	40%
New equipment purchased	31	15	48%

New business plan/strategy implemented	28	14	50%
Change of leadership or management in R&D team	22	7	32%
Other changes in senior management	20	7	35%

Source: SQW

7.37 This evidence suggests that whilst other changes/development were regularly seen to be equally or more important that the ATC support in generating outcomes, the ATC was also commonly responsible for, or contributed to, these changes being progressed in the first place. As such, the relative contribution of the ATC to the outcomes identified is more pronounced that the data set out in Table 7-5 may suggest. The survey data also suggests the **high level of integration of ATC activity with wider business development plans and actions**, with engagement in ATC one of a number of factors that together have been responsible for bringing about the outcomes identified.

7.38 The overall findings from the survey on contribution were corroborated by the case study evidence – with other factors and changes in organisations often working together in a reinforcing fashion to realise outcomes. In four of the seven project case studies, other changes or developments in the partner organisations were identified as being important in realising the outcomes associated with the project, with revised business strategies and the leveraging of other assets and equipment not funded directly by the ATC project important factors identified (with an example provided in the box below).

Case study example: Maximising mycoprotein substrate utilisation and nutrition:

At the same time of the delivery of the ATC project the lead partner invested in new DNA sequencing technology (to support wider business development activity); this technology was piloted as part of the research activity for the ATC project, which supported the progress made in realising the research outcomes and insight.

7.39 However, the case studies also provided further insight on the relative contribution of the ATC and how this is realised practically alongside other factors, and how this may have varied across outcome types, project partners and delivery contexts. Four points are noted.

7.40 First, **the perceived relative contribution of the ATC can vary by outcome-type within individual projects**. As may be expected, the case study evidence suggests that for outcomes that are principally technical in nature (e.g. on specific research insights and findings, and skills and R&D capacity) the relative contribution of the ATC project is high, with other factors generally of lesser relevance or importance across the case study examples. However, for outcomes associated with innovation behaviours, and the commercial development and exploitation of new products/services, the influence of other factors and organisational changes/developments are more pronounced, including where further investments and activity will be required in the future to take products/services to market.

7.41 Second, **the perceived relative contribution of the ATC can vary between partner within projects.** This may in part reflect the different roles that partners are playing in project delivery – with the lead more directly engaged across project elements than partners who can focus on specific research elements, leading to different perspectives on the relative importance of the project on observed outcomes. An example from the case studies is set out in the box below.

7.42 Third, the case studies highlighted **the important role that earlier or contemporary research projects can play in enabling and informing ATC project activity**, including for early stage ATC projects (which accounted for five of the seven case studies). The 'feeder projects' identified in the case studies includes earlier-stage Innovate UK/TSB project (e.g. innovation vouchers), research council funding, research projects funded by other government departments (e.g. DEFRA), and a range of other public research programmes and initiatives. As precursors to the ATC, or as projects being delivered alongside ATC, these 'feeder projects' have been important in providing existing knowledge and insight that the ATC activity has leveraged and utilised. This is a positive finding, indicating that the ATC programme is effectively aligning with, and leveraging the research from, other schemes focused on supporting innovation in the agricultural sector. This said, it does highlight the importance of these other schemes in laying the platform for ATClevel activity (be this early stage or late stage grants), and that other factors in the wider innovation landscape are likely to be required to enable the outcomes that the ATC programme is expected to generate. This is consistent with the survey evidence that indicated a third of lead beneficiaries surveyed had received other public funding that led to the ATC application.

7.43 Fourth, in a number of cases, the case studies highlighted **how organisations delivering multiple technically non-related ATC projects have observed benefits from this combination of activity funded by the programme**. In these cases, the specific ATC project that was the subject of the case study was seen to have reinforced other ATC activity notably around the attitudes to, and capacity for, innovation activity within the relevant organisations, and also working alongside other public funded interventions.

Case study example: Lobster Grower 1:

For the lead, the ATC project was regarded as crucial in achieving the outcomes – including related to R&D capacity and skills of the organisation – with other factors less important. However, for other partners, although similar outcomes were realised, the contribution of the ATC project was seen as more modest and/or less direct, with other factors including new equipment, other R&D activities, and other new innovation partnerships more important that the ATC project. Whilst all partners valued the ATC project the relative contribution varied in line with their involvement.

Case study example: Wheatscan:

Following the project that was the focus of the case study, the project lead has been involved in a number of other ATC projects as both a lead (in two other cases) and collaborator (in six cases). While the projects were not related to Wheatscan in terms of the specific innovation or technology area, it was seen to be this collective engagement with ATC that led to outcomes around a change in business strategy, with an increase focus on activity that can generate IP as a source of future revenue.

7.44 Five other points are noted from across the sources of evidence from the evaluation on the relative contribution of the ATC:

- Both the case studies and beneficiary survey indicated the **importance of external factors** – not influenced or controlled directly by participants – in the ability of the projects to realise their full commercial potential (where relevant), with issues around regulation and the policy landscape (including the implications of Brexit), and levels of market demand identified. These factors were seen as potential barriers to the full realisation of benefits, although wider market and societal changes – including, for example related to a reduction in waste, enhanced efficiency, and changing consumer patterns – were also identified by beneficiaries as important potential enablers, helping to generate demand for innovations. As one survey participant noted in response to a question regarding external factors that have influenced the progress/impact of the project:

"The changes in government policy on plastics. [We] might use our knowledge in a different way in the future to comply with this, because of this grant we were searching for this information and the agenda being pushed by the EU, consumers, retailers and supermarkets"

- Linked to this, the evidence highlights the **complex role that internal and external factors can play in projects**: they can be the initial rationale for the activity (i.e. a new regulatory driver or change in business strategy can help to inform the development of the project), and subsequently, can influence the ability of the project to generate outcomes, or realise these fully in the future.

- Strategic consultees highlighted **the importance of the wider Agri-Tech Strategy in enabling and unlocking the outcomes generated by projects**, at a programme level. Many of the consultees believed the Catalyst and the Strategy were mutually reinforcing, and neither would have been successful separately. The Strategy was seen to demonstrate government's strategic commitment to the sector, with the Catalyst funding putting this into practice in terms of resource and direct support. As part of the wider strategy, it is challenging to unpick the specific influence of the ATC as distinct from this wider context – and the Strategy was not identified explicitly by any of the participant organisations surveyed or consulted in the case studies. However, the evaluation does suggest that this strategic context has been important in raising the profile of the ATC, helping to generate demand from organisations, which may have contributed to the observed (by stakeholders) and evidenced (by the monitoring data) quality of applications.

- The large majority of beneficiaries (and unsuccessful applicants) consulted had **already been active in collaborative R&D**, most financed by other UK-based public funds or internal funds. This is likely to influence a businesses' R&D capacities and ability to bring forward positive outcomes from the ATC-funded project.

- The evidence indicates that **in some cases the contribution of the ATC to the observed intermediate outcomes can be very strong, with no other factors outside of the project identified as influencing outcomes.** For example, for three of the seven case studies, no other factors were identified as being required to bring about the outcomes to date. In one case, this was for a project that did not involve a collaboration, where the project was self-contained within a business that had a long-record in innovation activity. However, in two of the cases, a range of partners were involved, and the relative contribution of the ATC project was regarded as consistently high, with no other factors identified that were of equal or higher importance. This said, in all three of these cases, it was recognised that the ability of the project to realise its commercial potential will rely, or is relying, on other influences not associated directly with the ATC award. This is expected and consistent with the survey data indicating that most projects that expect to realise future benefits will require further investment.

7.45 Taken together, the evidence from the surveys and case studies suggests that **the relative contribution of the ATC in generating intermediate outcomes for early stage and late stage projects around innovation progress/capabilities can be significant, and in some case decisive** (e.g. progressing projects through TRLs, generating knowledge, skills and networking benefits). However, **in most cases, the programme will rely on other investments and activity for the commercial and economic potential of these intermediate outcomes to be realised fully.**

8. Conclusions

8.1 In this final section, we present a summary of the overall contribution story for the ATC for the early stage and late stage awards, and reflect on overall programme performance against objectives and rationale and lessons learned so far. It is important to re-emphasise that this is the first phase of a two-phase interim impact evaluation, focusing on only half of the programme portfolio. In the final report in early 2019, we will provide a comprehensive assessment for the programme as a whole, and provide recommendations for the approach to final impact evaluation in future.

Overall contribution story

8.2 In the paragraphs that follow, we summarise the findings against the key questions that form the basis of the contribution analysis approach and provide a framework for the assessment of the contribution of the ATC to the outcomes observed, drawing on the evidence from across the evaluation's research strands:

- Is there a reasoned Theory of Change, and have activities been implemented as set out in the Theory of Change?
- Is there evidence that the expected results have occurred?
- Was it the Catalyst, rather than other influencing factors that made the difference, or the decisive difference?

Is there a reasoned Theory of Change, and have activities been implemented as set out in the Theory of Change?

8.3 A logic model and Theory of Change were developed at the outset of this study, based on a review of programme documentation and scoping consultations with key strategic and management leads for the Catalyst. The **intended path from activities through to outcomes and impacts appeared to be plausible**, notwithstanding the potential risks identified in the Theory of Change including potential technical failure, on-going barriers to commercialisation (including related to finance), and the level of take-up of the innovations in the wider agricultural sector. This Theory of Change – and the assumptions underpinning it – have been tested throughout this evaluation.

8.4 There is **strong evidence to support the underlying rationale**, particularly in terms of the level of risk involved in supported projects, uncertainty and time-lag to impact, and co-ordination failures that can inhibit collaborative R&D on high-risk projects.

8.5 This said, the evidence on difficulties by participants in accessing finance (and therefore validating the need for ATC support) is mixed. For many projects, ATC was critical in taking forward an idea, because internal funds were unable or insufficient for this type of R&D activity, and there was a gap in the wider support landscape for this type of R&D in this sector. However, most applicants we surveyed (both successful and unsuccessful) were already R&D active – including in collaborative R&D – and only half considered alternative sources of finance to ATC. This does call into question whether the lack of finance was a genuine issue for some beneficiaries, with implications for the additionality of the public funding through ATC. That said, many of the projects were completely new, involved working in many cases with some new partners, and the funding enabled this risk to be shared which can be particularly important in 'unlocking' the activity. The high level of previous R&D experience also de-risks project delivery, and in many cases the ATC has encouraged a collaborative approach (and the associated benefits) that might not have occurred otherwise.

8.6 The inputs have focused on the intended audience and **activities have been implemented as set out in the** Theory of Change:

- Demand for the programme was strong and the quality of projects supported was high, reflected in the fact that a high number of applications exceeding the Innovate UK assessment threshold were not funded due to limited resources.
- The funding catalysed new R&D activity in the agri-tech sector, with approaching half of project leads surveyed stating that the availability of Catalyst funding stimulated the project idea (with a similar level for unsuccessful applicants, which in some cases have been taken forward).
- The programme encouraged spill-ins, of partners who were new to agri-tech and in some cases those who were new to R&D (especially public sector R&D). It has stimulated new collaborations and the convergence of technologies, and stimulated new ideas for new products, services and processes. Notably, whilst many projects include partners that have worked together before, three quarters of participants surveyed worked with at least one new partner through the ATC project.
- The nature of activities delivered align closely with the proposed scope of early and late stage awards, and supported projects to move through technology stages. The process of innovation has been iterative for many projects, with some activities diverging from their original plan (often for good or unforeseen reasons) and others raising new research questions that create feedback loops to earlier TRLs.
- There is a high level of 'activity' additionality, with the evidence suggesting that under half of the activity funded by ATC would have progressed in some form without the support; there is strong alignment between what successful applicants said they *would have done* if they had not received ATC support and what unsuccessful applicants *actually did*, which provides confidence that this assessment is robust. Where projects were progressed without ATC by unsuccessful applicants, in all cases they were delayed, with some also smaller and/or of a lower quality.
- Technological progress has been made more quickly that would have been the case without ATC support. Many of those taking projects forward after ATC have required further investment (either via collaborator/customer funding or public sector grants) to do so; this is to be expected, particularly for early stage grants with ATC focused on progression within TRL levels before commercialisation.

8.7 However, **six important issues have been identified where the Theory of Change has not been realised as expected**, some of which may limit the programme's potential for future and/or wider impacts:

- Projects have not been able to progress through the ATC grant types as anticipated in the original Theory of Change, due to the short timeframe of the programme. The risk is that projects are unable to continue to commercialisation if they are unable to secure funding from elsewhere (for many, the original challenges that led them to apply for ATC funding have not disappeared).

- There has been limited knowledge exchange across the ATC project portfolio, which may be a missed opportunity in terms of synergies between projects and generating greater impact on aggregate from the projects funded.
- Dissemination activities have been sub-optimal. Whilst there is some evidence to demonstrate project-level dissemination in very sub-sector specific areas and programme-level promotion by Innovate UK and DIT, there is widespread concern amongst stakeholders that current dissemination levels and mechanisms are insufficient if the programme is to achieve wider impacts.
- Links to the Centres for Agricultural Innovation have not been realised as expected to date. The expectation was that ATC project participants would engage with the Centres to assist in sharing research and scaling-up implementation: the evaluation evidence suggests this has happened to a limited degree only. This is owing in large part to the misalignment in timing between the ATC programme and establishment of the Centres which is outside of the influence of ATC, however, this was viewed by some strategic consultees as a missed opportunity for synergies under the Agri-Tech Strategy.
- There is limited evidence of links between ATC projects (especially the late stage projects, but potentially others) and DIT. This would be useful to help ATC beneficiaries to exploit their technologies globally and take advantage of the substantial export opportunities. The DIT representatives consulted were certainly keen to play a greater role in supporting beneficiaries to export and facilitating links with potential investors (for example, by creating a ‘pitch book’) and overseas customers.
- Improved understanding of private sector investor requirements/opportunities, as a result of ATC support, is evident for around half of beneficiaries. Whilst this was not an explicit objective of ATC, it is a key assumption in the Theory of Change that will enable many projects to progress ideas to market and grow their businesses, and suggests that there is a need for linkages to other related interventions that do focus on this issue to be developed further, including through the project aftercare process.

Is there evidence that the expected results have occurred?

8.8 The evaluation also indicates that there has been **mixed performance in delivery against project-level objectives**: of the surveyed participants of completed projects, half reported that they had fully achieved the objectives of the project, with a third indicating that objectives had been achieved in part, and some (four of 32) that the objectives had not been achieved at all. This view was consistent across project stages and between leads and collaborators, and participants in on-going projects provided similar perspectives, with around a half expected to meet all their objectives.

8.9 This reflects the non-linear process of innovation, with examples in case study research where early stage prototypes required more rounds of iteration than expected, and where progress with one aspect of the innovation raised research questions for other parts of the product ecosystem that required testing. Issues around how IP developed through ATC projects would be managed also appear to be evident, preventing projects from meeting their objectives fully. Further, some project failure in R&D programmes is to be expected, and arguably is desirable; zero or no failures would imply that the programme was overly risk averse – or supporting only low risk projects – suggesting lower additionality of the public funding.

8.10 The evaluation indicates that the **outputs and intermediate outcomes set out in the original logic model have been achieved to date, although the nature and scale of effects varies**:

- Early stage and late stage projects are expected to secure £7.4m of private sector investment in R&D through match funding for ATC projects, and there is some evidence of ATC projects leveraging further investment to continue the R&D process and/or take the innovation to the market post-completion of the ATC project. Although illustrative only given the small sample size, the scale of this post-ATC investment was linked to the TRL level at the point of project close for the examples identified in the evaluation.
- Common outcomes observed to date – by both leads and collaborators, and early and late stage projects – include enhanced R&D and commercialisation capacity (detailed below), improved profile, credibility and reputations, improved staff skills and knowledge, improved understanding of market position and opportunities, and new or strengthened relationships between industry and academia. There is very little difference in the nature or extent of outcomes observed by early and late stage projects.
- Capacity building effects have been considerable, and it is plausible that these will have a sustainable legacy in terms of R&D and commercialisation behaviours and innovation looking forward. For example, collaborations have been sustained, beneficiaries are more likely to invest internal funds in R&D in future and/or bid for public funding, business plans have become more commercial, knowledge and capacity (in terms of skills, expertise and staff) will be used to inform future R&D activities, and (leads in particular) have gained R&D management skills that they are/will employ to help deliver future R&D activity more effectively. These benefits have often been realised even where the specific technical/scientific focus of the project has not been realised in full, or requires further investment.
- There is evidence of new products/services, and in some cases processes, reaching the market, with more to follow in the near future, although most will require further R&D investment to do so. This is evident for both early and late stage projects, although late stage projects are more likely to have reached the market, with the evidence suggesting that around half of late stage projects have led to a new product/service in the market at this point. Participants regularly experience a combination of these effects i.e. both new product/service development to take to the market, and process improvements leading to internal productivity and efficiency gains, reflecting the integrated and often multifaceted nature of ATC project activity.
- There is evidence of modest quantitative effects on employment and sales (supporting business growth) so far as a result of new products/services reaching the market, although there is significant variation across the beneficiaries consulted and some very positive examples where beneficiaries are successfully exporting their products/services; this is consistent with the wider evidence on R&D and innovation support where the benefits are often uneven across participants. Employment effects have been evident within the R&D process in advance of

market activity, as participants have taken on staff to develop the project further. The majority of the employment and turnover impacts remain expected rather than realised, reflecting the time-paths to impact of R&D.

8.11 There appears to have **been limited impact on the wider agricultural sector to date** – as we would expect from R&D projects of this nature, and given the timing of the evaluation, with many projects still in the R&D stage and/or early in their commercial roll-out. There is greater confidence in future impacts on productivity, produce quality and environmental sustainability (and more modest impacts on animal health and welfare), but beneficiaries appear to be most focused on direct benefits for those involved with limited consideration of how their projects will have a wider, large scale impact on the sector.

8.12 Figure 8-1 provides a headline summary of progress against the intended outputs and outcomes set out in the original logic model for ATC, based on evidence gathered for this first phase of the evaluation for early and late stage projects only.

Figure 8-1: Progress against outputs and outcomes set out in the original logic model [✓✓✓ indicates strong progress; ✓✓ indicates some evidence of progress, ✓ indicates limited progress to date]

Activities	
Early stage - test commercial potential of scientific ideas/ feasibility of new technologies (taking ideas up to TRL 4)	✓✓✓
Late stage awards, to test/trial innovations in real-life context ahead of larger-scale deployment, incl. commercial assessments for technologies that are closer to commercialisation (to TRL 9).	✓✓✓
All projects involve collaboration between industry and research base.	✓✓✓

Outputs	
Additional private sector investment in R&D	✓✓✓
New patents filed	✓✓✓
Number/New collaborations between industry and research	✓✓✓
Skills acquisition	✓✓✓
Commercial applications (incl. 'spill ins'), tech. progress, reduced risk of failure	✓✓✓
Research outputs	✓✓
New data available to industry	✓✓

Outcomes/impacts	
Intermediate outcomes	
Increased business engagement with research base	✓✓✓
Strengthened & sustained collaboration	✓✓✓
Greater understanding of innovation processes	✓✓✓
Changes university attitudes, behaviour, knowledge of commercialisation process, understanding business needs, propensity to collaborate	✓✓
Leverage of further investment	✓✓
New products/processes taken to market	✓✓
Business growth/productivity for participants	✓✓
Take-up of new products/processes (UK/overseas)	✓
Turnover (incl. exports) and employment in wider AT sector	✓

Source: SQW

Was it the Catalyst, rather than other influencing factors that made the difference, or the decisive difference?

8.13 The evidence suggests that the programme has **achieved high levels of outcome additionality.** Whilst the unsuccessful applicants evidence suggests some degree of deadweight and there will inevitably be some optimism bias in self-reported beneficiary estimates of additionality, there is a consistent message across the consultations undertaken that over half of the outcomes observed to date would not have been achieved without ATC, or would not have been brought about as quickly, to the same scale or quality. Most projects led by unsuccessful applicants did not progress, and those that did were substantially different and delayed in most cases.

8.14 **The collaborative approach has added significant value to the scale, quality and speed of outcomes achieved through ATC.** Collaboration was consistently identified as the critical factor in enabling pathways to impact – projects benefited from the technology convergence and synergies associated with complementary expertise, skills and experience, research could be undertaken at sufficient scale to validate results, industry provided commercial pull and expertise in commercialisation processes, and businesses and membership bodies provided routes to market.

8.15 In terms of the contribution and relative importance of ATC compared to other factors, the evidence suggests that ATC is nearly always one of a number of factors that have influenced the outcomes achieved. In many cases, other internal factors – especially other R&D activities, new equipment, new innovation partnerships or collaborations and new business plans – were regarded as more or equally as important as the Catalyst in realising outcomes. However, crucially, ATC support was commonly responsible for – directly or indirectly – these other internal factors being introduced. Overall, at this stage of the evaluation, we conclude that **ATC is one of a number of interdependent and reinforcing factors that have been important in realising the project-based outcomes observed by businesses consulted, but that ATC was the decisive factor for many beneficiaries particularly in terms of intermediate outcomes.** This said, we recognise that the large majority of beneficiaries (and unsuccessful applicants) consulted had already been active in collaborative R&D, most financed by other UK-based public funds or internal funds. This is likely to impact upon the businesses' R&D capacities and ability to bring forward positive outcomes from the ATC-funded project. Further, in most cases, the **programme will rely on other investments and activity for the commercial and economic potential of these intermediate outcomes to be realised fully.**

8.16 In this context, it is notable that **engagement with sources of innovation support/expertise that are not included within the consortium to develop the idea/innovation appears to be a common element of ATC project delivery:** of the 20 leads surveyed for this stage of the evaluation, eight (40%) indicated that they had received other forms of support to develop the idea *during delivery of the ATC project*, including from other research organisations, RTOs, and private providers. This external support was accessed across project types (e.g. academic and business leads, early stage and late stage projects, projects at different stages of technology development). This may reflect the iterative nature of innovation, with expertise/capabilities that were not expected at the outset required. However, how and why this external support is required will be an issue that we will seek to probe more fully in the next stage of the evaluation with industrial stage awards, to inform the overall contribution analysis.

Overall programme performance against objectives and rationale

8.17 Early evidence gathered for this first phase of the evaluation suggests **the programme is performing well against its aims to "***accelerate translation of research into practical solutions, best practices …***" and encourage greater R&D in the sector.** It is probably too early to assess whether this is then translating into *"… applications of new technologies in agriculture"*, increased turnover and exports, improved agricultural productivity and reducing environmental impacts, and improved competitive position of the UK's agri-tech sector internationally. The foundations appear to be in place to achieve these wider impacts – many of the projects expect to deliver against these – but the key question is whether the mechanisms are in place (and implemented) to ensure these wider impacts are realised.

8.18 **More broadly, the programme appears to be delivering against the Agri-Tech Strategy's ambitions for the Catalyst**, which focused on supporting collaborative relationships between academics and industry, attracting co-investment from the private sector (it has secured match from those directly involved, but has been less successful in leveraging wider private sector investment), supporting SMEs to take part, and catering for a wide range of project types.

8.19 **The programme has also addressed many aspects of the original rationale.** For those involved, co-ordination failures have been addressed in a sustainable way, as evidenced by ATC collaborations providing access to networks, partners continuing to work together on R&D postATC and a greater propensity of those involved to collaborate with others. It has also addressed – in part – information and risk failures and uncertainty, by enabling technological progression that reduces the risk associated with taking the idea to the next stage of development. However, many projects have or will require further R&D to fully address these issues, and there is some concern about projects' investment readiness to secure finance from the private sector (at an appropriate point). The programme has performed well in terms of some spillover effects – such as knowledge and R&D capacities – but it is too early to assess market spillovers and wider externalities for the agricultural sector as a whole.

8.20 Further, it is important to recognise that **the performance of the ATC at this point has relied to a significant degree on other factors in the wider innovation landscape**, and it is one of a number of complementary factors that have been required to deliver outcomes for participants. These factors include both pre-ATC research funding and investment through 'feeder programmes' (that had supported around a third of project leads), other R&D activities, collaboration and support activities that have been delivered in parallel to ATC project, and the strategies and plans of participant organisations that have aligned with and complemented the ATC activity. Importantly, and reflecting the high level of innovation activity participants in the programme, these factors, including the ATC, have been reinforcing and complementary, not independent.

Key lessons learned

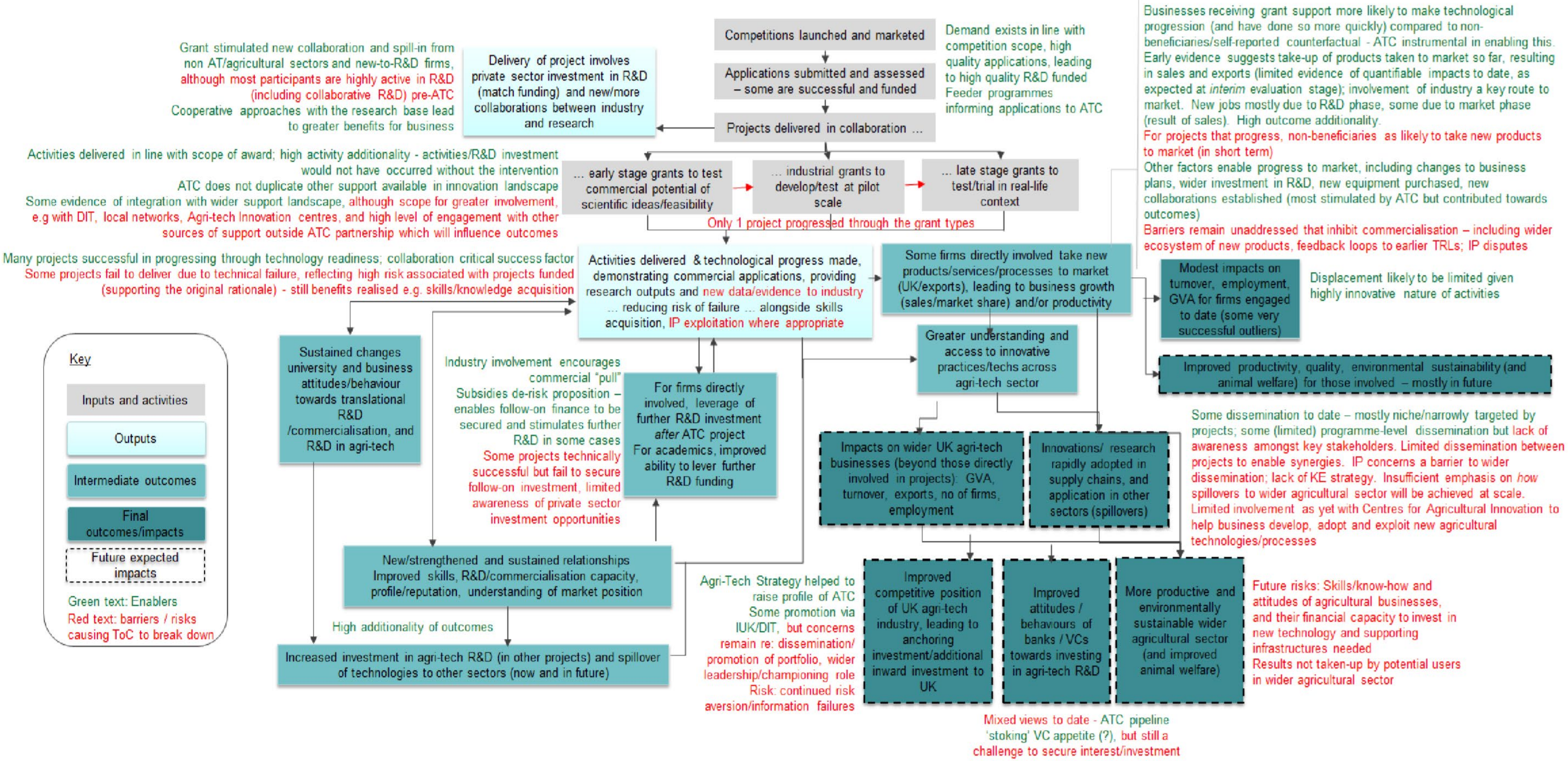
8.21 Key lessons to date around what has enabled or hindered progress and pathways to impact are summarised below:

- Ensure the programme duration is sufficiently long to enable a seamless transition to next stage funding, accelerating technology progression further, and mitigating the risk that viable technologies will be stalled as a result of a lack of follow-on finance
- The success of a broad challenge-based competition to attract spill-ins, leading to new/innovative convergence of technologies
- High demand, with high-quality, innovative and high-risk projects selected, which creates strong foundations for subsequent outcomes/impacts

- The added value of a collaborative approach in terms of effective project delivery and progress, and routes to impact; this does not in all cases need to include all new partners, the evidence suggests projects can be successful where there is a mix of both established and new partners, balancing risk-mitigation and leveraging of existing relationships, with the potential for new opportunities and knowledge sharing
- Scope for greater integration with elements of the wider support landscape during and after ATC projects, particularly to assist in securing follow-on finance and accessing markets (including overseas) – support could include DIT, local networks and clusters, mentoring, signposting/brokerage with private investors, and the Agri-Tech Innovation Centres.
- The importance of knowledge exchange and exit (next stage development) strategies for each project, and developing these as early as possible. On the latter, effective programme and project dissemination is essential, including clear responsibilities for undertaking this after project completion, to ensure awareness and adoption across the wider agricultural sector.

8.22 Finally, the diagram below presents a summary of findings from Phase 1, in terms of the outcomes and impacts achieved/expected, and key factors that have enabled or hindered pathways to impact for early and late stage projects (or might do so in future). It shows how the original Theory of Change (set out in Section 3 of this report) has played out in practice. This will be tested again in Phase 2, before final conclusions are made for the programme as a whole.

Figure 8-2: Theory of Change in practice – A summary of outcomes/impacts and key enablers/barriers for early and late stage projects



Source: SQW

Annex A: Further detail on methodology

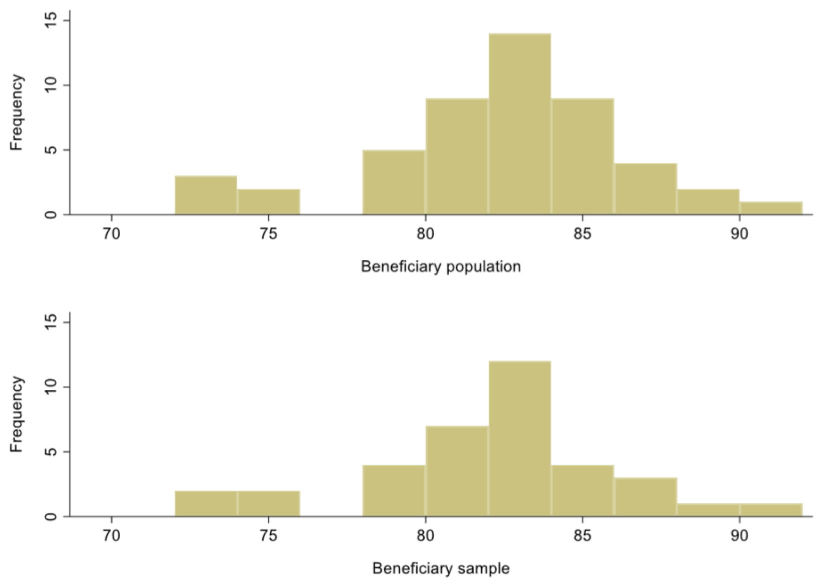
Beneficiary survey

A.1 The composition of the beneficiary survey sample is broadly similar to the programme population:

- 77% of all respondents were industry (vs 75% of population)
- 75% of lead respondents were industry (vs 78% of population)
- 78% of collaborator respondents were industry (vs 73% of population)
- for industry leads, respondents had a similar profile terms of business size and sectors to the population. For example, 42% of the early stage survey respondents were in the Professional, Scientific and Technical Activities, compared to 44% of all early stage projects, and 33% were in the Agricultural sector, compared to 28% of the population. In terms of business size, 41% and 22% of early and late stage projects respectively had 0-9 employees (cf 43% and 25% respectively for the population).

A.2 The beneficiary sample is representative of the population in terms of the average assessor scores on applications, i.e. the difference between the mean scores for the two samples is not statistically significant (see Figure 8-3)[131]. The mean average score for beneficiary sample was 81.6 compared to 81.9 for the population. Table A-1 below provides some further descriptive statistics for the two samples.

Figure 8-3: Distribution of application scores (beneficiary sample vs population)



Source: SQW analysis of application scores

[131] A t-test was used to determine if the sample mean is equal to population mean (the null hypothesis). A p-value of 0.63 indicates that the differences in mean values is not statistically significant (i.e. we could not reject the null hypothesis).

Table A-1: Further descriptive statistics on application scores (beneficiary sample vs population)

	Beneficiary Sample	Population
Observations	36	49
Mean	81.6	81.9
Min	72	72
Max	91	91
Std. Dev.	4.1	4.0
Variance	16.5	15.9
Skewness	-0.5	-0.7

Source: SQW analysis of application scores

Unsuccessful applicant survey

A.3 We have compared the unsuccessful applicant survey respondents to the population of unsuccessful applicants, which shows:

- 83% of lead respondents were industry (vs 83% of population)
- for early stage unsuccessful applicants only, 81% were industry leads (vs 80% of all early stage unsuccessful applicants)
- for late stage unsuccessful applicants only, both were industry leads (vs 100% of all late stage unsuccessful applicants).

A.4 For industry leads, respondents had a similar profile terms of business size and sectors to the population. For example, early stage respondents were similar in size to all unsuccessful early stage applicants, with a median number of employees of 12 (cf 14 for population) and turnover of £750k (cf £690k for the population).

A.5 The sample of unsuccessful applicants was not designed to be representative of the full population of 201 applications that did not receive funding, but rather representative of subset of “fundable” unsuccessful applications. These were defined as all applications that received an assessor score of 70 or more. Due to the small number of late-stage applications above this threshold (two), the subset also included all late-stage applications, irrespective of the assessor score. The mean score of this subset was 73.4 compared to 74.7 for the sample surveyed. The difference between the mean scores for the two samples is not statistically significant[132]. Figure 8-4 provides a comparison of the distributions of the subset and sample, while Table A-2 provides some further descriptive statistics for the two samples.

[132] 132 A t-test was used to determine if the sample mean is equal to population mean (the null hypothesis). A p-value of 0.07 indicates that the differences in mean values is not statistically significant (i.e. we could not reject the null hypothesis).

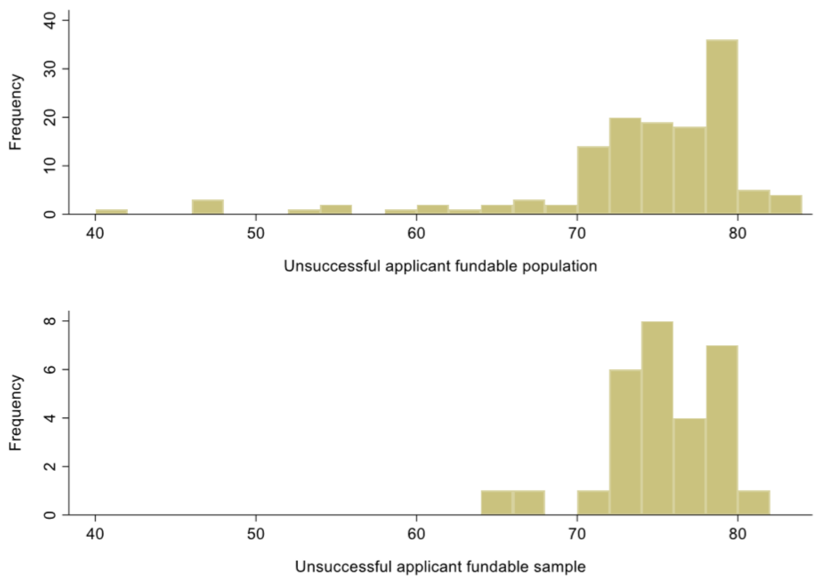


Figure 8-4: Distribution of application scores (unsuccessful applicant "fundable" population vs sample)

Source: SQW analysis of application scores

Table A-2: Further descriptive statistics on application scores (unsuccessful applicant sample vs "fundable" population vs total population)

	Unsuccessful Applicant Sample	Unsuccessful Applicant "Fundable" Population	Unsuccessful Applicant Total Population
Observations	29	134	201
Mean	74.7	73.4	68.7
Min	64	41	23.2
Max	81	83.6	83.6
Std. Dev.	3.8	7.4	10.6
Variance	14.8	54.3	112.7
Skewness	-0.7	-2.1	-1.4

Source: SQW analysis of application scores

A.6 Also, when comparing unsuccessful applicant respondents to beneficiary respondents, we can see that:

- Current employment is higher in beneficiary lead firms (median=20) compared to unsuccessful applicant firms (median=12), but turnover is similar for both groups (median=£750k for both)
- Beneficiary lead firms on average older than unsuccessful applicants, but there is significant diversity within each group

Annex B: Additional monitoring data analysis

Applications

Table B-1: Number of applications submitted and % successful by round and type of grant[133]

	Early		Industrial		Late		Total	
Round	**Applications**	**Success rate**	**Applications**	**Success rate**	**Applications**	**Success rate**	**Applications**	**Success rate**
One	30	27%	21	67%	5	40%	56	43%
Two	51	18%	39	33%	4	25%	94	24%
Three	45	20%	20	45%	8	50%	73	30%
Four	48	8%	27	30%	9	33%	84	18%
Five	43	16%	39	26%	7	29%	89	21%
Total	**217**	**17%**	**146**	**37%**	**33**	**36%**	**396**	**26%**

Source: IUK monitoring data

133 All applicants could reapply once after being unsuccessful. As such, the numbers here do not account for duplication and therefore the number of unique applicants will be lower than the number of applications.

Table B-2: Percentage of applications scoring 70 or more

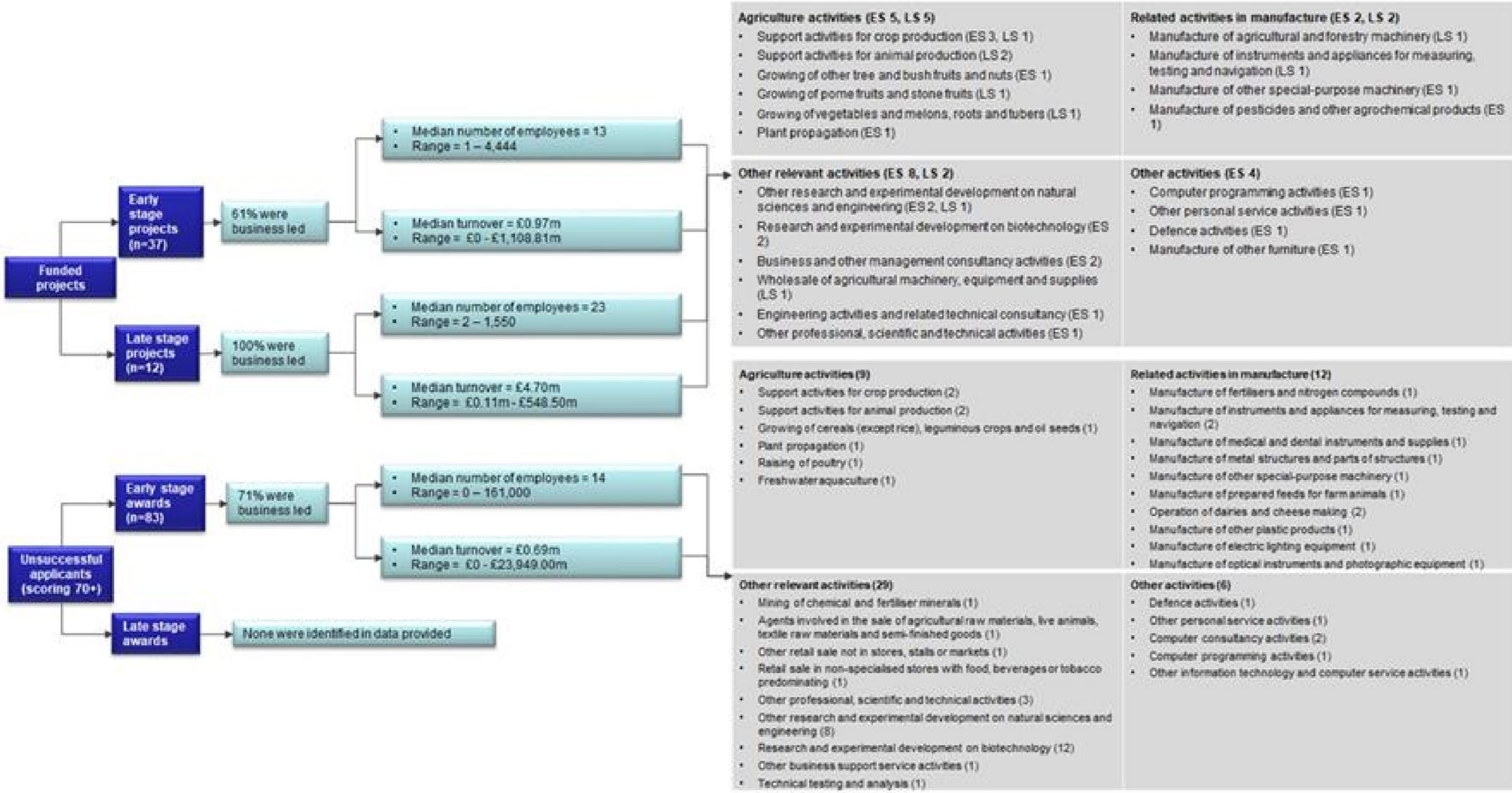
	% of applications scoring 70+				% of applications scoring 70+ that were funded			
Round	**Early**	**Industrial**	**Late**	**Total**	**Early**	**Industrial**	**Late**	**Total**
One	60%	81%	40%	**66%**	44%	82%	100%	65%
Two	75%	87%	25%	**78%**	24%	38%	100%	32%
Three	62%	70%	50%	**63%**	32%	64%	100%	48%
Four	67%	89%	44%	**71%**	13%	33%	75%	25%
Five	79%	87%	57%	**81%**	21%	29%	50%	26%
Total	**69%**	**84%**	**45%**	**73%**	**25%**	**44%**	**80%**	**36%**

Source: IUK monitoring data

Characteristics of applicants

B.1 According to baseline data contained within the application forms, the characteristics of lead organisations is broadly similar in terms of scale and sectoral focus (see below). In terms of employment, **the median number of employees is similar for leads of funded projects and unsuccessful applications for early stage awards** (13 employees for project leads, and 14 employees at leads of unsuccessful applications**). The median number of employees is notably higher for leads of late stage projects,** at 23. The pattern is similar for turnover.

Table B-3: Application data analysis – summary (Note: for sector, the numbers in parentheses represent the number of businesses in that sector)



Source: IUK monitoring data

Number of projects

Table B-4: Number of projects by round and type of grant

Round	Early	Industrial	Late	Total
One	8	14	2	**24**
Two	9	13	1	**23**
Three	9	9	4	**22**
Four	4	8	3	**15**
Five	7	10	2	**19**
Total	**37**	**54**	**12**	**103**

Source: IUK monitoring data

Table B-5: Status of projects, across all three types of grants

Type of grant	Closed	Final Claim	Live	% Total	Total number of projects
Early	51%	22%	27%	**100%**	**37**
Industrial	2%	2%	96%	**100%**	**54**
Late	83%	0%	17%	**100%**	**12**
All three	**29%**	**9%**	**62%**	**100%**	**103**

Source: IUK monitoring data

Table B-6: Status of projects, by rounds (early stage only)

Round	Closed	Final Claim	Live	% Total	Total number of projects
Early					
1	88%	13%	0%	100%	8
2	78%	22%	0%	100%	9
3	56%	33%	11%	100%	9
4	0%	50%	50%	100%	4
5	0%	0%	100%	100%	7
All rounds	**51%**	**22%**	**27%**	**100%**	**37**

Source: IUK monitoring data

Table B-7: Status of projects, by rounds (late stage only)

Round	Closed	Final Claim	Live	% Total	Total number of projects
Late					
1	100%	0%	0%	**100%**	**2**
2	100%	0%	0%	**100%**	**1**
3	75%	0%	25%	**100%**	**4**
4	100%	0%	0%	**100%**	**3**
5	50%	0%	50%	**100%**	**2**
All rounds	**83%**	**0%**	**17%**	**100%**	**12**

Source: IUK monitoring data

Number of leads and collaborators

B.2 In total, there were 83 unique leads involved in the 103 ATC funded projects. Of the 83:

- Fifteen leads were involved in leading more than one project[134]
- ten leading on two projects
- and five leading on three projects.

B.3 Within **early stage projects** specifically, there were **31 unique leads**, of which six were leading on more than one project. In contrast, there were **12 unique leads leading the 12 late stage projects**.

B.4 Furthermore, of the 83 unique leads across the whole programme, **14 leads were also acting as collaborators on other ATC projects**. Although six of these leads were only involved in one other project as a collaborator, the remainder were involved in two or more projects as collaborators (and one was involved in 15 projects as collaborator).

Table B-8: Number of leads leading more than one project, across all three types of grants

	Early	Industry	Late	Total
Number of unique leads	**31**	**40**	**12**	**83**
- Lead in 1 projects	25	31	12	68
- Lead in 2 projects	6	4	-	10
- Lead in 3 projects	-	5	-	5
Total number of projects	37	**54**	**12**	**103**

Source: IUK monitoring data

B.5 In aggregate, there were **229 unique collaborators**, of which 44 organisations collaborated in more than one project. To note, the 229 figure includes those 14 leads mentioned in the table above, i.e. leads who were also collaborators on other projects.

B.6 Focusing on **early stage projects**, there were **78 unique collaborators**, of which nine played the role of collaborator in more than two projects. There were 19 unique collaborators for late stage, all of whom played the role of collaborator on one project.

[134] In total, the 15 leads were involved in 35 projects; 16 of which were early stage, 15 industrial, and four late stage.

Table B-9: Number of collaborators, collaborating in more than one project, across all three types of grants

	Early	Industry	Late	Total number
Number of unique collaborators	78	132	19	229
- Collaborating in 1 project	69	97	19	185
- Collaborating in 2 projects	7	24	-	31
- Collaborating in 3 projects	1	3	-	4
- Collaborating in 4 projects	-	3	-	3
- Collaborating in 5 projects	1	1	-	2
- Collaborating in 6 projects	-	1	-	1
- Collaborating in 7 projects	-	1	-	1
- Collaborating in 9 projects	-	1	-	1
- Collaborating in 15 projects	-	1	-	1
Total number of collaborators	**91**	**132**	**19**	**318**

Source: IUK monitoring data

Type of leads and collaborators

Type of leads

Table B-10: Type of lead across all the types of grants

Type of organisation	Early	Industrial	Late	Programme
Micro business	30%	20%	25%	24%
Small business	16%	26%	33%	23%
Medium business	5%	6%	17%	7%
Large	14%	46%	25%	32%
Academic	35%	0%	0%	13%
Charity	0%	2%	0%	1%
Total %	100%	100%	100%	100%
Total number of projects	37	54	12	103

Source: IUK monitoring data

Type of collaborators

Table B-11: Type of collaborators, by type of grant

Type of organisation	Early	Industrial	Late	All three
Micro	19%	15%	21%	17%
Small	13%	17%	42%	18%
Medium	7%	4%	21%	6%
Large	23%	29%	16%	26%
Academic	31%	26%	0%	26%
Catapult	1%	0%	0%	0%
Charity	0%	0%	0%	0%
Research and Technology Organisation	7%	5%	0%	5%
Public Sector Research Establishment	0%	1%	0%	1%
Unknown	0%	1%	0%	1%
Total %	**100%**	**100%**	**100%**	**100%**
Total number of collaborators	**91**	**208**	**19**	**318**

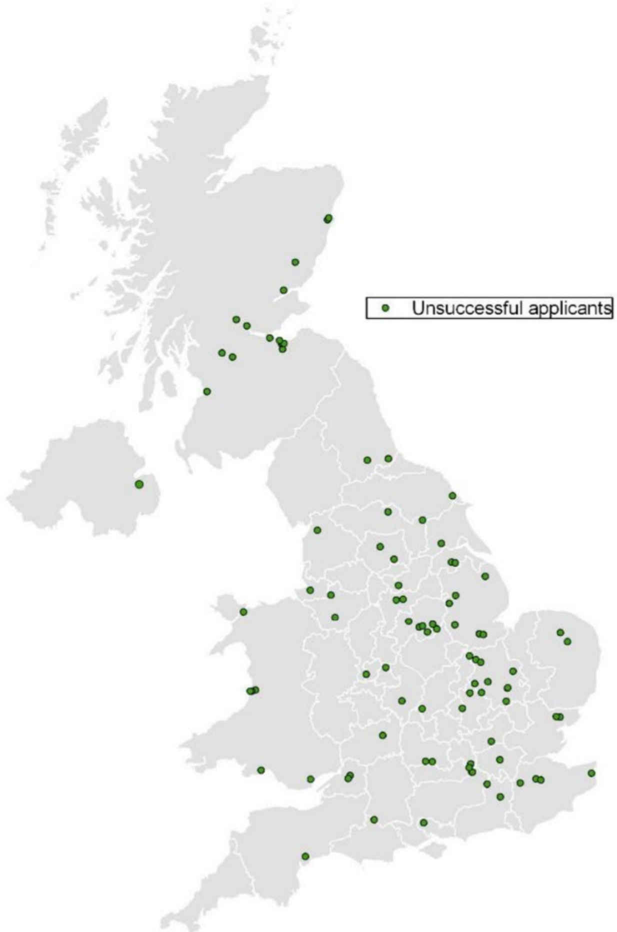
Source: IUK monitoring data

Table B-12: Beneficiaries and Unsuccessful applicants by region

	Beneficiaries	Unsuccessful
East Midlands	13%	14%
East of England	16%	18%
London	8%	6%
North East	1%	7%
North West	4%	6%
Northern Ireland	1%	1%
Scotland	18%	17%
South East	11%	17%
South West	10%	5%
Wales	2%	6%
West Midlands	11%	3%
Yorkshire and the Humber	6%	0%
Total %	**100%**	**100%**
Total number of organisations	**131**	**100**

Source: IUK monitoring data

Figure8-5: Unsuccessful applicants by region



Source: IUK monitoring data

Annex C: Case study reports

Case Study – Maximising mycoprotein substrate utilisation and nutrition

Key messages

• The project was an early stage feasibility study, awarded in Round 3, seeking to test the potential to address major challenges in primary agricultural production with the development of new and enhanced ways of producing mycoprotein (produced and sold in the UK as Quorn).

• The project was led by NIAB-EMR, a research institution specialising in research on horticultural crops and plants and their interactions with the environment, in collaboration with Marlow Foods Ltd ("Marlow Foods") - an industrial food producer, and world-leaders in the mycoprotein production, who conduct business as Quorn Foods.

• The project proved successful and investments are currently underway to exploit the results through further R&D, including to test new sugar sources at scale.

• The most significant impact of this work has been changes in attitude and strategy by Marlow Foods towards R&D following the success of this project. At the time of the application, Marlow Foods were not conducting R&D beyond work to incrementally improve processes within their production facilities. As a direct result of this project, the leadership at Marlow Foods developed the confidence to invest substantially in R&D efforts, first through the recruitment of an R&D specialist, then in securing two PhD studentships (one with NIAB EMR and another with Nottingham University), and the development of a KTP with Teesside University. The company have also recently invested more than £2m in the development of a new pilot testing facility. In combination, these investments are viewed as laying the foundations for the development of Marlow Foods in-house R&D capabilities to support the future development and expansion of the business.

• Key enabling factors supporting the success of the project included the experience of NIAB EMR in related technology areas in addition to their pro-active approach to seeking out new areas to exploit their expertise. More broadly, increasing demand for non-meat sources of protein is increasingly creating opportunities to be exploited by companies with suitable products like Marlow Foods.

Source: SQW

Introduction

In 2015, an **early stage Agri-tech Catalyst** (ATC) grant of just under £385,000 (£317k awarded) was awarded to support a feasibility study exploring the potential to, among other things, produce mycoprotein – a form of protein derived from fungi (*Fusarium venenatum*) grown in vats using sugar as a source of food – from alternative sugar sources. The project, titled "Maximising mycoprotein substrate utilisation and nutrition", was led by East Malling Research (now "NIAB EMR") – a research institution specialising in research on horticultural crops and plants and their interactions with the environment – in collaboration with Marlow Foods Ltd ("Marlow Foods") – an industrial food producer, and world-leaders in mycoprotein production, who conduct business as Quorn Foods.

The study was delivered between November 2014 and August 2016, generating a range of outcomes that have each seen further investment and progress since the close of the project. Not only has the project generated valuable new knowledge into new sugar sources for producing mycoprotein, which is forming the basis for further R&D efforts to reach the market, but it has also changed the strategic direction of Marlow Foods. Marlow Foods have not conducted R&D into new innovations arising from scientific developments since the late 1990s. Following the success of this feasibility study, the company have since recruited an R&D specialist, have taken on PhD studentships to develop promising new research arising from the project, and have committed over £2 million to the development of a pilot plant to support future R&D efforts. Indicatively, in terms of progression towards commercialisation, the project advanced from TRL level 3 to 5. Since completion, follow-on work has been conducted in related and spin-off areas. Once the pilot testing facility has been developed, further progress is planned to advance the potential to use new sources of sugar, as well as new strains of fungus, to develop new and improved products and services.

The case study involved consultations with the two project partners, building on survey responses received at an earlier date from each, in addition to a review of the project application and closeout reports.

Project overview

Reducing the consumption of meat has become a global priority[135] for reducing carbon emissions and alleviating pressures on land use for raising and feeding meat production. This ATC-funded project is a response to these pressures, arising out of some brainstorming by the NIAB EMR team into new areas to apply their growing expertise in *Fusarium* (a genus of fungus), and specifically in controlling *Fusarium graminearum* – a pathogen that infects wheat and barley. Following this brainstorming exercise, the team identified the "*Quorn story*" and proactively approached Marlow Foods to discuss the potential to innovate in new areas. In collaboration, NIAB EMR and Marlow foods identified the following challenges as the basis for developing an application for ATC funding:

- The potential for using alternative sources of sugar for mycoprotein production, as production is currently reliant upon one source (wheat-derived glucose), for which there is only one supplier in the UK.
- A lack of knowledge of certain aspects of the mycoprotein production process, particularly in terms of the production of undesirable by-products (secondary metabolites, such as mycotoxins, for which there is zero tolerance in production) and unwanted morphologies (c-variant, which leads to undesirable product quality), regarding which increased knowledge could generate production efficiencies and cost savings.
- A more general lack of knowledge about the properties of *Fusarium venenatum* at a detailed, genomic level. This foundational work is required for further R&D work to be progressed.

[135] Harrison, R. and Johnson, R, (2018) Mycoprotein production and food sustainability, Microbiology Today, forthcoming

This project was the first time the project partners had collaborated. In fact, for Marlow Foods, this project represented the first instance of R&D work since the late 1990s, when the work that had been continued from when the company was established[136] was allowed to lapse. NIAB EMR, as a research organisation established in 1913, have a long history of engagement in R&D projects at various TRL levels, which includes several ATC-funded grants in unrelated areas, as well as other Innovate UK grants, and grants and PhD studentships with BBSRC.

The project involved a series of workstreams (please see the Theory of Change diagram, below), some in parallel and some interdependent. A first step was for NIAB EMR to sequence the genome of *Fusarium venenatum*, as the basis for subsequent (and future) research into the biology of the organism. Once completed, further work to identify the triggers of mycotoxin and other undesirable by-products was progressed. Complementary work was also completed to edit the *Fusarium venenatum* genome using CRISPR[137] technology to identify strains of the fungus with enhanced characteristics, as well as the development of a library of mutagens of the fungus using non-GM (i.e. so as not to produce Genetically Modified Organisms) methods (specifically, a method called downstream Tilling[138]). In parallel, Marlow Foods conducted tests on the development of by-products (c-variant, in particular) during scale production in order to generate data to support future research, as well as to test for the potential to realise efficiencies in production. For example, Marlow Foods currently run production campaigns in their fermenters until levels of c-variant reach a certain threshold[139], however this threshold had not been rigorously tested. The results of the testing provided evidence to suggest that the currently tolerance threshold could be altered. Follow-on R&D is currently underway to more comprehensively understand the implications of changing the level of c-variant permitted in production runs.

Effects and role of the Catalyst

The project was regarded as successful by both project partners, and proved the feasibility of using alternative sources of sugar for the production of mycoprotein, advancing the technology in this respect from TRL 3 to approximately TRL 5. The key outputs of the project were as follows:

- Fully sequenced genome to pave the way for the rest of the ATC project R&D (also with potential to inform other future R&D activity).
- Two alternative sources of sugar identified for further R&D.
- Generation of a large quantity of data on Marlow Foods’ production campaigns, incorporated to inform future research.
- Increased understanding of effects of different levels of c-variant. Findings suggest that current tolerance thresholds can be increased, subject to further R&D.

[136] Marlow Foods were incorporated 1983 in order to commercialise Quorn, following 15 years and over £1 billion (current value) in investment by Rank Hovis McDougal and Imperial Chemical Industries.
[137] Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) is a technology designed to target and edit specific stretches of genetic code.
[138] Targeting-induced local lesions in genomes (TILLING) is a powerful, cost-effective method used to detect mutated organisms to support things like gene discovery and assessment.
[139] As levels of c-variant increase, the product develops different qualities, such as an altered texture, which are undesirable.

- Development of a library of approximately 3000 *Fusarium venenatum* mutagens (following downstream tilling), including several priority targets to progress in subsequent research (a result of the gene editing work using CRISPR technology).
- The development of methodologies for all of the above, with may be exploited in future research.

As is typical of feasibility studies, the potential commercial outcomes to result from this work are subject to further R&D. While aspects such as the use of alternative sources of sugar may take a number of years to be exploited, some economic returns may be realised within the next 12 months. For example, the team at Marlow Foods have progressed their understanding of c-variant occurrence and control in their production campaigns. Subject to some final R&D, the benefit of this work is the ability to raise thresholds for c-variant accumulation in the fermentation, as well as allow for a more flexible approach production. This is projected to realise cost benefits in production of around £150k per annum.

For the consultees, aside for the technical successes in terms of the project's stated objectives outlined above, the most significant benefit from this work has been the change in attitude by Marlow Foods to conducting R&D. During the course of the project, Marlow Foods were made aware of the significant "gap in the base science" that offers a range of opportunities to improve processes and develop new products. Much more than just prompting this change in attitude, the project was also reported to have made a major contribution in terms of laying the foundations for conducting a range of future research and strengthening of in-house capabilities at Marlow Foods. It was noted that had it not been for the speculative approach from NIAB EMR, work in this area would not have progressed and Marlow Foods would have continued operating as they had been – i.e. very limited R&D. **In other words, the project's outputs and outcomes are regarded as fully attributable to this ATC-funded project's success.**

The following are notable as a set of direct results that have emerged from the ATC project, and that would not otherwise have been realised:

- Recruitment of an R&D specialist to lead the development of an R&D team/capabilities. This R&D specialist, with 30 years of experience, brought an established network of potential collaborators in industry and academics to engage with in future R&D (the KTP with Teesside, noted below, provides one example). Marlow Foods are currently organising a workshop with their network of academics to explore opportunities for new areas of research.
- Investment confirmed for the development of a £2 million pilot testing facility, including a chemostat bioreactor. This will support future R&D work in areas such as strain improvement.
- Securing two PhD studentships to advance promising avenues of research identified during the project (one in collaboration with NIAB EMR as a logical extension of this work – to understand the fundamental genetic changes associated with different levels of c-variant and another with Nottingham University – to study the potential of new fungal varieties).
- Work is currently underway to secure a KTP with Teesside University to look at the proteome of the organism following fermentation. This will act as a base for regulatory approval and for process improvement and validation.

- The establishment of a collaborative relationship between NIAB EMR and Marlow Foods, which has since been progressed as part of the PhD studentship above, but also in terms of the development of a co-authored article to be published in Microbiology Today later in 2018 to disseminate the key findings from the project. The project partners are actively exploring new opportunities to innovate, subject to appropriate R&D funding opportunities.

- The establishment of a set of R&D projects with the CPI, fully funded by Marlow Foods, to extend the fermentation knowledge and establish the groundwork for future R&D work.

In the longer term, the project may well contribute to the broadening of the supply of mycoprotein from a range of sugar sources, which will contribute to addressing the global challenge of reducing protein consumption derived from meat. This may be of particular consequence to emerging markets should other sources of sugar in plentiful supply in such locations (e.g. sugars derived from rice) prove commercially viable.

The work as also had some indirect, wider benefits. In parallel and separate to this project, Marlow Foods made a £50 million investment in a new production fermenter. Once installed, there were some difficulties in its initial operations. Through a combination of applying elements of the research findings from the ATC project, and the expertise of the newly recruited R&D specialist, these (business-critical) issues were addressed rapidly, and the fermenter was made fully operational. The newly appointed R&D specialist is also occasionally called-upon to support ongoing incremental process innovation activities within the production facilities.

For NIAB EMR the results of the ATC project have supported work they are undertaking in other areas. One example is the development of knowledge in fermentation, which is having enabling, spill-over effects in other areas of work, including in viticulture and brewing science – two areas of research that NIAB EMR have recently started working in, following recent investment in two fermentation units. This work and experience has supported the development and deepening of relationships, including with the Kent Fungal Group.

Our overall assessment suggests that this outcome, as well as the specific technical outcomes of the project, **are "high additionality", and "would not have occurred had the project not gone ahead".** In terms of **the contribution of the ATC** to the achievement of the noted outputs and outcomes, as compared to other factors, our assessment is that this can equally be regarded as high. For Marlow Foods, who were neither engaging in, nor considering, R&D of this nature before being approached by NIAB EMR, the project work, and investments in their R&D capabilities post-project, are regarded as a direct outcome of the work. In terms of wider factors, the emphasis on protein derived from non-meat sources may have played some role in securing their involvement and subsequent investments in R&D. Similarly, the company's reliance on one type of sugar from a single supplier, combined with price volatilities, may have also shaped how receptive the company was to make progress in this area. From the NIAB EMR perspective, the work built on their longstanding expertise in a closely related area, as well as past expertise of the particular researcher involved (e.g. expertise in fermentation developed in a previous role). Unrelatedly, NIAB EMR also invested in a new, more sophisticated DNA sequencing technology, which was piloted on the Fusarium venenatum organism, which supported progress made.

In terms of challenges and arose during the course of the project, the feedback was generally limited. Initially, as this was Marlow Foods' first engagement in substantial R&D for many years, it took time to get up to speed with the technologies involved and engage fully with the study. In addition, aspects of the project were put on hold or revised as the company reassessed the risks and costs involved. As Marlow Foods were using their main production facilities to conduct the R&D, some tests proposed were changed as understanding of this risks and costs involved increased. For example, the original scope included testing of a new sugar source in the main production fermenters. However, due to perceived risks that the testing may affect commercial production, and also because of the costs involved in doing so, this planned testing was instead carried out at lab scale. As noted, the company are now investing in a pilot plant facility where R&D of this nature can be carried out in future.

The diagram below summarises the progress made during the project, including how the ATC project led to outcomes and impacts. On the whole, the routes to impact were as expected at the outset – the main difference being some redefinition of objectives due to a re-assessment of the risks and costs associated with carrying out tests on a new sugar source in Marlow Foods' main production fermenter.

Legacy and next steps

As noted, the major outcome and legacy of this project is the triggering of a change in strategy at Marlow Foods to develop their in-house R&D capabilities.

Following the completion of the project, a series of R&D activities are ongoing. These are mostly at the fundamental science-level (early stage TRLs), particularly while Marlow Foods progresses with their investment in a new pilot plant facility. Once complete, the company will begin to exploit their growing in-house R&D capabilities to advance a number of research avenues towards commercialisation, particularly in terms of testing new sources of sugar, but also in terms of conducting research into new strains of fungus with promising properties (some of which were identified as part of the ATC project). As this project has successfully de-risked several avenues of research, it is likely that further R&D will be funded by the business. However, building on the success of the collaboration, new areas of research are, and will be, progressed in collaboration with NIAB EMR (such as the current PhD studentship) as well as via public funding opportunities if suitable schemes arise. Successful exploitation of the projects results will also depend on the successful completion of a range of relevant food-safety standards and regulations.

Lessons

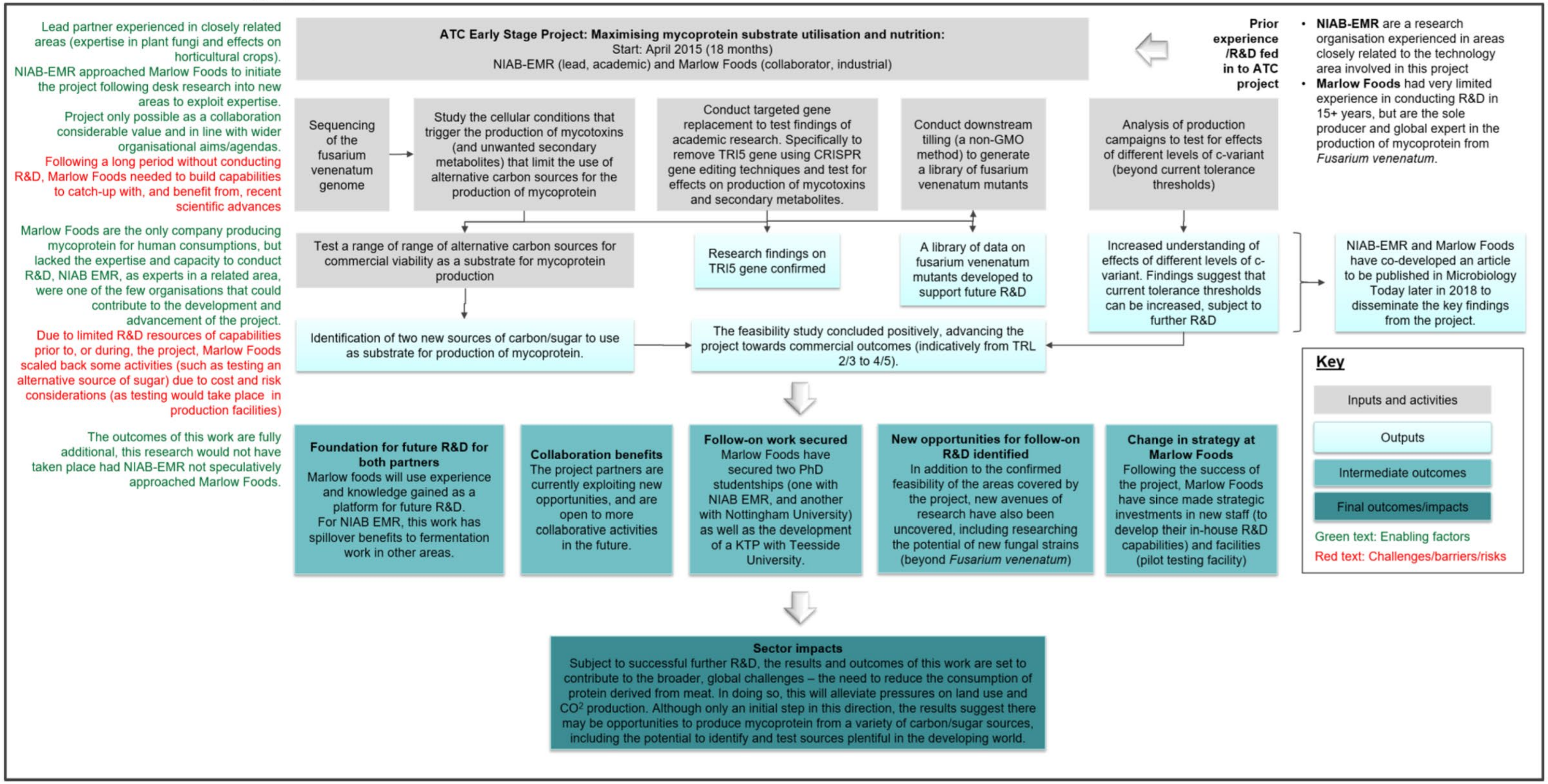
The principal lesson to take from this project's progress is the important role of organisations like NIAB EMR for seeking to identify new areas to develop and exploit their expertise by engaging in collaborative R&D work. The ATC funding model proved highly complementary to this process, effectively providing the level of funding required, with sufficient risk appetite, to de-risk and encourage investment in targeted technology areas and sectors. The consultation feedback suggested that this promising work would likely not have been funded via other Innovate UK competitions, both before or after the Catalyst, nor by the BBSRC. Without some form of funding, this project would not have gone ahead due to the costs and risks involved. As such, the ATC model be regarded as important for catalysing a wider set of R&D investment and activities that may have a very substantial and sustainable long-term impact once brought through to commercialisation.

The collaborative nature of the project was essential to the success of the project. Marlow Foods are the only company producing mycoprotein for human consumptions but lacked the expertise and capacity to conduct R&D. NIAB EMR, as experts in a related area, were one of the few organisations that could contribute to the development and advancement of the project. Equally, a key lesson for projects involving companies that going back to doing (or are new to) R&D is the need for realism in terms of what can be delivered given timing and other practical issues. In this case, the use of Marlow Foods' main production facilities to conduct the R&D proved too risky for strands of the work as initially proposed.

As a feasibility study, the project also highlights the need to recognise that the full benefits from work of this nature take time – and require further investment – to deliver tangible effects. However, as this case study has highlighted, work of this nature can also result in some quick wins, in this case in terms of cost savings from process innovations anticipated in the next 12 months.

Figure C-1: Project Theory of Change in practice

CASE STUDY FOCUS: Maximising mycoprotein substrate utilisation and nutrition



Source: SQW

Case Study – WheatScan: in field sensing for precision application of Nitrogen and control of milling wheat protein content

Key messages

• The project was an early stage R&D grant, awarded in Round 1, seeking to develop a sensor for autonomous mapping of protein content across wheat fields to enable precision application of nitrogen. Nitrogen is the primary input cost in milling wheat production; however, it is over applied in three out four cases.

• Key benefits delivered to date include:

➢ Increased skills and R&D capabilities – for workforce in dealing with large datasets, developing prototypes and project management.

➢ Changed behaviour towards innovation and applied R&D - increase consciousness amongst senior management at ADAS to exploit opportunities where there is potential to create IP and generate future revenue. ADAS are now more inclined to lead projects, rather than subcontracting and facilitating research, which has been the principle focus.

➢ Key learning and lessons learnt - partners learnt that a tractor-mounted sensor was not a) practical, or b) financially viable for the intended market, and that growers and agronomists are more likely to be interested in purchasing a smaller, cheaper and more practical handheld unit. The scope of the project was revised accordingly.

➢ Knowledge transfer – researchers at the UoM gained access to agricultural expertise provided by ADAS and Camgrain growers. ADAS accessed skills of a university-based partner and developed knowledge of developing a prototype.

• Future anticipated benefits to the wider industry include intelligence gathering - the sensors will gather important data, creating significant opportunities such as reduction in nitrogen waste on farms and aiding farmers in management decisions to improve efficiency on farm.

• The collaboration between ADAS and UoM, and access to Camgrain network of growers were critical to the success of the project. The collaboration enabled the development of the prototype to be completed over a shorter timeframe, at a much lower cost, and calibration of the dataset was much larger than otherwise.

• The WheatScan sensor is still two-to-three years away from market. Partners were unsuccessful in securing follow-on ATC funding to take the project further. However, a UoM spin out company has been formed to develop the technology further. Precision Decisions, a private limited company, have funded a PhD student for this task.

Source: SQW

Introduction

In 2014, an early stage Agri-Tech Catalyst (ATC) grant of just over £200,000[140] was awarded to a project named **'WheatScan: in-field sensing for precision application of Nitrogen and control of milling wheat protein content'** as part of the first ATC competition. The project was led by ADAS, in collaboration with the E-Agri Sensors Centre at the University of Manchester (UoM) and Sainsburys[141].

The project fuses agronomy research, on rapid assays for milling wheat, with engineering of photonic sensors, image recognition and mechatronic systems. The original goal was to deliver a tractor-mount scanning unit for autonomous mapping of protein content across wheat fields, to a high spatial resolution at full field application speeds for precision application of nitrogen. Nitrogen is the primary input cost in milling wheat production; however, it is over applied in three out four cases. This system aims to enable growers to dynamically map protein distribution in the crop canopy so that all areas attain the threshold 13% content. The scope of the project changed in the early phases of the project, where it become evident through conversations with growers and because of practical limitations, that developing the on-tractor sensor was not a feasible objective. Instead, the project developed a prototype for a hand-held sensor, which would be much simpler, cheaper to produce, more versatile and therefore more attractive to end users. The early stage project was delivered between May 2014 and October 2015.

This was ADAS's first ATC grant. Since this project, ADAS has been involved in a further eight ATC projects, two of which it has led on, and six it has collaborated on. Of the eight projects, six were industrial stage and two were early stage. However, none of these projects was directly related to the WheatScan project, and had all started before the completion of the first project. The case study involved consultations with both ADAS and the UoM, supported by survey responses by ADAS, and a review of project applications and the close-out report[142].

Project overview

Prior to this project, ADAS received HGCA[143] and DEFRA funding through the Sustainable Arable LINK scheme for a project titled "Predicting grain protein to meet market requirements for bread making and minimise diffuse pollution from wheat production". This project developed protein calibrations for the Bruker Matrix NIR spectrometer. The work has been commercialised further through joint work with Sainsbury and Camgrain. The major limitation to full commercial exploitation of the Bruker instruments has been the intra-field variation in grain protein content, necessitating uneconomic sampling effort of bringing wheat ear samples back to the lab for analysis and interpretation. The work proposed in the ATC project intended to develop a sensor system that can work 'on the go' in the field, thus capturing the intra-field variation with zero sampling effort, and using the understandings in Nitrogen requirements and protein calibrations developed in the LINK scheme project to give effective interpretation, decision and variable rate application for the farmer.

The motivations and rationale for engaging with the ATC varied by partner:

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[140] Total cost of the project was just over £252k.

[141] Grower members of the Sainsbury's 'Wheat Development Group' within the Camgrain co-op.

[142] Under the revised scope, Sainsbury did not have a major role in the development of the prototype. As such, the project lead did not think it would be worthwhile to consult Sainsbury for this case study.

[143] HGCA is a division of the Agriculture and Horticulture Development Board.

- For UoM, **the ATC enabled industry and academic collaboration** – UoM had received ESPRC funding for very early stage development of the engineering sensor concept. After project completion, UoM reached out to Sainsbury to discuss the wider application of the sensors and potential route to market. Sainsbury informed UoM of its earlier LINK project with ADAS and some of the challenges faced. Initial discussions suggested the sensors could potentially overcome issues related to sampling, and be a useful tool for agronomist and growers. In order to develop the technology further, UoM required access to agricultural expertise provided by ADAS and Camgrain growers. The ATC enabled a new partnership, as UoM had not previously collaborated with ADAS.
- For ADAS, **the ATC provided the finance to engage in a high-risk early stage project, which it would not have done so otherwise** – ADAS has mainly acted as a subcontractor and facilitated research. It undertakes publicly funded research and consultancy for a wide range of government department and agencies, as well as levy bodies (AHDB) and research councils via sub-contracts with collaborators. Recently, there has been a slight shift in business strategy, where ADAS are more actively looking to pursue areas of research where there is potential to generate IP and revenue for the business. This requires taking on higher risk, and the responsibility of leading projects. In December 2016 (just after the ATC project), ADAS went into voluntary insolvency and was purchased by RSK. The financial environment in ADAS in the preceding few years was not conducive to high-risk investments. Funding a project considered as being outside core business activity and high risk through the businesses own internal finances was considered not feasible.

As highlighted in the introduction, the scope of the project was revised in consultation with Innovate UK and Camgrain growers. The project initially intended to develop a tractormounted unit, but this was reviewed within the first three months of the project, when it became apparent this would not be a feasible objective. Instead, the project aimed to develop a hand-held sensor. The revised delivery plan had two key objectives: a) the development of the prototype, and b) the development of a calibration to predict the wheat ear protein content. Whilst UoM successfully completed the first objective within timeframe, there were some specific challenges in completing the second. To complete the second objective, a calibration dataset was required. Within the 18-month project, two growing seasons had been targeted for the collection of these samples including wheat ears with a range of protein contents, varieties and developmental stages. This initial calibration dataset included scanning over 120 wheat ear samples from both ADAS field trials and Camgrain farms. These calibration samples were collected so that they could be scanned using the WheatScan sensors and these outputs could then be compared to the known protein contents of the wheat ears from other analyses including the Bruker matrix from the LINK scheme project. Whilst the dataset has been successfully developed for this, progress with the calibration development was slower than anticipated as consequence of unexpected complications in the image analysis. This included correcting for shadows in the images caused by the positioning of the LED lighting. As such, the final phase of the project, which aimed to determine whether there are relationships between the images and protein content was slightly delayed.

Effects and role of the Catalyst

The partners regarded the project a success, as it delivered against the two original objectives, albeit with the need for a revision in scope. The project successfully i) developed a prototype for the hand-held sensor, and ii) developed calibration to predict wheat protein content.

The early stage project brought about a range of benefits for those involved including:

- **Learning** regarding the development of the technology. The partners learnt that a tractor-mounted sensor was not a) practical, or b) financially viable for the intended market and that the intended market (growers and agronomists) are more likely to be interested in purchasing a smaller, cheaper and more practical hand-held unit. In addition, partners learnt practical lessons in how to develop a WheatScan sensor e.g. importance of maintaining a steady hand whilst sampling and the important to resolve shadow problems, which can change the results of a sample. Both ADAS and UoM had not anticipated these issues at the beginning of the project, but are now more aware, and this knowledge is considered to be invaluable for future development of these units.

- **Knowledge transfer between partners.** Through consultation with ADAS's network of growers and agronomists, the team at UoM developed a better understanding of their requirements. Without the collaboration, UoM would not have benefited from such information. Moreover, the project allowed ADAS to develop a better understanding of sensors and the type of challenges faced in the developing a prototype.

- The **ATC improved skills and R&D capacity** for both partners. Specifically, it enabled ADAS to improve its skills and capabilities in handling large datasets, as well as project management skills. The consultee at ADAS said they had benefitting from IUK processes, where they have incorporated IUK monitoring requirements such as the risk registers onto other R&D projects. For UoM, the project enhanced existing knowledge of sensors.

- Whilst partners have not engaged in any major dissemination activities, there have been **a number of publicity documents** produced including; a project outline video produced by Sainsbury, blog on the Agri-Tech website, blog on ADAS website, Posters presented at ADAS open days in 2014, 2015, and at the Agri-Tech East REAP conference. UoM do aim to publish non-commercially sensitive areas of the research in peer reviewed journals.

- For ADAS, the combination of several IUK projects, including this ATC project, has led to a **change in business strategy and approach**. ADAS has traditionally facilitated research, acting as sub-contractor in most instances. On this project, ADAS led the project and contributed matched funding. Consultees noted an increase in consciousness amongst senior management at ADAS to exploit opportunities where there is potential to create IP and generate future revenues.

Whilst the WheatScan sensor is believed to be at least two to three years away from full commercialisation, which will require further R&D activity and investment, the project does expect to **create benefits for the wider industry in the future**. The collection of data, as enabled by this project, will create potential significant opportunities for reduction in nitrogen waste on farms, aiding farmers in management decisions to improve efficiency on farm leading to reduced costs and higher yields.

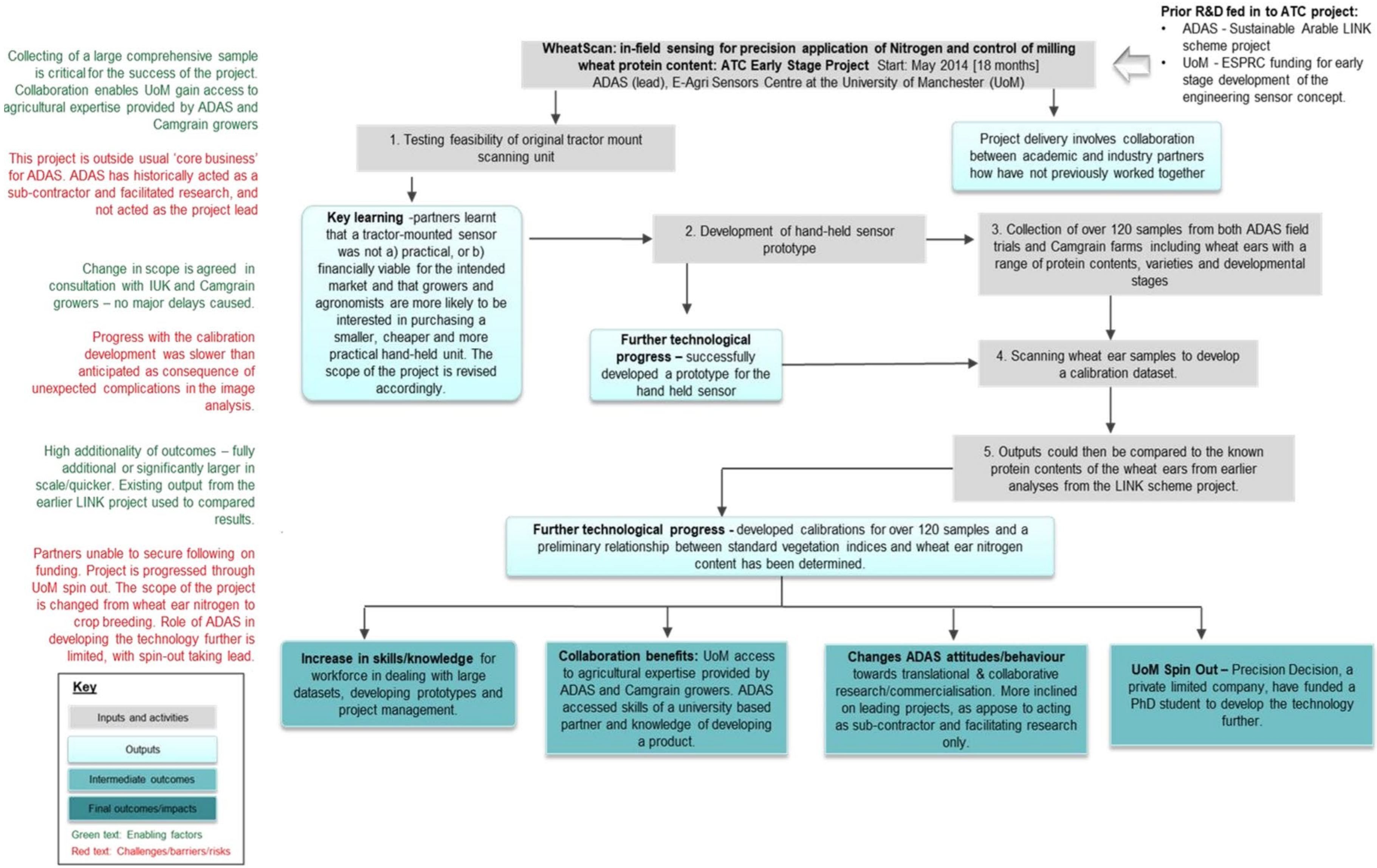
Overall, the **'additionality' of the outcomes achieved so far is high** – both project lead and collaborator consulted indicated the project would *"probably not"* have achieved the outcomes without the ATC. As mentioned above, ADAS went into voluntary insolvency in December 2016 (just after the ATC project end). The financial environment in ADAS in the preceding few years was not conducive to high-risk investments, particularly for projects where return on investment could be several years. For the UoM, although there may have been options to seek research council funding for the project, the collaborative nature of ATC call made it particularly attractive. The linkages with ADAS and access to Camgrain growers was critical, as it ensured a comprehensive sample to test the validity of the prototype. Without access to ADAS's networks, UoM would have found it difficult to collect the samples. **The added value of the collaboration meant the project was completed over a shorter timeframe, at lower cost, and calibration of the dataset was bigger than otherwise.**

The relative contribution of ATC achieving the outcomes highlighted above compared to other factors are twofold:

- First, there are **some outcomes**, which the ATC project has directly contributed towards, **with no other factor influencing it**. These in principle are the technical and scientific related outcomes of the project. For example, knowledge development and learning around the infeasibility of a tractor-mounted sensor, and the requirement by growers and agronomist for a more flexible hand-held sensor. Another example is the learning around the importance of maintaining a steady hand whilst sampling and the importance to resolve shadow problems. No other factors outside the project contributed to these specific outcomes.
- • Second, there are **certain outcomes where other factors, notably the feeder project (i.e. LINK scheme project), have either enabled the ATC project to achieve the outcomes, or have also directly contributed towards the outcome.** The results from the LINK project were compared against the ATC project to confirm validity. Another example is the change in business strategy and approach, where there is increase consciousness amongst senior management at ADAS to exploit any opportunities where there is potential to create IP and generate future revenues. This was a result of a several public research grants, not just the ATC.

Figure C-2 below summarises the activities delivered on the ATC project, and how these have led to outputs/outcomes to date and expected to have an impact in the future. The annotation in the green text highlight key factors that have enabled progress (or will in the future), and the red text are key challenges to date/risk to achieving intended impacts in the future.

Figure C-2: Project Theory of Change



Source: SQW

Legacy and next steps

The project continues to have an impact on how both project lead and collaborator view R&D and commercialisation activity (discussed above). The project was able to develop calibrations for over 120 samples and a preliminary relationship between standard vegetation indices and wheat ear nitrogen content has been determined. Going forward, consultees identified a number of remaining barriers to commercialisation including:

- For the sensors to be reliable and commercially viable, a much larger and robust calibration to predict wheat ear nitrogen content is needed. This is reliant on a relationship between early season protein content and final grain protein content, with the aim of modifying foliar nitrogen applications based on the output. Whilst this is still a useful aim of this project, discussions with growers have indicated that it would be more marketable and useful to growers if they could use the sensor to assess wheat plant (leaf/stem) nitrogen content at a range of growth stages. Follow-up work would ideally further develop the existing wheat ear protein content calibration to extend throughout the season, so you can also determine the leaf nitrogen content before the ears are developed. This requires significant investment in generating calibration datasets beyond those collected as part of the early stage project including samples from a wider range of growers, nitrogen application rates and varieties.

- Partners were unsuccessful in applying for a follow-on industrial stage ATC grant. However, a spin-out company has been created by UoM, where Precision Decisions, a private limited company, are funding a PhD student to develop the technology further, although the scope is wider than the ATC project. ADAS has had no role in this activity to date, but are still actively pursuing opportunities to develop the technology alongside UoM and Precision Decisions, with plans to submit a proposal in collaboration with the two partners in the upcoming ‘Transforming Food Production” call. ADAS continues to work with Precision Decisions on multiple other projects.

- The project also needs to develop the manufacturing and market side of the project, which can only be achieved once the calibrations are robust

Lessons

The collaboration and the funding to enable the collaboration to proceed were the overriding critical factors influencing the success of this project. The collaboration enabled UoM access to agricultural expertise provided by ADAS and Camgrain growers. The finding from the earlier LINK project highlighted the requirement for more efficient sampling efforts, which the hand-held sensors developed by UoM provided. Moreover, the collaboration allowed the project to calibrate a large enough dataset (over 120 samples) to establish proof of concept. As such, the collaboration led to better quality of output, at a lower cost, and provided benefits for those involved (e.g. knowledge and skills development and attitudes towards R&D and its commercialisation). Aside the collaboration, the learning from the earlier LINK scheme project, where results were compared to test the validity of the prototype, also contributed to the outcomes/outputs achieved under ATC project.

The project was an early stage feasibility study, and although it achieved all of its key milestones, the concept is still two-to-three years from entering the market. The lack of follow-on funding has hindered the process. Partners were unsuccessful in their application for the ATC industrial stage grant. With the project still at an early stage and high risk, ADAS were unable to make a strong case to continue the development of the technology through its own internal funding. Whilst UoM have managed to spin out a company to take the technology forward, the scope of activity has changed from assessing levels of wheat nitrogen to crop breeding. Both consultees highlighted the need for IUK to provide further support to ensure successful projects receive follow on funding, and are able to complete the process of commercialisation.

More widely, the case study indicated two other important lessons for the ATC programme. First, the effects of involvement with ATC funded projects on behaviour and capacities of participants can be significant even in those cases where the commercial application of the specific technology/innovation idea is not realised within the project as anticipated. Second, and related to this, the potential route to market for the technology/innovation can be complicated, with significant follow on activities and investment required to bring the product to market, with partners outside the original consortium developing the technology further. Whilst, this may not be the desired outcome for the original project lead, the potential benefits to the wider industry remain. This said, for the ATC programme, impacts would rely on external factors for anticipated benefits to be realised.

Case Study - Evaluate a potential proxy test for Feed Conversion Efficiency in beef cattle

Key messages

• The project was an early-stage R&D grant, awarded in Round 3, seeking to develop a protocol to improve Feed Conversion Efficiency in UK beef cattle. The project was led by Scotland's Rural College (SRUC), in collaboration with the Aberdeen-Angus Cattle Society (AACS), and was delivered between September 2015 and May 2017.

• Key benefits delivered to date include:

➢ Increased skills and R&D capabilities – technicians have gained new skills in relation to sample collection and processing.

➢ Changed institutions behaviour towards innovation and applied R&D – SRUC senior management puts greater emphases on the commercialisation of research and has recently introduced a full time post for 'commercialisation director'.

➢ Knowledge transfer and learning - SRUC briefed AACS technicians on how to collect the samples. AACS networks provided learning opportunities for SRUC, where it provided 1,000 samples for processing.

➢ Improve profile, reputation and credibility – SRUC presented to Aberdeen Angus breeders from the UK and internationally at the World Angus Forum. Event provided networking benefits and opportunity to raise awareness of FCE in the industry.

• Future anticipated benefits to the wider industry include opportunity for breeds to produce more valuable stock (sales of bulls, semen and embryos) and for all beef producers to reduce feeding costs. Improvement in efficiencies of beef production can also create environmental benefits, reducing greenhouse gas emissions.

• The collaboration with AACS, and access to its national network of farms and animals was critical to the success, accelerating the development of the prototype, as well as enhancing scalability and quality of output. Aside this, existing projects also played an important role in enabling the success of the ATC project.

• The development of the protocol is still 2-3 years away from market, and no formal IP has been created yet. The project was halted slightly due to the resignation of AACS CEO towards the latter end of the project.

Source: SQW

Introduction

In 2015, an early stage Agri-Tech Catalyst (ATC) grant of just under £120,000[144] was awarded to **"Evaluate a potential proxy test for Feed Conversion Efficiency in beef cattle"** as part of the **third ATC competition**. The project was led by Scotland's Rural College (SRUC), in

[144] Total project costs £158,768 - IUK contribution £48,353, BBSRC contribution £70,854, Matched contributions £39,561.

collaboration with the Aberdeen-Angus Cattle Society (AACS). The project aims to develop a new protocol to identify feed efficiency cattle, without the need for expensive data collection. By doing so, the project targets large feed costs savings for the UK beef cattle industry. The project also aims to provide preliminary information to AACS about genetic variations and correlations – to help with incorporation of the new tool into breeding programmes. The early stage project was delivered between September 2015 and May 2017.

SRUC had received two other ATC industrial stage grants prior to this project, but neither of were related to this project. The case study involved consultations with both SRUC and AACS, supported by survey responses by SRUC, and a review of the project application and close out report.

Project overview

Prior to this project, SRUC had received £1.5m from DEFRA to fund a project centred on a similar idea i.e. improving the Feed Conversion Efficiency (FCE) of beef cattle. More specifically, SRUC partnered with the Agriculture and Horticulture Development Board (AHDB) to develop a testing infrastructure for traditional FCE testing in UK beef animals. The project was at a much larger scale than the ATC, and involves lengthy and costly protocols to measure growth rates and feed intakes over a period of two months, and presented challenges of sourcing suitable animals for testing. Animals had to be brought into testing stations from various parts of the country, increasing the risk of disease spread. As such, the early learning from the DEFRA project suggested the need to have a biomarker or proxy for FCE that can be measured on sample taken 'on-farm' – removing the need to move animals to testing stations.

The project lead at SRUC had previously worked for the Department of Agriculture in Ireland, where the idea of using hair/blood samples as a proxy method for FCE had originated. To take the idea any further, the approach of using hair/blood samples as a proxy for FCE needed to be validated, and it would need to be tested on a large sample of beef cattle. For the latter, SRUC identified AACS, who at the time were implementing the BreedPlan programme[145], and so had access to the breeders, animal samples and other data collection associated with the programme. By including AACS as a formal project partner, the project would benefit from substantial costs savings, as the samples could be collected alongside existing AACS activity on the BreedPlan programme. Moreover, AACS have access to farms across the country, providing a comprehensive sample for the study, and enhance the quality of output. SRUC and AACS had not previously worked with one another; the collaboration was instigated by SRUC's project lead directly approaching the chief executive at AACS with the idea/concept.

SRUC, is an academic research institute, had substantial experience in R&D activity, including several IUK projects, two of which were ATC industrial stage projects. Nevertheless, this was the first IUK project for the project director at SRUC, who brought knowledge and learning from previous R&D experiences to inform this project. Whilst the two industrial stage ATC projects had focused on developing an actual product, centred on the engineering/technology side; this specific ATC project was considered a new venture and outside 'core business', where it develops a protocol and focuses on the biological aspect. For AACS, though it had been involved in collecting its own research data, it had not previously engaged in an R&D project to this extent, nor had it ever applied for any IUK funding. As such, this specific ATC **project was viewed to be outside core business for both partners.**

[145] BreedPlan offers bull breeders the potential to accelerate genetic progress in their herds, and to provide objective information on stock they sell to commercial breeders – see http://www.breedplan.co.uk/

According to the project lead, the ATC funding was sought because the **project was viewed to be high risk,** as it was outside partners core business, and secondly, it **provided the necessary funding to enable the collaboration** with AACS, which was critical to the success of the project. The project lead said it would not have been able to fund the project itself due to a lack of internal finance. Alternative sources of funding would most probably have been through the research councils, but the IUK ATC call was preferred as it provided the necessary funding to collaborate with an industry partner.

The delivery plan outlined three interdependent strands of activity:

- SRUC verifying that the blood-based/hair proxy predicts FCE well
- Collecting the samples, which AACS led on and were able to collect 1000 samples
- The samples were then processed by SRUC, and forwarded onto ISO analytical, who were sub contracted for the analysis of the genetic variations.

Effects and role of the Catalyst

The project was successful, and delivered against its original objectives and broadly in line with the original delivery plan. The project was able to i) demonstrate that hair (as an alternative to blood) can be used as a sample – thereby facilitating an easy method for on-farm sampling; ii) develop a protocols for collection and processing of hair samples; and (iii) demonstration of genetic variation in FCE using this approach.

The early stage project brought about a range of benefits for those involved:

- Both the SRUC and AACS consultees said the project **increased their skills and R&D capabilities** as the scope of project was outside the organisations core activity. For SRUC, the project helped improve its understanding of developing protocols for testing activity. Moreover, the use of hair samples was considered a novel approach, and so the project developed understanding of new sampling processes for both partners. There was also **knowledge transfer in both directions** between the two partners; SRUC provided guidance to AACS technicians on how to collect the hair samples, whereas the access to 1000 samples through AACS networks provided learning opportunities and added a greater level of robustness to SRUC's research, which would not have occurred without the collaboration.
- The consultee at SRUC said the ATC project, together with other IUK projects, had **changed the institutions behaviour towards innovation and applied R&D** – SRUC now sees greater potential, opportunities and benefits of developing an IP from its research to generate revenue. SRUC has recently introduced a full time post for a 'commercialisation director' whose role is to identify key opportunities to translate SRUC research into commercial outcomes. The management at SRUC is said to have become much more commercially focused, which although has largely been driven the new Principle and CEO, the IUK projects have also contributed to this. For AACS, consultees noted a greater desire from its network of farmers to engage in 'modern science', and reap the associated benefits.
- SRUC **disseminated some of the findings** at the World Angus Forum, where it presented to Aberdeen Angus breeders from the UK and internationally. This provided **opportunities to network** with breeders from across the world, and **raise industry awareness** of the importance of FCE and the potential to use proxies to

breed for FCE. Moreover, the forum provided opportunities for both SRUC and AACS to **improve its profile, reputation and credibility**. Having said this, partners are reluctant to engage in any significant dissemination activities until a formal IP is in place to provide protection.

Whilst the development of the protocol is still in its infancy, around 2-3 years away from commercialization, the project does expect to create **benefits for the wider industry in the future.** The pig and poultry industries have already seen the benefits of FCE, where there has been great reduction in production costs. The long generation interval of cattle and the high costs of running testing stations means there has been little FCE testing. Commercially, the proxy method is an opportunity for breeds to produce more valuable stock (sales of bulls, semen and embroys) and for all beef producers to reduce feeding costs. Aside this, beef production is considered to be a key contributor to global greenhouse gas emissions. Any improved efficiencies in the beef production can potentially bring about **environmental benefits**. Nevertheless, whether these future outcomes/impacts are achieved, will depend on a number of factors, discussed in the section below.

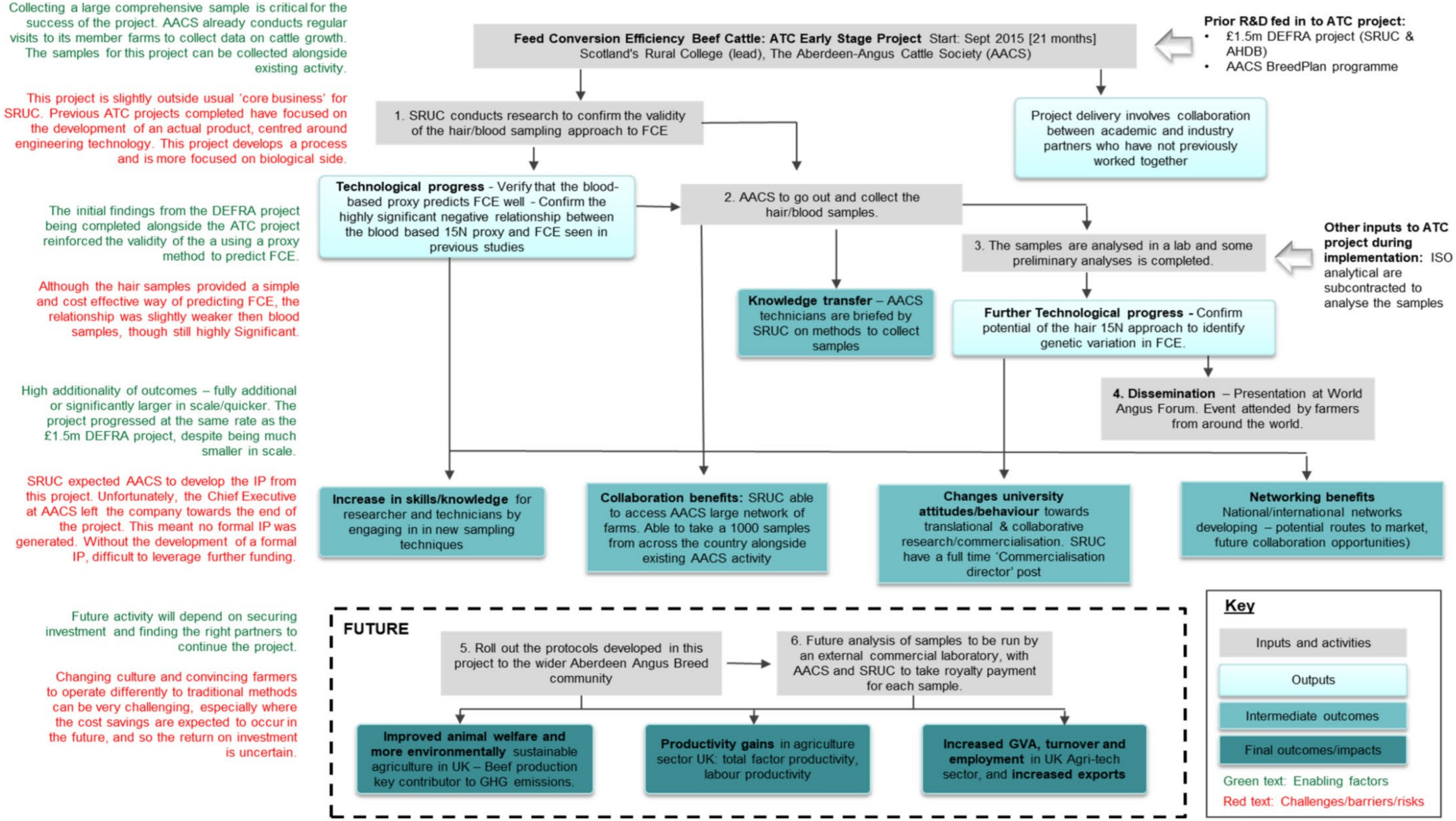
Overall, **the 'additionality' of the outcomes achieved so far is high** – both the project lead and collaborator consulted said the project would *'probably not'* have achieved the outcomes without the ATC. The project director at SRUC was not aware of any other funding sources that allowed the inclusion of an industry partner. The **added value of collaboration**, alongside the funding for the project, was critical to the success of the project. The funding enabled the collaboration to exist, and without either partner, the project would not have been viable. The collaboration with AACS meant **the scale of the project was much bigger, the development of the protocol was quicker, and of better quality.**

The **relative contribution of ATC to achieving the outcomes highlighted above, compared to other factors are twofold:**

- • First, there are **some outcomes**, which the **ATC has directly contributed towards, with no other factor influencing it.** For example, specific type of knowledge and skill development has occurred as a direct result of the ATC project, where technicians working as part of the AACS/BreedPlan animal recording scheme have gained new skills in relation to sample collection and processing. Without the ATC project, AACS technicians would not have developed this type of specific know how.
- • Second, there are **certain outcomes where other factors, notably the two feeder projects (i.e. the £1.5m DEFRA project and AACS BreedPlan programme), have either enabled the ATC project to achieve the outcomes, or have also directly contributed towards the outcome.** For example, the changes in institutional behaviour towards innovation and applied R&D, where SRUC have introduced a specific post for a 'commercial director' happened as result of a combination of IUK projects, engagement with the Agri-Tech centres and a new Principle and CEO. Similarly, the DEFRA project provided key learning for the ATC project, and it was AACS existing BreedPlan programme that provided the opportunities for cost savings. Had it not been for these other factors, the outcomes achieved may not have been as significant, or may not even have been realised. As such, it becomes important to consider the wider landscape in which the ATC operates it, in order to understand the overall contribution.

The diagram below summarises the activities delivered on the ATC project, and how these have lead to outputs/outcomes to date and expected to have impact in the future. The annotations in the green text highlight key factors that have enabled progress (or will in the future), and the red text are key challenges to date/risk to achieving intended impacts in the future.

Figure C-3: Project Theory of Change in practice



Source: SQW

Legacy and next steps

The project continues to have an impact on how both the lead and collaborator view R&D and commercialisation activity (discussed above). Going forward, a number of key activities will need to happen to bring the process to market. The project is yet to develop any formal IP, and so this will be a priority. The process of developing formal IP was delayed somewhat due to the AACS CEO resigning during the latter stages of the project. SRUC expected any formal IP development to be undertaken by AACS. The long term plan will be to roll out the protocols developed in this project to the wider Aberdeen Angus breeder community, as well as other breeds managed through the same team in UK (the AACS provides pedigree services for 10 other cattle breeds) or globally (sister Aberdeen Angus breed societies in other countries). There is an option to establish a charged service designed to cover the costs of sampling (by AACS technicians), sample processing (either by SRUC technicians or a new AACS employee) and analysis by an external commercial lab. The anticipated model is for future analysis of the samples to be run by an external commercial laboratory, with AACS and SRUC to take royalty payment for each sample.

The consultees identified a number of potential barrier to commercialisation:

- First is related to **pricing offer** i.e. for the sample collection, sample processing and analysis costs. Although there are great potential reduced costs benefits for the industry, changing culture and convincing farmers to operate differently to traditional methods can very challenging, especially where the cost savings are expected to occur in the future, and so the return on investment is uncertain.

- Second challenge is more technical, and related to the **presentation of results**, where although the project is significantly related to FCE, the outputs of the analysis are no standard FCE terminology (e.g. weight gain per unit feed consumed).

- Third, by not having formal IP in place already, there is a risk that **competitors** in other countries may reach the market much quicker, or develop other cheap FCE methods for the beef industry.

Lessons

The collaboration and the funding to enable the collaboration to proceed were the overriding critical factors influencing the success of this project. The collaboration provided SRUC access to important players in the livestock breeding industry, who they had not worked with previously, as well as access to a credible national network of farms and animals within the breeder members of the AACS. This link accelerated the development of the protocol, led to better quality output (which has influenced networking benefits, profile / reputation / credibility, attitudes towards R&D and its commercialisation) and created benefits for those involved (e.g. knowledge and skills development). Aside the collaboration, the two feeder projects were also an important enabling factor, which allowed the ATC project to achieve certain outputs/outcomes.

The project was an early stage feasibility study, and although it achieved all of its key milestones, the concept is still at least 2-3 years away from entering the market. With no IP generated yet, the realisation of the outcomes achieved is uncertain. Whilst there were issues with the AACS CEO resigning towards the latter end of the project, halting any decisions related to IP, the consultee at SRUC highlighted the lack alternative sources of finance or follow on funding to pursue the concept any further. With the ATC call now ended, the consultee at SRUC noted the difficulty in getting funding for an Agri-tech specific project under the IUK health and life sciences funding competitions. The increase in competition from projects in other sectors makes it less worthwhile to invest significant resources in submitting an IUK grant application.

Case Study – CAPSEED – a new seed controlling process for arable and horticultural crops

Key messages

• The project was an early stage feasibility study, awarded in Round 3, seeking to test the potential of a Cold Atmospheric Plasma (CAP) treatment for improving the performance, health and economic potential of seeds and associated crops. The project was led by Gnosys Global, a contract R&D organisation, in collaboration with the National Institute of Agricultural Botany (NIAB) and two industrial partners, Frontier Agriculture and G's Fresh Ltd.

• By the end of the project, the feasibility of a CAP treatment for achieving the intended outcomes was not proven – the treatment produced highly unpredictable results. More fundamental research is needed to understand the mechanisms by which the germination properties of different seeds can be enhanced using plasma.

• The project did, nevertheless, generate a number of key benefits for the partners involved, including:

➢ The identification of new avenues for further industrial research in other areas relevant to the agricultural sector, including using CAP treatments to reduce bacterial and fungal risks in crops (alfalfa and mung beans), to improve sterilisation of fruits and vegetables in transit (much as mangoes and strawberries), and to manufacture plasma-treated, antibacterial water as a treatment for crops.

➢ More generally, the project has increased each project partners understanding and access to innovative technologies, practices and market opportunities. Gnosys – a spill-in to the agri-tech sector – have identified a range of new areas in agriculture and food production to apply their knowledge of CAP. NIAB, Frontier and G's Fresh have each been introduced to the potential of plasma technologies for a range of applications relevant to their lines of work. This new knowledge is likely to support future R&D work with plasma technologies in the next few years for a range of related applications, potentially with the project team.

➢ Establishment and strengthening of relationships. Gnosys have established relationships with three new organisations, and are actively exploring future collaborative R&D projects. The NIAB, Frontier and G's Fresh have maintained and/or strengthened their pre-existing relationships.

• Delivering the project through a multi-disciplinary collaboration was critical to the benefits realised, and will be needed if any of the identified avenues for future work are to be progressed. The delivery of the project was made straightforward in management terms by the experience each organisation brought in conducting R&D, including collaborative projects.

• All organisations involved agree that there is still potential for CAP treatments to prove feasible for improving the performance of seeds following some more fundamental (PhD-level) research to better understand the mechanisms involved. The project team were – at the time of the case study research – arranging a meeting to explore avenues for future collaborative work.

Source: SQW

Introduction

In 2015, an early stage Agri-Tech Catalyst (ATC) grant of just under £277,000 was awarded to explore the feasibility of using a novel Cold Atmospheric Plasma (CAP) treatment to improve the performance, health and economic potential of a range of seeds and associated crops. More specifically, the feasibility study sought to test the effectiveness of CAP treatments – which alter the surface properties of treated seeds - on crop establishment and uniformity, and for controlling seed-borne diseases. The project was led by Gnosys Global Ltd ("Gnosys"), in collaboration with the National Institute of Agricultural Botany (NIAB) and two industrial partners, Frontier Agriculture ("Frontier") and G's Fresh Ltd ("G's Fresh"). The early stage feasibility study was delivered between July 2015 and December 2016.

Overall, the outcome of the project was to demonstrate that the technology is not yet feasible for commercial applications. Although some promising results were achieved, the effects of CAP treatments were inconsistent and revealed a need for more fundamental research into the underlying mechanisms before a commercially viable CAP process could be developed. The project did, however, realise a number of key benefits. These include new avenues for further R&D work, some of which are actively being considered by the project team, newly established and strengthened relationships, and increased knowledge-development within each of the partners involved.

The case study involved consultations with the three of the four project partners (Gnosys, NIAB, Frontier[146]), and built on survey responses received at an earlier date (from Gnosys, G's Fresh, and Frontier). In developing this case study, project application and close-out reports were also reviewed.

Project overview

A range of key challenges face primary crop production, including challenges arising from the natural environment, diseases and pests, but also regulatory changes that place increasing constraints on the effective use of insecticides and fungicides, which are further compounded by the development of resistance to such treatments. As such, the search for new approaches to tackle these challenges is of key interest to industry. The CAPSEED project was designed to meet this need by **testing the feasibility of a novel, non-chemical technology, CAP, to improve seed performance and health.**

Prior to the project application, **Gnosys had not previously worked in the agri-tech sector**. The company had 20 years of experience developing CAP for applications in the utilities (using CAP in the manufacture of power cables) and health and beauty sectors (employing CAP as an anti-bacterial and anti-fungal treatment with applications in oral health and nail care). As a multidisciplinary science and technology innovation company, Gnosys routinely search for **opportunities to apply their in-house capabilities to new technology areas and sectors.** It was through the monitoring of the state-of-the-art in plasma applications that the Gnosys team became aware of the potential to apply CAP to seeds to improve their performance (germination rates) and storage properties. It is notable that Gnosys' motivation to explore new technology areas was partly motivated by a strategic decision to develop their own IP and license revenues. Gnosys secured permission from Linde who own IP in relation to the CAP

[146] G's Fresh were approached for interview, but were not able to participate.

technology, which whom Gnosys have a contract R&D arrangement, to develop applications for CAP outside of their core industrial of operation.

As a new entrant to the sector, Gnosys identified NIAB as a potential source of information, and as a potential collaborator, and made contact to explore the opportunity further. NIAB, who had not worked with plasma technologies previously, but were aware of existing applications of other forms of plasma treatments in agri-tech, were receptive to the idea and were quickly able to identify and secure collaborators for the ATC project application. Frontier, a major agricultural distributer and agronomy service provider involved in seed processing and treatment, and G’s Fresh, a major vegetable and salads producer, represented two agricultural end-users who had both engaged with NIAB previously in collaborative R&D. The key commercial opportunities for each can be described as follows:

- As a distributer of processed and treated seeds and agronomy service provider, Frontier recognised the potential of CAP as an alternative to existing seed condition treatments that are increasingly subject to regulatory pressures.
- For G’s Fresh, CAP treatment presented a number of opportunities, including to replace heat treatments for seed-borne diseases with a “cold” alternative which would pose less risk to damaging seed viability, as well as generally developing a new, more effective and cost-efficient means of controlling disease and improving crop production.

Gnosys Global led the application and were the lead partner on the project, responsible for project management and overall coordination. Each of the collaborative project partners provided their (technological or commercial) expertise to support project delivery. For NIAB, a leading agricultural research organisation, this involved exploiting their expertise in seed health testing and evaluation[147]. Frontier provided access to commercial seeds, as well as field testing support, with a particular focus on oilseed rape (and to a lesser extent, maize). G’s Fresh similarly provided access to alternative seed varieties and supported large-scale field testing. NIAB, Frontier and G’s Fresh had a history of collaboration in R&D as individual organisations, but also in partnership with each other. The project therefore combined both a **completely new collaboration involving a new market entrant** (Gnosys Global with the three partners), and the **development and continuation of existing relationships between the other three partners**, helping to reduce risk and leverage existing learning and knowledge sharing.

The project involved a series of workstreams (please see the Theory of Change diagram, below), some in parallel and some inter-dependent. For Gnosys, a major stream of work was the **testing and optimisation of different gas-plasma mixtures in readiness for treating a range of seeds.** As part of a relatively distinctive stream of work, Gnosys also worked to devise and design a large-scale plasma applicator device, which would be needed to treat seeds at a commercial scale. Once Gnosys had completed initial tests to optimise the gasplasma mixture, the various varieties of seeds were treated (by Gnosys) and distributed (coordinated by NIAB) to the partners to test in the field (by all collaborative partners) and in the both the lab (mostly by NIAB). More specifically, tests were carried out:

- on the speed of establishment of **oilseed rape and maize** (conducted by Frontier and NIAB)

[147] NIAB are an accredited International Seed Testing Association (ISTA) member, and the official seed testing organisation in England and Wales.

- for controlling seed-borne disease in **celery, onion and broad bean seeds** (conducted by G's Fresh and NIAB)
- on crop uniformity of **iceberg lettuce seeds** (conducted by G's Fresh and NIAB).

Effects and role of the Catalyst

The overall result of the CAPSEED project was to **confirm the unpredictability of CAP treatments for different seed varieties.** For example, although the CAP treatment was successful for some seeds, it also proved highly unpredictable when used with closely related varieties. It was also found that the success of the treatment varied significantly depending on a range of other factors, such as the dose rate, intensity and orientation of the seed when treated. The overall outcome of the project was **to highlight the need for further fundamental research to better understand the mechanisms by which seed germination and emergence properties are enhanced**, which currently represents a poorly understood area of biochemistry. Nevertheless, despite the headline results not turning out as hoped, the results generated provided increased understanding of these methods involved – which may be of use in the future – but also provided some valuable findings in secondary areas that may be exploitable through further R&D.

Gnosys also made some progress in terms of developing a large-scale plasma application device, however more R&D is still needed to produce a device that works consistently at scale. This is an area of work that Gnosys are progressing, as this will unlock the potential to scaleup any potential applications of CPA in other areas – a few of which are discussed below.

Outside of the core objective, **the project did generate potential new opportunities and benefits for the lead and collaborators, both collectively and individually. Most importantly, the project partners have identified new avenues for further industrial research in related areas relevant to the agricultural sector** including: the potential for CAP treatments to reduce bacterial and fungal risks in hard to treat crops, such as alfalfa and mung beans; and the potential to improve sterilisation of fruits and vegetables in transit (such as mangoes and strawberries). Another related and promising unanticipated outcome of the project was the development of plasma-treated water with antibacterial properties. At the time of writing the project partners were planning a meeting to discuss potential plans for future collaborative R&D, where discussion on the potential to use plasma-treated water on a range of crops will be explored.

Individually, as the project lead, Gnosys are exploring other related applications in the broader food production sector, for example, the possibility of working with a company involved in the distribution of frozen fish products to assess the feasibility of CAP to reduce bacterial and fungal risks in shipping. This provides an example of how new expertise and experience fostered in new areas can help to expand the services Gnosys has been able to provide to existing clients. In this case Gnosys had worked with the frozen fish distributor in another area, where they employed their capabilities in data science.

For the collaborators, NIAB, Frontier and G's Fresh, have been introduced to the potential of plasma technologies for a range of applications relevant to their lines of work. This new knowledge has the potential to support future R&D work with plasma technologies in the next few years for a range of related applications, potentially with the project team, if opportunities arise.

The project has also resulted in the **establishment and strengthening of collaborative relationships**. Gnosys have established relationships with three previously unknown organisations, and are actively exploring future collaborative R&D projects. NIAB, Frontier and G's Fresh – each with a history of collaboration with each other – have strengthened their relationships.

There are a number of key factors that have enabled progress to date, and some issues and concerns raised by those consulted. These are summarised in the Theory of Change figure below, key points include:

- • NIAB's large membership network and expertise across agri-tech were instrumental in establishing the collaboration. They are also regarded as critical for the exploitation of any future opportunities that arise in related areas.
- • The multidisciplinary expertise, knowledge and skills of the collaboration added considerable value, each working towards wider organisational aims, but towards a common goal for which capabilities of each was essential to achieving results.
- • In terms of barriers, aspects of the project were delayed due to a protracted contracting period. The consequence of this was that the autumn oilseed rape planting window was missed, which meant that this work got underway later than intended (in spring), but an additional autumn test was carried out in the same sowing year as the spring test. As a result, this work progressed from spring onwards.

In terms of the effectiveness of the collaboration, each provided distinctive capabilities, however **due to the nature of the project opportunities to exchange technical knowledge and skills was limited**. For example, Gnosys led the CAP treatment, supplying treated seeds to their collaboration partners for subsequent testing in the field. NIAB conducted the seed health testing and evaluation independently. There was, however, **significant transfer of commercial and technological awareness** amongst the project partners, for example: Gnosys developed a much wider awareness of the agri-tech landscape, and have identified a range of opportunities in new areas to progress in the future; and both Frontier and G's were introduced to the potential of plasma treatments, which they are interested in, and may engage in future R&D activities (potentially with Gnosys and the wider project team) to explore opportunities identified.

Overall, due to the novel nature of the technology concerned, and the fact that the lead partner was not only new to the sector but also to the collaborators involved, our analysis suggests that the outcomes realised (related to identification of future opportunities, collaborations and relationship benefits, and transfer of commercial and technological awareness), are **"high additionality"** and **"high contribution"**. The feedback from the consultees suggests that this was a good example of a relatively risky feasibility-study in a novel area, where public R&D support is required to de-risk investment. As is the nature of R&D, sometimes the results are not as expected, however the work is likely to lead onto new research in related areas that may be of benefit to several of the project partners involved.

Figure C-3 below summarises how the activities delivered by the project have led to outputs/outcomes to date and their expected impact in future. The annotations in green text highlight key factors that have enabled progress (or will in future), and the annotations in red text are key challenges to date/risks to achieving intended impacts in future.

Legacy and next steps

Overall, the project partners involved agree that there is still potential for CAP treatments to prove feasible for improving the performance of seeds, but new breakthroughs supported by fundamental research will be needed to better understand the mechanisms involved. From a commercialisation standpoint, this may take upwards of five years to develop, although this is hard to estimate owing to the uncertainty associated with the potential findings of the research.

In terms of future work, Gnosys team are currently engaged in discussions with potential partners and collaborators in other parts of the agriculture and food sectors to explore the potential for CAP treatments to disinfect fragile foodstuffs and food preparation processes. For example, as noted, Gnosys are currently seeking to exploit some of the findings of the CAPSEED work with an existing client involved in the distribution of farmed fish. Gnosys had worked with this client previously using their expertise in big data techniques to identify contamination in frozen fish, and are now seeking to investigate the potential to apply the anti-bacterial effects of CAP to the transports and storage of frozen fish.

Although the project team do not currently have immediate plans to progress with further collaborative R&D work to investigate their positive findings in terms of the potential antibacterial and anti-fungal properties of CAP treatment, which may have applications in seed storage (to ensure seeds are clean and have a higher rate of success once taken out of storage), a meeting is planned in the near future to discuss future opportunities to collaborate.

Lessons

Delivering the project through a multi-disciplinary collaboration was critical to the benefits realised. If any further avenues of work are progressed in future, it is likely that Gnosys will work with the collaborative partners again. As noted, at the time of writing, Gnosys have arranged a meeting with their collaborators to catch-up and explore potential new opportunities to conduct R&D.

The project also demonstrated the demonstrated the ability of ATC to support new spill-ins into the sector. Although Gnosys identified opportunities in agri-tech independently, and sought the expertise of NIAB to explore this in greater detail, without the ATC as a source of funding it is unlikely that this work would have gone ahead. By facilitating the development of a multi-disciplinary collaboration, the ATC has supported the de-risking of a new technology area with promising findings by aligning the knowledge of a technology area expert, with the experience of established players in the agri-tech sector.

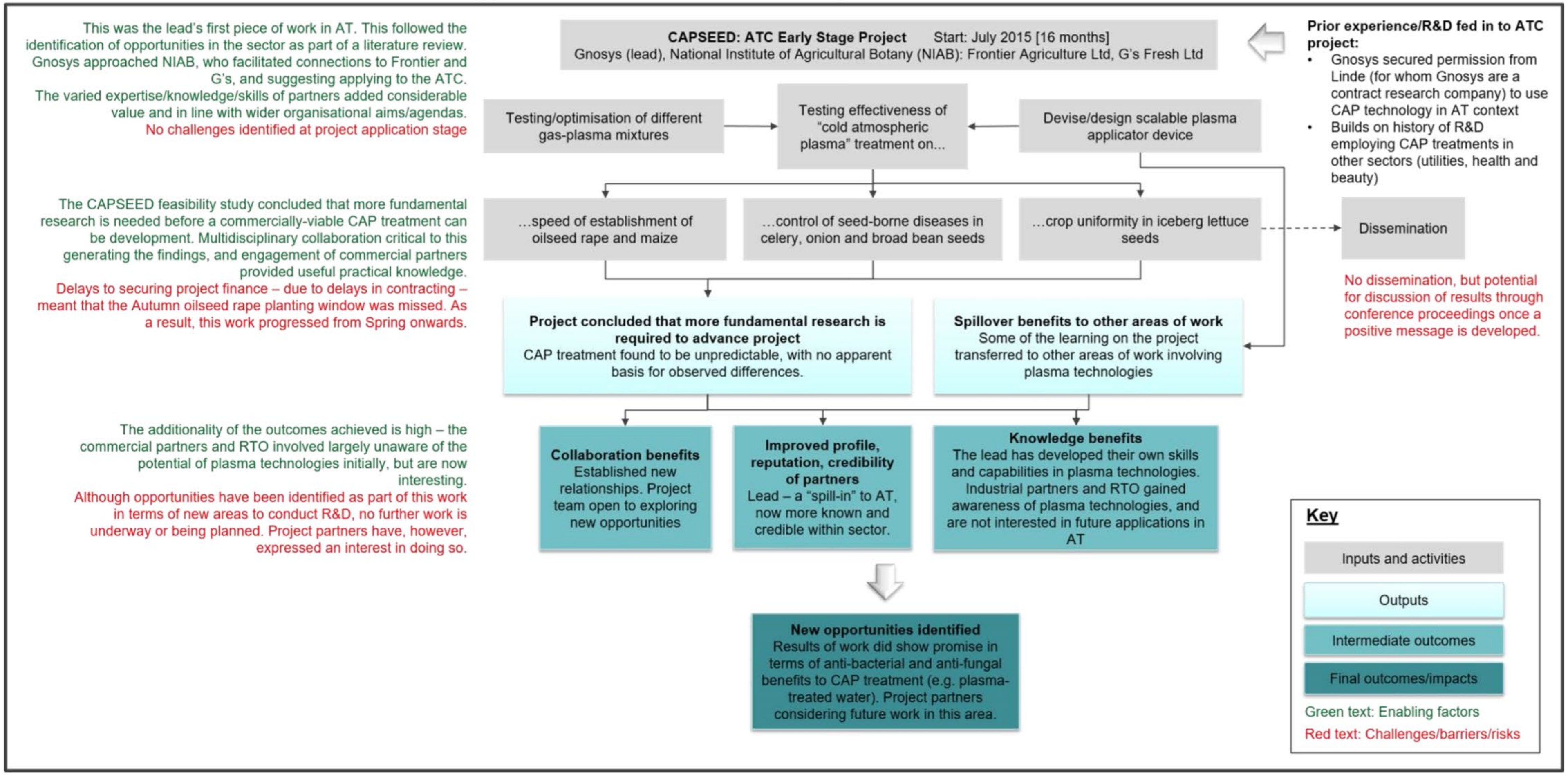
NIAB were noted as having played a critical role in supporting the development of the collaboration drawing on their network and existing relationships, while Gnosys were instrumental in identifying the opportunity and initiating the dialogue that led to the project application. More generally, the delivery of the project was made straightforward in management terms by the experience each organisation already had in terms of conducting R&D, including collaborative projects. This experience was particularly important and effective in terms of supporting a company new to the agri-tech sector to negotiate the challenges that naturally arise from working in a new area.

It is important to note that no dissemination of the findings has been made to date, which is not wholly due to the findings being seen as bad. Although it was suggested as part of consultations that a positive message will need to be developed from the results. There is a recognition that the project has generated significant learning, even if this is not quite what was intended. Dissemination of this nature, while tricky for early stage feasibility studies projects which are (by nature, and as part of the rationale for public funding) sometimes not successful, is important for informing future work.

Finally, the CAPSEED project highlights the iterative and complex nature of innovation. As often proves the case, feasibility studies seeking to assess the commercial potential of a specific outcome may in fact require going back a step or two, owing to the findings, in order to progress. More than this, while a short-term a failure of this type highlights the need for further investment and fundamental research, it also highlights the potential for such work to generate wider opportunities and commercial ideas that may subsequently be realised (e.g. work to exploit the potentials of plasma-treated water).

Figure C-3: Project Theory of Change in practice

CASE STUDY FOCUS: CAPSEED - a new seed controlling processes for arable and horticultural crops



Source: SQW

Case Study – Lobster Grower 1 – developing the technology to fast track the aquaculture potential for the European Lobster

Key messages

• The project was an early stage R&D grant, awarded in Round 1, seeking to develop a container system prototype that would enable the European Lobster to be farmed in the UK in a commercially viable and sustainable way ("Lobster Grower 1"). The project was led by the National Lobster Hatchery (NLH), in collaboration with the Universities of Exeter and Falmouth, Fusion Marine (an SME), the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) and Westcountry Mussels of Fowey (WMOF), and was delivered between May 2014 and April 2016. It was immediately followed by an Industrial Stage ATC grant to test the prototype in industrial field trials ("Lobster Grower 2").

• Key benefits delivered to date include:

➢ encouraging spill-ins of non-agricultural technologies/expertise into aquaculture for the first time (more quickly than might otherwise have been the case)

➢ technological progress, which has been "significantly quicker" than would have been the case without the grant (from TRL 1 before Lobster Grower 1, to TRL 4 at the end of that project, and TRL 6 now via Lobster Grower 2)

➢ improved knowledge and understanding (e.g. R&D process skills, other disciplines and their application to aquaculture, improved understanding of the market position and opportunities), strengthening collaborator relationship, the creation/safeguarding of a small number of highly skilled jobs, improving the profile/reputation/credibility of partners, changing attitudes towards R&D in agri-tech, networking benefits and supply chain impacts

➢ sufficiently de-risking the proposition to secure follow-on investment from ATC, which in turn has secured further investment in R&D by partners involved.

• Delivering the project through a multi-disciplinary collaboration critical to success, accelerating technology progression and enabling a better-quality output. The seamless transition to industrial stage research, strong and structured project management, and early engagement of commercial partners was also important.

• There are different perspectives when the product could start to generate revenue, and some concern that the loss of the private sector manufacturer at the outset dampened the commercial drive. However, the creation of an Industrial Steering Group for Lobster Grower 2 has sought to address this.

• The key challenge for this project looking forward will be securing late stage funding, and ensuring other aspects of the product's ecosystem/supply chain are in place to make it commercially viable.

Source: SQW

Introduction

In 2014, an **early stage** Agri-Tech Catalyst (ATC) grant of just over £211,000[148] was awarded to **"develop the technology to fast track the aquaculture potential for the European Lobster"** (Lobster Grower 1) as part of the **first ATC competition**. The project was led by the National Lobster Hatchery (NLH), in collaboration with the University of Exeter and Falmouth University, Fusion Marine (an SME), the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) and Westcountry Mussels of Fowey (WMOF). The aim was to develop a Sea Based Container Culture (SBCC) system prototype that would enable the European Lobster species to be farmed in the UK in a commercially viable and sustainable way. The early stage project was delivered between May 2014 and April 2016. This was **immediately followed by an Industrial Stage ATC grant** of just over £1m[149] to *"assess the technical, economic and environmental potential for a novel candidate aquaculture species"* (Lobster Grower 2). This Industrial Stage project includes most of the same partners[150], and will be completed in early 2019. This project tested the prototype developed by Lobster Grower 1 in industrial field trials.

The focus of this case study is on Lobster Grower 1, but we discuss the subsequent progress made with Lobster Grower 2 and interdependencies between the two grants below. The case study involved consultations with the National Lobster Hatchery and Universities of Exeter and Falmouth, supported by survey responses from CEFAS and WMOF and a review of project applications and (for Lobster Grower 1) close out report.

Project overview

National Lobster Hatchery (NLH) managed the project overall, and each partner provided their expertise throughout the delivery process. This included hydrodynamic expertise and laboratory testing facilities at the University of Exeter, biological assessment and marine regulation expertise at CEFAS, industrial design engineering and 3D-printing knowledge and facilities at Falmouth University, marine product design and manufacture experience at Fusion Marine, and practical expertise in a related industry and a pilot trial site at WMOF. Fusion Marine's role changed soon after the project began – it became apparent that injection moulding activities would need to be sub-contracted out[151], but they continued to input on the design; furthermore, the ATC intervention rate became a challenge for the business (for early stage R&D, and especially for the subsequent industrial stage project), and the business faced internal capacity issues (for a small business, it was difficult to prioritise activities that had such a long payback period).

The NLH had **prior experience of R&D activities, including some in collaboration** with partners involved in Lobster Grower 1. This included:

- The charities' own internal research programme (small-scale projects, including one with WMOF to undertake preliminary work using oyster spat containers, and various other collaborative research with the University of Exeter and CEFAS over a number of years).
- Two R&D projects which informed Lobster Grower 1: first, a Coastal Communities Fund project to develop IP relating to the SBCC culture; and second, a small TSB

[148] Total project cost - £246,000.
[149] Total project cost - £2.9m.
[150] Fusion Marine did not take part – explained below.
[151] Due to firm ownership issues; sub-contracting out this activity resulted in a change in costs faced by Fusion Marine.

Innovation Voucher project (in partnership with Fusion Marine) to support an initial conceptualisation of an SBCC container, for rearing lobsters. Following the completion of the latter, the (then) TSB signposted the NLH to the ATC programme as a potential source of follow-on funding to progress the innovation project, demonstrating how ATC has integrated with other R&D programmes.

The NLH had not worked with Falmouth University before Lobster Grower 1, nor had the consortium as a whole worked together. All partners had previously been involved in R&D activities to varying degrees, but the project **successfully encouraged spill-ins** of non-agricultural technologies/expertise into aquaculture for the first time. For example, Falmouth University's product design team had not worked in aquaculture before – whilst food security was becoming more prominent on the University's agenda, taking part in ATC accelerated their involvement in the sector (probably by five-to-six years). For the University of Exeter, applying offshore renewable energy expertise to aquaculture was a new area of research, and ATC enabled the University to undertake R&D in this field on a much larger scale.

According to the lead, ATC funding was sought because of a **lack of internal finance**, particularly given the relatively high cost (compared to other uses of finance), **uncertainty** in relation to the outcome and/or commercial return, and the **availability of Catalyst funding** stimulated development of project idea (following on from the Innovation Voucher project above). For the NLH specifically, the product was seen as an opportunity to generate revenue to support the charity's wider environmental/social objectives. Both universities saw the project as a route to establishing a position at the forefront of aquaculture product design, with a rapidly growing market internationally.

The project involved an iterative process of engineering design, biological assessments, and hydrodynamic testing to develop one prototype (and associated variations in design). Alongside this, partners undertook research into regulatory issues, and secured IP (patent on the SBCC container) and a marine licence (permission for field testing Lobster Grower 2). The project took slightly longer to complete than originally intended (23 as opposed to 15 months), mainly because of the time taken to find a company to manufacture the prototype within the original budget (to replace Fusion Marine) and slightly more iterations in design than expected[152]. The project partners have engaged in a range of dissemination activities – both through Lobster Grower 1 and since – including via local and aquaculture press releases, academic journals, in UK/international trade publications and at international aquaculture conferences.

Effects and role of the Catalyst

Lobster Grower 1 was successful, and delivered against its original objectives and broadly in line with the original delivery plan. This was not dependent upon other related projects.

Before commencing Lobster Grower 1, the lead thought the idea was at Technology Readiness Level 1 (TRL 1: basic principles observed) and by the time the project closed it had reached TRL 4 (basic technological components integrated) in the form of a prototype for a novel container suitable for the European Lobster. This aligns directly to the objectives of early stage ATC grants to progress ideas to TRL 4. Subsequently – through Lobster Grower 2 – the project has progressed to TRL 6 (testing the prototype in a simulated operational environment).

[152] Due to the withdrawal of Fusion Marine, the project has only been able to develop one prototype rather than two (due to the increased costs associated with having to replace with a sub-contractor to manufacture the prototype), but this has not impacted negatively on progress with Lobster Grower 2 so far (and is not expected to in future). It did, however, mean that further iterations were needed on the one prototype produced to ensure it was fit for field trials in Lobster Grower 2.

All of those consulted and responding to the survey felt that **technological progress has been "significantly quicker"** than would have been the case without the early stage ATC grant. Without it, the lead argued the idea would still be at TRL 1 or 2. In addition to the funding to stimulate the project and engage partners at the outset, there was consensus amongst all partners that the **multi-disciplinary collaboration enabled by the ATC funding has been critical to accelerating progression**, by enabling simultaneous inputs and feedback loops, rather than bilateral engagement between the NLH and each partner separately, **and has led to a better-quality output** owing to the complementary strengths and synergies of partners working together. Further, it has enabled the NLH to undertake **R&D activity on a far larger scale** than would otherwise have been the case without ATC due to lack of internal resources.

The early stage project has brought about a range of benefits for those involved:

- All of those consulted have **developed their knowledge and understanding** through Lobster Grower 1. For example, the lead has improved their **R&D process skills**, which has enabled them to deliver R&D activities more efficiently and effectively, and broadened their knowledge of IP and regulation; the lead and academics have learned about the other disciplines involved (e.g. materials, techniques, holistic design, real world application), including **how to apply spill-in technologie**s to aquaculture. All partners consulted/surveyed also have an improved **understanding of the market position and opportunities**, even from the early stage process. The lead partner has also improved their understanding of private sector investor opportunities and expectations (less common across partners).
- **Collaborative relations have developed and strengthened** through the project, between business, academic and charity partners, leading to subsequent collaborative R&D activity and a joint funded PhD student between CEFAS, the University of Exeter and NLH.
- A small number of **highly-skilled jobs were created and safeguarded** (c. 7.5 FTE) through the delivery of Lobster Grower 1 (and teams have been retained, and for the lead, expanded, since Lobster Grower 2)
- The ATC project has played an important role in **improving the profile, reputation, credibility of partners involved**, internally within their own organisations (for example, at Falmouth University, it was reported that senior management now recognise the value in applying product design thinking and technology in the agri-tech context) and externally (for example, the lead believes that ATC has raised the NLH's profile as a respected research charity).
- Taking part in the project has **changed attitudes towards R&D in agri-tech** within the Universities who had not previously applied their expertise to aquaculture before – the individuals involved are now more likely to work in AT in future, and it is starting to change perceptions of colleagues towards working in the sector.
- • The lead in particular has observed **networking benefits** as a result of disseminating the learning from Lobster Grower at national and international conferences. This has led to early discussions on potential collaboration opportunities abroad (applying the Lobster Grower technology in new contexts or for different species) and developing potential routes to market in future.

- • The NLH has also **created a trading company** that could be used if the new container system becomes commercially viable, profits from which would support core charitable work. This was not an anticipated outcome at the outset.
- • The delivery of Lobster Grower 1 also generated some **small-scale supply chain impacts** (c. £65k) through sub-contracting a UK-based manufacturer, as noted above.

Crucially, Lobster Grower 1 meant that the project was **sufficiently de-risked to secure follow on investment** from the ATC industrial stage Lobster Grower 2 project[153] and complementary European Maritime and Fisheries Fund (EMFF) R&D funding, which in turn has secured **further investment in R&D by partners involved.** This has enabled the team to further the knowledge and collaboration benefits described above (especially relating to market opportunities/positioning) and should help to de-risk the project further to secure late stage funding in future.

It is hoped that the new container system (and associated processes/services to support that) will be taken to market in three or more years from now, assuming late stage funding is secured. The lead believes it will be five-to-ten years before it generates turnover/exports and jobs benefits for those involved[154], although the commercialisation of knowledge through consultancy services could generate economic benefits sooner. Partners consulted/surveyed were more optimistic about when a product/service could be taken to market – there appeared to be more appetite from academic/research partners to commercialise sooner – although the lead was more cautious about the state of the technology at present, and timescales for commercialisation.

Because of the product developed through the project, there will be the potential for the development of a new market for European Lobster farming in the UK, which is where the potential for significant economic impacts will be felt (i.e. in the wider sector, beyond the partners involved in the project). The NLH lead thought that other aquaculture producers could enter the market for European Lobster farming in ten or more years, initially through diversification of existing fishery businesses and then entirely new entrants to the sub-sector.

There are a number of key factors that have enabled progress to date, and some issues and concerns raised by those consulted. These are summarised in the table below.

[153] Field testing on pilot scale lobster farm, design/test anchoring system, develop aqua-economic model (predictive tool to assess economic viability).

[154] For the NLH, income will come from container IP, supply of seed/juvenile lobsters, commercialisation of knowledge via consultancy; West Country Mussels will operate the first European Lobster farm. The NLH and academic partners can also generate income from exploiting the technology/knowledge with other species / in other contexts, leading to further investment in R&D.

Table C-1: Factors influencing progress

Enablers	Issues/Concerns
• Most partners were already known to lead, and proximity (for most) was helpful. • A collaboration agreement at the outset clarified partner roles. • The multidisciplinary collaborative approach – the varied and complementary expertise/skills of each partner added considerable value to the project. • The project was closely aligned with the lead's wider organisational aims/agendas. • Engagement of commercial partners at early stage was important to draw on practical knowledge when testing ideas. • Strong project management by the lead, combined with project structure and momentum provided by the IUK monitoring process. • Dissemination to date has focus on methodologies developed/tested, due to concerns about IP – this has enabled wider reach, because it is relevant for multiple applications (not just lobsters). • The smooth and seamless transition from the early to industrial stage ATC projects was key – it enabled the project to maintain momentum and kept most partners on board. • For Lobster Grower 2, the project has an Industrial Steering Group, which ensures market pull / a clear route to market.	• Innovation is a non-linear process, and ensuring the wider product ecosystem is in place will be critical for success - Lobster Grower 1 highlighted other challenges/research questions that now need to be addressed to ensure the container is successful (e.g. anchoring), taking aspects of the system back to earlier TRLs. • There was some concern that the intervention rate was a challenge for industry in early stage (and industrial stage) ATC projects. There was some concern amongst consultees that this had implications for the commercial pull and route-to-market for the product (an Industrial Steering Group has now been created for Lobster Grower 2). • There are some differences in opinion within the consortium on timing of commercialisation – some believe there are opportunities to commercialise aspects of the project sooner, whereas others have concerns about IP and/or would rather wait until the final product (and supporting technologies) is ready. Dissemination feels restricted to some partners due to IP concerns, despite having a patent, which they believe could have limited early revenue opportunities. There are slightly different drivers for academic and industry partners (publication and protection of IP respectively), and this can cause some tensions, despite dissemination restrictions being made clear to all partners via a collaboration agreement at the outset.

Source: SQW, based on consultations

The diagram below summarises progress made and how the ATC projects have led (or will lead) to outcomes and impacts. On the whole, the routes to impact have been as expected at the outset – the main differences have been (i) producing one rather than two prototypes, and (ii) the expectation in the application that early outcomes from Lobster Grower 1 could generate revenue which would help to fund follow-on R&D (although ATC industrial stage funding was secured anyway, even though the project is not yet generating revenue).

Overall, the 'additionality' of the outcomes achieved so far is high – almost all of those consulted/surveyed would "definitely not" have achieved the outcomes at all without ATC, and one would "probably not" have achieved them anyway.

There were **varying views on the relative contribution of ATC to achieving the outcomes** above compared to other factors, with the lead being most positive.

- For the lead, ATC has directly or indirectly led to changes in the management structures and the management of R&D activity, due to the increased scale of R&D activity now underway. The NLH is also currently revising its business plan with a greater commercial emphasis, and has pursued other R&D activities. The lead thought these factors were less important than the ATC project itself in achieving the outcomes observed so far, but will play a role in enabling the NLH to realise the full outcomes of the project in future. The ATC that has been the key stimulus, and without it none of the outcomes would have happened – for the lead, the project has been absolutely necessary and made a very strong contribution to achieving results.

- ATC has been less influential for others – for example, WMOF has introduced new equipment and engaged in other R&D activities that were not related to ATC (although some arose from connections made via ATC), but have been more important in achieving their outcomes (skills, new products to market, employment etc).
- And for some, the picture is more complicated – for example, Cefas has experienced a change of leadership/management in R&D team which was less important than ATC in realising outcomes, but ATC indirectly led to other R&D activities have been implemented and new innovation partnerships or collaborations established which are more important than the support from the ATC.

More broadly, consultees noted wider factors that have/will contribute to the overall success of the product, including increasing importance of food security, marine environments, and sustainable protein production on global agenda. However, looking forward Brexit (and associated regulatory changes) might impact upon the success of the product in the UK.

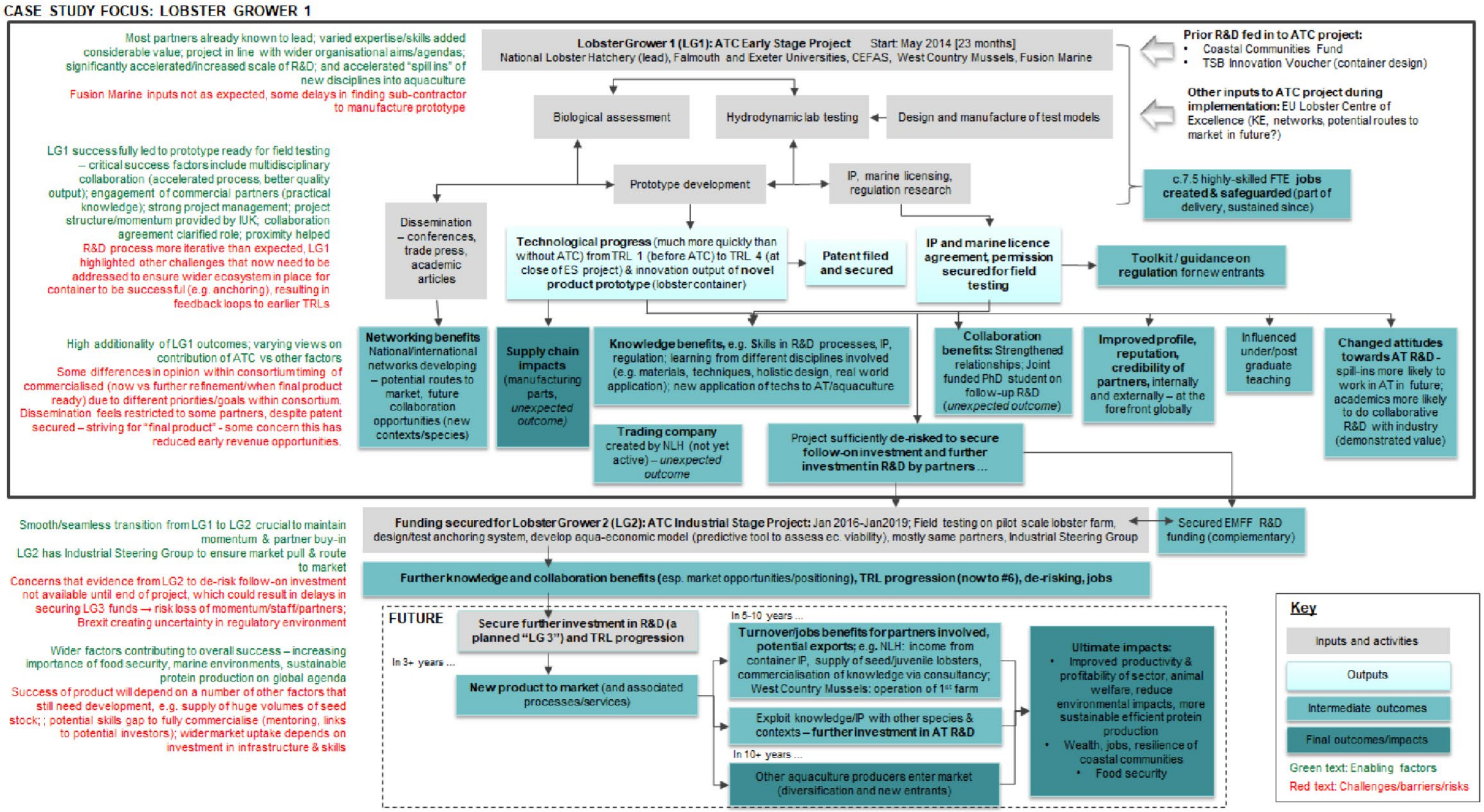
The diagram below summarises the activities delivered by Lobster Grower 1 (and then Lobster Grower 2), and how these have led to outputs/outcomes to date and expected to have impact in future. The annotations in green text highlight key factors that have enabled progress (or will in future), and the annotations in red text are key challenges to date/risks to achieving intended impacts in future.

Legacy and next steps

Following the anticipated completion of Lobster Grower 2 in January 2019, follow-on investment will be required to support late stage R&D activity but also associated early stage technology developments. Without the ability to progress within the ATC programme, there are some **concerns that there will be a pause in progress while funding is sought** – partly because evidence from Lobster Grower 2 (to effectively de-risk follow-on investment) will not be available until right at the end of project, which could cause delays in securing follow-on funds, and risk loss of momentum, staff and partners. The lead also highlighted potential skills gap within project team to fully commercialise the product, and thought that support (such as mentoring and links to potential investors) would be useful during the late stage R&D.

The successful commercialisation will also **depend on all aspects of the container system progressing** (see comment above on feedback loops, e.g. anchoring) and wider inputs in place for European Lobster farming to be a viable enterprise (e.g. supply of huge volumes of seed stock). Moreover, wider market uptake will also depend on market entrant's ability to **investment in infrastructure** and having appropriate **skills/capabilities in aquaculture**.

Figure C-4: Project Theory of Change in practice



Source: SQW

Lessons

Delivering the early stage project through a multidisciplinary collaboration has been the overriding critical factor influencing the success of this project, and has accelerated technology progression. It led to a better-quality output (which has influenced networking benefits, profile/reputation/credibility, attitudes towards R&D in agri-tech, and the ability to secure follow-on finance) and to benefits for those involved (such as knowledge development). The **smooth and seamless transition to industrial stage research** was also important in maintaining momentum and commitment from partners, as well as strong and very focused project management by the lead and IUK monitoring structures to keep the project on track. **Engaging commercial partners** at early stage was important to draw on practical knowledge when testing ideas and (in theory) ensure a commercial pull. Within the collaboration, there have been different perspectives on the timing to commercialisation, and there were some concerns that the loss of the private sector manufacturer dampened the commercial drive and lost a potential route to market within the early stage R&D project – however, this has since been addressed through the creation of an Industrial Steering Group for Lobster Grower 2. The key challenge for this project looking forward will be **securing late stage funding, and ensuring other aspects of the product's ecosystem/supply chain** are in place to make it commercially viable.

Case Study – Harnessing Natural Fungi to Control Insect and Mite Pests in Grain Storage -v2

Key messages

• The project aimed to develop a bio pesticide to combat mites in grain silos. It was led by Exosect and EsEye, with subcontracted services provided by FERA, Campden BRI, David Williams & Associates, CamGrain and Sylvan Bio.

• It built on previous development work undertaken by the partners, sometimes in collaboration, over the previous ten years. • The project was technically successful achieving most of its goals.

• Additionality was high: the ATC support was instrumental in bringing the partners together that would not have happened without the funding and building on prior research.

• Regulatory approval from the EU is still required but progressing, and discussions on commercialisation of the product are ongoing.

Introduction

This project aimed to **develop a new method of pest control for grain storage. It was a Late Stage Round 1** project which began in May 2014 and was completed in October 2015 after a six-month extension. The project was led by Exosect Limited with EsEye as a partner. Both are SMEs. Important technical work was sub-contracted to FERA, Campden BRI, David Williams & Associates, CamGrain and Sylvan Bio. The total cost of the project was almost £186,000, 50% funded by the ATC.

Both Exosect and EsEye responded to the evaluation's telephone survey, and follow-up consultations were completed with the project lead Exosect, and FERA. These were complemented by a review of the project application for funding, and the project completion report.

Project overview

Concerns over resistance development, residues and environmental impacts together with changes in EU legislation have led to a **decline in available pesticides to protect stored food**. Harvested grain is at risk of spoilage from insect and mite infestation during on-farm storage. Infestation results in damage, loss of quality, and likelihood of rejection when the grain is traded. Chemical insecticides have traditionally been used for admixture treatments, but few products are approved under EU legislation. Insect-specific entomopathogenic fungi offer a biological alternative to the use of chemical insecticides.

The consortium aims to optimise the formulation of a mycoinsecticide containing an isolate of *Beauveria bassiana* (Bb) for admixture into grain, building on previous success with a preharvest building treatment containing this isolate (discussed in more detail below). Although of specific interest to EU grain producers, there is a global market demand for this type of product in higher value stored commodities.

The project had three key objectives:

- • adapt the formulation so that it can be suitably mixed with grain and remain cost effective without detrimentally affecting grain quality
- • engineer solutions for safe application of the product as it enters the store, as well as measuring other indicators of grain quality desired by end-users
- • gather sufficient data for a product registration in the UK and EU.

The **ATC project sought to build on substantial previous research and represented continuing collaboration between some of the main partners.** The collaboration had its roots in 2003, when scientists from CABI and FERA, through a Sustainable Arable LINK funded project, confirmed the potential for biological control of storage pests in the UK using indigenous isolates of Bb. The project showed that, under storage conditions, it was essential to develop formulations to improve uptake, germination and penetration into the pests. Between 2005 and 2009, under a further Sustainable Arable LINK project, Exosect and consortium partners CABI, FERA and Sylvan Bio (the spore manufacturer) established the potential for one of the candidate isolates, to control UK storage pests when combined with Entostat. By optimising mass-production and developing prototype formulations the consortium produced isolate and carrier combinations with more than 80% field efficacy on adult insects. In 2010 the consortium continued to work together and, with the addition of a pest control operator as a partner, TSB funded a project to develop the formulations, improve efficacy, assess application methods and provide data for a regulatory dossier to register the active ingredient Bb isolate. The project was very successful.

The product developed in these projects was designed for the treatment of empty stores but Exosect had been running an in-house project since 2010 to examine the potential for the formulations to be used as an admixture treatment applied directly to grain. Heavy infestations in a store will not be eradicated by structural treatment alone and pesticides which farmers can admix with grain bulks to offer protection from infestation are very limited. Therefore, the ability to offer treatments for empty stores and for admixture to grain would increase the chance for commercial success and market acceptance. Some of the major challenges to develop a suitable mycopesticide had already been addressed but, **application directly to the stored grain raised significantly different issues that required further R&D; the subject of the Late Stage ATC project.**

Exosect, the lead partner, is a SME which develops patented technology for commercialisation for out-licensing to major agrochemical manufacturers. As discussed above, it had previously developed an electrostatic method of attaching Bb to grain in a TSB supported project and brought this technology to the ATC project. Exosect would also drive commercialisation of project outputs through licensing to major manufacturers, initially in the main EU markets of the UK, Germany and France.

EsEye was responsible for developing machine-to-machine devices to measure and control the application of the fungi to grain as it entered storage silos.

The main research institute inputs were made by FERA. FERA holds the commercialisation rights to the Bb isolate. It was responsible for testing appropriate dose rates of the fungus and electrostatic powder component in laboratory-scale experiments

Effects and role of the Catalyst

The project is considered by all those consulted to have been technically successful and demonstrated that in-silo treatment of grain with Bb is effective, safe and environmentally sustainable. EU regulatory approval has not yet been granted but is contingent on review of a final study to evaluate possible mycotoxins in the grain. If approval is obtained, further discussions between Exosect and FERA are required before commercialisation.

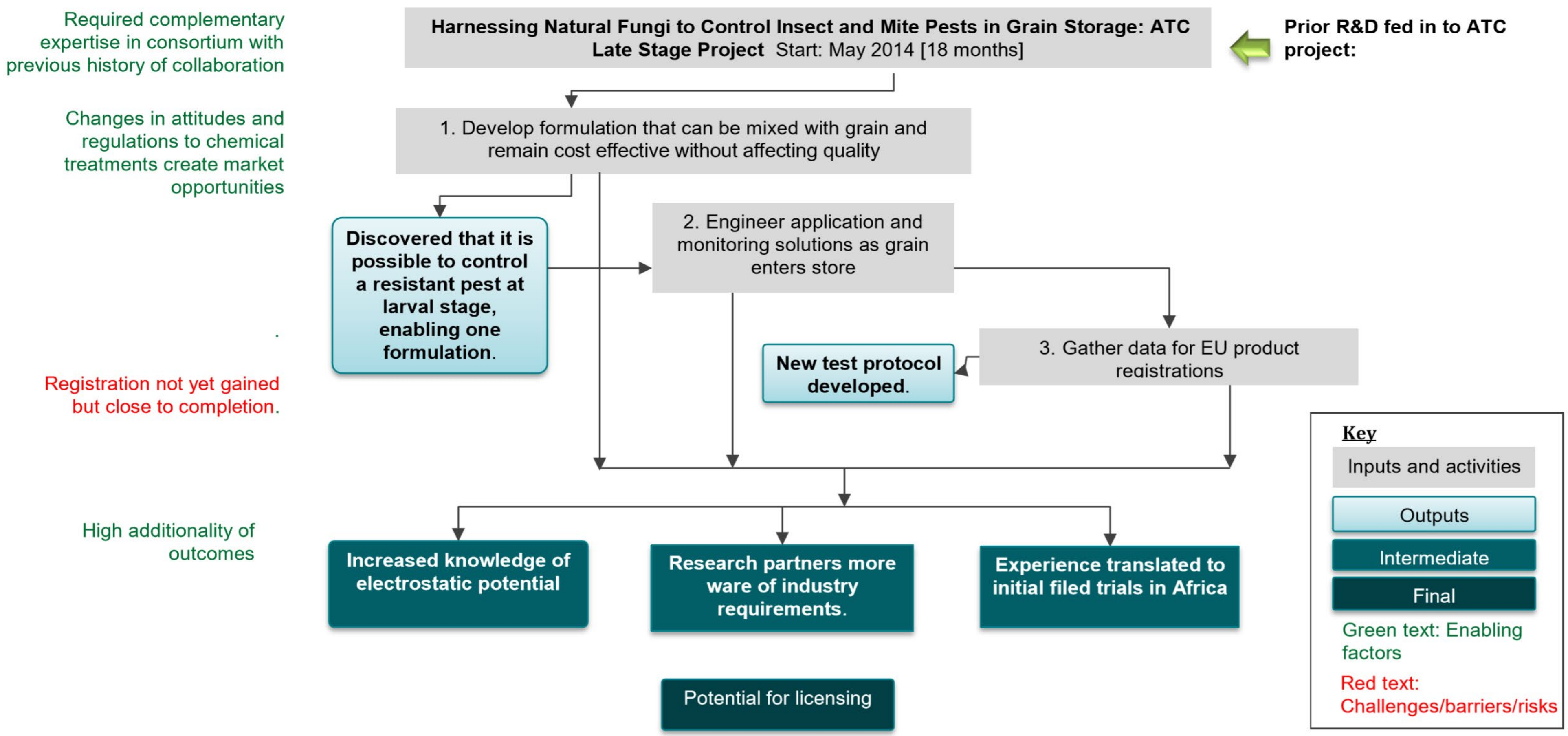
There have been benefits to partners although these have not so far led to any direct impacts:

- There are a range of **technical/scientific knowledge-related benefits** that may have potential benefits in the future in other contexts and for other projects, for example:
    - Exosect has gained further experience in the application of its electrostatic technology which has been useful in other fields.
    - During the laboratory efficacy testing it was discovered that the fungal spores were less able to control one notably resistant species at adult stage, however it was proven to control the pest at a larval stage. This is an important discovery in that it should be possible to control the full range of common grain insect pests with the one formulation.
    - For regulatory purposes, it was required that the formulation is tested in a silo, representative of those used by farmers. Given the need for replicated trails and comparison with commercial equivalent products a complex trial design was developed in consultation with the EU regulators. The outcome was a new trial protocol for biological assessments in grain silo
- **FERA has gained further insights into industry requirements**.

Those consulted reported that **the consortium had worked very well together, and the technical success of the project supports this**. Partners had complementary expertise and well specified roles, and some has successfully collaborated in the past.

The **additionality of project outcomes is high**. Technical success required complementary expertise which no single partner could bring to the project. The lead partner is a SME which could not have borne the risk of funding the research institutes which were essential to the project and enabling the lead to leverage further the in-house research that they had funded via their own resource, especially given the relatively modest returns expected**. ATC support was instrumental in bringing the partners together and building on prior research**.

Figure C-5: Project Theory of Change



Source: SQW

Legacy and next steps

Regulatory approval is still being sought. Subsequent development of project outputs is contingent on discussions between project participants.

Lessons

The key lessons from this project are:

- a consortium with complementary expertise with some partners having previous experience of working together
- drawing on a long period of successful R&D.

Case Study – Sly Agri Limited – IMTS Track System Rubber Track Undercarriage Systems for Controlled Traffic Farming

Key messages

• The project was a late stage grant, awarded in Round 5, which was focused on developing and launching a track system for trailed vehicles in agriculture. • Key benefits delivered to date include:

➢ the development of four and two-wheel track systems for trailers

➢ the successful launch of these new products onto the market and increased sales for the company

➢ the recruitment of additional specialist staff with has increased the capacity for future growth

➢ improved credibility with customers arising from involvement in active R&D to improve existing and launch new products.

• The Agri-Tech Catalyst (ATC) grant was instrumental in helping a small, but fast-growing SME create the capacity to accelerate product development.

• The project has already led to the development of new markets, improved credibility with customers and allowed new relationships in the supply chain which have reduced costs, which in turn has had the added benefit of opening-up new markets for existing product ranges.

• The challenges for the future are focused on being able to sustain the growth the project has facilitated, with further investment needed in market development and production capacity as the company expands.

• The company is very keen to secure further R&D support to continue to develop its product range (possibly including driven-track systems) and to assist with expansion into additional overseas markets.

Source: SQW

Introduction

In 2016 a **late stage** Agri-Tech Catalyst (ATC) grant of £69,108 was awarded to develop a Rubber Track Undercarriage Systems for Controlled Traffic Farming as part of the **5th Round** ATC competition, with the company adding match funding £128,344. The project was run by Sly Agri working on its own. The aim was to develop new products which would allow Sly Agri to become a worldwide supplier of rubber track systems for trailed agricultural applications.

The project was delivered between 1st July 2016 and 30th June 2017. The focus of this case study is on the way in which the company approached the project, the changes they made during delivery to respond to feedback from the marketplace and the impacts the project has had on the company’s growth prospects. The company has already successfully launched new products onto the market as a result of the project and has been able to grow its market globally as a result.

The case study included reviewing the original project application, project closure report and company website, together with an interview with Paul Chapman and George Sly of Sly Agri Ltd.

Project overview

Sly Agri Ltd managed the project **which was conducted entirely in house**, with the exception of some minor use of local sub-contractors who already provide engineering services to the business for specialist engineering tasks which arose during project delivery.

The project was focused on **developing track systems which could be used on agricultural trailers, chaser bins and spreaders (trailed vehicles) to reduce the loading on the soil so that moving heavy trailed vehicles on farmland causes less compaction.** Lower compaction helps to improve soil structure and function allowing better water infiltration, facilitating root growth and leading ultimately to healthier plants. The project included developing OEM and retrofit track systems to replace both four-wheel and two-wheel units. The original plan was to develop trailed, braked and driven track systems.

The driven system concept is designed to help deliver traction and motive power and to recognise that the trailed vehicles are often substantially heavier than the towing tractor. There was also an ambition to develop row crop track systems to reduce the compaction caused in growing crops by machinery such as sprayers and spreaders.

Sly Agri Ltd had **prior experience in R&D**, involving the design and build of new agricultural machinery and components. However, the ATC grant allowed the development of track systems to be accelerated and the scope of the track development programme broadened compared to what a small and rapidly growing SME could have delivered using in-house resources only.

The move into tracked systems began in 2006 when the company started to provide a service for imported Challenger tractors. This ultimately led to the company beginning to source its own tracks at the same time as it was making the rollers needed for track systems.

Before applying for the grant, the company had already built a trial-driven tracked system, which was over-engineered and thus very expensive – at least 50% more expensive than the largest trailed track systems which cost c. £40,000.

The **motivation for undertaking the project was feedback from the market to which they were already selling tracks and providing servicing, which demonstrated demand for track systems for trailed vehicles.** Demonstration of their trial track system in the UK and France demonstrated that there was a large potential demand in the market for the development of tracked systems for trailed vehicles.

This led to the company exploring ways in which they could develop a more cost-effective, simpler and more flexible track system which could be sold profitably into the agricultural market. The company was keen to develop a system which could be manufactured in different sizes (width and track length) for a range of vehicle types and uses and which would allow trailed, braked and driven systems using as many of the same components as possible to reduce costs.

The business was unable to finance the full costs of the project themselves and whilst researching potential sources of finance, Agri-Tech Catalyst (ATC) grants were identified through a web search and the business MD, George Sly, wrote the application for the project.

As the project led to working prototypes and ultimately sales in multiple international markets, the key dissemination route is by getting the product to market. Dissemination has also included hosting two farm-demonstration days in May 2018 (after project closure), the first attracting 100 farmers and the second for the company's international dealership team.

Effects and role of the Catalyst

The most important impact of the Catalyst was to **allow a SME which was growing fast and with limited cash resources to accelerate the development of the tracked systems.**

The company did look at collaborating with other partners, including a university. However, it was decided that running the project in-house and with no collaborators, would ensure that the prime intended beneficiary of the project – the company itself – would be able to ensure that the learning from the project was directly translated into the market in the most efficient way and that it would be able to develop its own team and capabilities.

Whilst the company would have still tried to develop the new track systems **without the support provided by the Catalyst, the time taken would have been many years as opposed to the very rapid progress made in one year** with Catalyst support. A lack of funding would also have meant that **the range of systems developed would have been smaller and would probably have focused only on four-wheel systems.** This would have meant that the company would have unable to develop the two-wheel system which is now being sold successfully into the French and other markets.

The company has a long term, but small team which has grown with the business. The development of track systems has involved all staff, who are passionate and knowledgeable about every area of the business. The company believes that much of its success is built on the fact that customers know that the staff are committed both to the company and the delivery of products which ultimately improve agricultural productivity and soil health.

Since the project commenced, the company MD George Sly, has taken over responsibility for a family farm and this is now providing a live testbed to trial and demonstrate the new products developed by the business.

The late stage project has delivered a range of benefits for the company:

- The **company has successfully launched new products into the market**. To date this includes four- and two-wheel braked and trailed track systems and the testing of row crop systems, the first commercial units of which are now being produced in 2018. These track systems have been sold to manufacturers in Canada, France, Austria, Belgium, Hungary and Australia. Six-to-nine months into the project, the decision was taken not to pursue driven systems which are inherently more costly and complicated to develop. This decision was made because the market demand for four- and two-wheel systems was strong whereas, in contrast, there has been no interest in the concept of driven systems and so the company decided to focus on the proven market demand for the four and two wheel systems.

- The project has also **helped the company to project itself as a progressive, innovative company and this has helped grow sales by improving the company's credibility in new markets.** The credibility which investing in R&D has brought is important as the company wants to continue to position itself as a specialist track supplier who delivers a high-quality track/track system rather than competing at the cheaper end of the market. As a result, the company has been able to increase sales of its tracks, which are manufactured in China. The increased volumes have allowed the cost-per-track to be reduced and this has opened up new markets, with the company for example supplying whole shipping container loads of tracks to Australia. The Chinese connections have been strengthened as a result and this is likely to develop into a more formal long-term joint venture targeting the global agricultural market.

- **Company turnover has increased** as a result of the project by over 15%, with the current year (to September 2018) likely to see a further 15-20% increase from a baseline of £1.4m per annum turnover before the project began. Within three years the company expects turnover to have doubled compared to its position before the project commenced.

- **The company has also increased its staffing** as a result of the development and marketing of the track systems. The development work which was needed and the growth of the company facilitated by the project has led to the recruitment of a full-time design engineer (as opposed to a part-time sub-contractor, although this sub-contractor is still used occasionally when needed); an additional sales person; a new storeman; an apprentice; and, a rubber chemist who works with the factory in China to ensure track quality. The ATC grant was the catalyst for this growth in staffing as the project required new skills and for example more engineering design input. Having made these investments the company is now able to undertake more design work for other products which is helping to fuel growth. The company expects to continue to grow its workforce as it realises the market potential of the new track systems which the STC grant facilitated, with increased sales both necessitating the additional staff and providing the finance to support their salaries and wages.

- The **recruitment of an additional salesman has allowed the company to explore new markets, which are increasingly international**. Only 20% of track sales by the company are now in the UK and this continues to fall as the company develops new overseas markets. The development of the global market needs active marketing and promotion and the additional staff resources has reduced the pressure on the MD who had previously undertaken all these sales trips. The additional marketing resource is also allowing the company to attend more trade events and improve its adverts and marketing.

The diagram below summarises the activities delivered by Sly Agri Ltd using ATC support and how these have led to outputs and outcomes for the company. It also summarises how the company intends to continue to exploit the developments that were started using ATC support. Green text highlights the key factors which have enabled progress (or will in future) and the red text are the key challenges experienced to date or which may restrict future delivery.

Legacy and next steps

Future development of the company is expected to include:

- A **continued push to develop new markets for its products with a focus on global markets.** For example the business already sells track system components to the USA, but believes there may be potential to use this as a springboard to sell complete track systems. The company has had some links with DIT (formerly UKTI) to help with overseas development but is keen to explore the potential for more support as the overseas market is where the greatest potential lies.
- There is still an **intention to develop driven track systems when market demand is evident and resources allow**. Currently the funding is not in place for this development and it will therefore be dependent on both evidence of market demand and the ability to secure funding either from further grants, loans or retained profits as the business grows.
- The track systems which have been developed potentially have a market in the industrial and construction sectors as well as agriculture and this may be exploited in future. However, the scale of the global agricultural market for track systems is such that **the company should be able to grow its market substantially without the need to move into non-agricultural markets**. Keeping the focus on agriculture will allow the company to deepen its expertise and profile in the market.

The company is committed to bo

given the excellent reception which the ATC project has received from customers. To this end, the company would be keen to explore the potential to bid for future grants to facilitate further development of its products.

In the short term the major focus will be on continuing to develop new and existing markets which exploit the systems developed in the ATC project. It is anticipated that most of this growth will occur outside the UK.

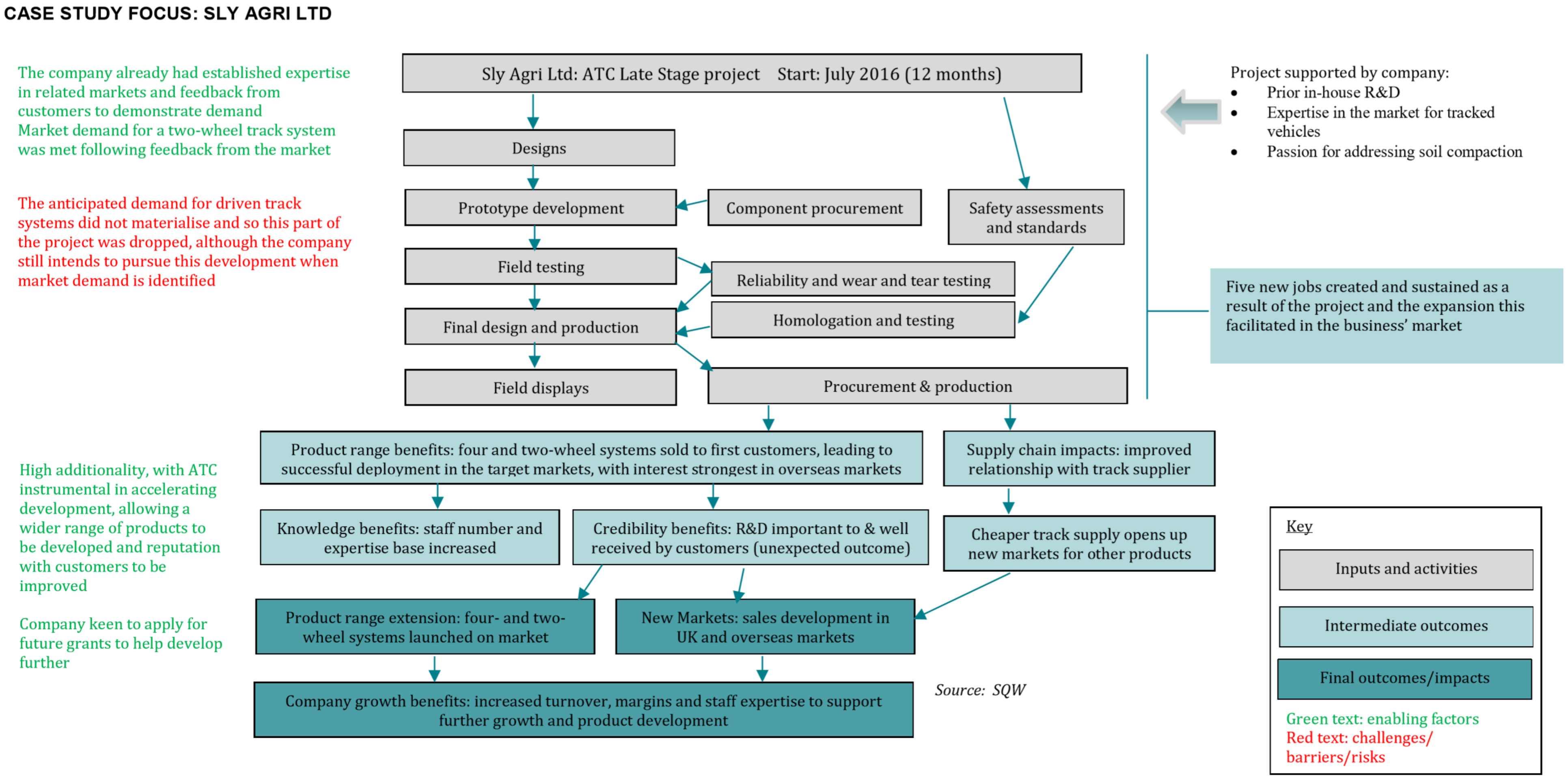
Lessons

The main lesson from the project is that **a single company project can delivery excellent results if the management team is committed and has the skills to deliver the goals set for the project.** The availability of funding has been transformational for a small growing company as it allowed the business to **recruit new skills, create the financial and organisational capacity to develop new products, and to take these rapidly to the international market.**

The decision, six-to-nine months into the project, to postpone the development of driven track systems due to a lack of market interest and instead to focus on developing two-wheel systems because of market demand (as well as the four-wheel systems which were always planned), was an important step in helping the company to develop new markets. The company is pleased that the funders were flexible on this point as it ensured that the project was able to meet market demands.

Through developing sales in new markets and engaging in R&D the company has increased customer confidence and in turn has used the **resultant increased sales volumes to reduce unit costs and increase margins.** This will allow the company to continue to invest and grow. Looking forward, the company is keen to grow the market aggressively for the products developed in the ATC project at the same time as continuing with R&D for new products.

Figure C-6: Project Theory of Change



Annex D: Further detail on beneficiary outcomes

Table D-1: Summary of beneficiary outcomes (of those that provided values for changes in turnover and/or employment

						TRL level…			Introduction of new or significantly improved…	
Project type	**Beneficiary type**	**Beneficiary role**	**ATC award led to change in employment/ turnover**	**Value of turnover change (£)**	**Number of new FTE jobs**	**…before project start**	**…at project end**	**…at time of survey**	**...products or services to the market**	**...processes to the market**
LS	Business	Lead	Y/Y	2,200,000	20	Other	8	9	Experienced	Experienced
LS	Business	Lead	Y/Y	350,000	2	8			Experienced	Will not experience
ES	Business	Collaborator	Y/Y	250,000	2				Experienced	Experienced
ES	Business	Lead	Y/Y	250,000	1	2	3	4	In future	Will not experience
ES	Academic	Lead	Y/Y	250,000	1	4	4	4	In future	Experienced
ES	Business	Collaborator	Y/Y	100,000	2				Experienced	Experienced
ES	Business	Lead	Y/Y	100,000	1	2			In future	In future
ES	Business	Collaborator	N/Y	50,000					Will not experience	Will not experience
ES	Business	Collaborator	Y/Y	15,000	1				In future	Experienced
ES	Business	Lead	Y/Y		5	3	5	7	In future	In future
ES	Business	Collaborator	Y/N		3				In future	In future
ES	Academic	Collaborator	Y/N		3				In future	Experienced
ES	Business	Collaborator	Y/N		3				Experienced	Experienced
ES	Business	Lead	Y/Y		2	1	5	9	Experienced	Experienced

						TRL level…			Introduction of new or significantly improved…	
Project type	**Beneficiary type**	**Beneficiary role**	**ATC award led to change in employment/ turnover**	**Value of turnover change (£)**	**Number of new FTE jobs**	**…before project start**	**…at project end**	**…at time of survey**	**...products or services to the market**	**...processes to the market**
ES	Business	Lead	Y/N		2	**1**	4	9	In future	In future
ES	Academic	Lead	Y/N		1	**1**			In future	In future
ES	Academic	Collaborator	Y/N		1				In future	Experienced
ES	Academic	Lead	Y/N		1	**1**	7	9	Will not experience	Will not experience
ES	Business	Collaborator	Y/N		1				In future	In future
ES	Business	Lead	Y/N		1	Other			Experienced	In future

Source: SQW

This publication is available from: www.gov.uk/government/publications/agri-tech-catalyst-atc-programme-interim-impact-evaluation