Evaluation of the Industrial Strategy Challenge Fund

Interim impact evaluation report: Annex

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Abbreviations

AI	artificial intelligence
AIDE	AI Deployment Engine
AOTF	Audience of the Future [ISCF Challenge name]
APC	Advanced Propulsion Centre
ATF	Automotive Transformation Fund
ATMP	advanced therapy medicinal products
AR	augmented reality
ATTC	Advanced Therapy Treatment Centres
AUKUS	Partnership between Australia, the UK and the UK.
BAME	Black, Asian minority ethnic
BEIS	Business, Energy & Industrial Strategy
BSD	Business Structure Database
CAA	Civil Aviation Authority
CAGR	compound annual growth rate
CHERI	Capability Hardware Enhanced RISC Instructions
CI	Creative Industries
CIH	Construction Innovation Hub
COPD	chronic obstructive pulmonary disease
CR&D	collaborative research & development
CRM	critical raw materials
CHRN	Companies House reference number
DARPA	Defense Advanced Research Projects Agency
DER	Driving the Electric Revolution [name of a challenge Fund]
DHTC	Digital Health Technology Catalyst
DiD	Difference-in-difference
DSBD	Digital Security by Design [ISCF Challenge name]
EDI	equity, diversity and inclusion (also ED&I)
EDiT	Energy Digitalisation Taskforce
EDT	Energy Data Taskforce

eV	electric vehicle
ERIS	Energy Revolution Integration Service
ESO	Energy Superhub Oxford
FBC	Faraday Battery [ISCF Challenge name]
FFC	Future Flight [ISCF Challenge name]
FI	Faraday Institute
FLIP	Federated Learning Platform
FTE	full-time equivalent
GDP	gross domestic product
GMP	good manufacturing practice
GVA	gross value added
ICAIRD	Industrial Centre for Artificial Intelligence Research in Digital Diagnostics
IDBR	Inter-Departmental Business Register
IDC	Industrial Decarbonisation Challenge
IDRIC	Industrial Decarbonisation Research and Innovation Centre
IFS	Innovation Funding Service
IIoT	Industrial Internet of Things
IP	intellectual property
ISCF	Industrial Strategy Challenge Fund
IUK	Innovate UK
KTN	Knowledge Transfer Network
LPWAN	low-power wide area network
MIDRI	Manufacturing Innovation Design and Research Institute
MMC	Medicines Manufacturing Challenge [ISCF Challenge name]
MoD	Ministry of Defence
MRL	Manufacturing Readiness Level
MSI	Manufacturing Smarter Innovation [ISCF Challenge name – formerly Manufacturing Made Smarter]
NERC	Natural Environment Research Council
NGS	Next Generation Services [ISCF Challenge name]
NICE	National Institute for Health and Care Excellence
NPIC	Northern Pathology Imaging Collaborative
OEM	original equipment manufacturer
OLS	Office for Life Sciences

ONS	Office for National Statistics
ORCA	Offshore Robotics for the Certification of Assets
PEMD	Power Electronics, Electric Machines and Drives
PFER	Prospering from the Energy Revolution [ISCF Challenge name]
PSM	propensity score matching
SNZI	Scotland Net Zero Infrastructure
QT	quantum technology
R&I	research and investment
RAI-EE	Robotics and Artificial Intelligence in Extreme Environments
RAP	Research Analysis Platform
RDD	regression discontinuity design
RPAS	remotely piloted aircraft system
RSW	Robotics for a Safer World [ISCF Challenge name – now called Robotics and Artificial Intelligence in Extreme Environments]
SFA	Story Futures Academy
SLES	Smart Local Energy Assests
SME	small and medium-sized enterprises
SMR	small modular reactor
SSPP	Smart Sustainable Plastic Packaging [ISCF Challenge name]
TCN	Transforming Construction [ISCF Challenge name]
TFI	Transforming Foundation Industries [ISCF Challenge name]
TFP	Transforming Food Production [ISCF Challenge name]
TRL	Technology Readiness Level
UKRI	UK Research and Innovation
VC	venture capital
VfM	value for money
VR	virtual reality
WGS	whole-genome sequencing
XR	extended reality

Annex A. Summary of the ISCF Challenges

This annex summarises the Industrial Strategy Challenge Fund (ISCF) Challenges and their key aims for which we have reviewed impact evaluation reports as part of our Fund-level impact evaluation of the ISCF.

Table 1. ISCF Challenges and their key aims

Cluster	Challenge	Key aims	Interim evaluation report available for this report?	Final evaluation report available for this report?
Healthy Society	Medicines Manufacturing	The Medicines Manufacturing Challenge (MMC) aims to promote the UK as a world leader in medicines manufacturing and the delivery of novel treatments. Subcomponent aims: • Digital Health Technology Catalyst (DHTC) programme – supports R&D projects aiming to accelerate the development and commercialisation of digital health technologies • Medicines Manufacturing Programme – developing next-generation medicines, increasing technology opportunities within the medicines supply chain, improving vaccine manufacture and innovation, promoting advanced therapy via cell and gene therapies, and promoting commercialisation of the same	Yes	Yes
	Data to Early Diagnosis and Precision Medicine	The Data to Early Diagnosis and Precision Medicine Challenge supports the development of precision medicine for improved early diagnosis and treatment and accelerate the use of research and health data. 3 focus areas:	Yes	No

		• Genomics: supports large-scale whole-genome sequencing (WGS) for precision medicine • Health data: combines NHS data with data from research and development programmes to provide analytical and data science support to businesses • Integrated and early diagnostics: via a network of 5 research centres across pathology, radiology, diagnostics and artificial intelligence (AI)		
	Healthy Ageing	The Healthy Ageing Challenge aims to enable businesses, including social enterprises, to develop and deliver scaled-up products, services and business models to support people as they age. The Challenge supports enterprises via investment partnerships, its Social, Behavioural and Design Research Programme, and competitions and awards for enterprises that focus on its 7 themes.	No	No
	Accelerating Detection of Disease	The Accelerating Detection of Disease Challenge supports research into the early diagnosis, prevention and treatment of chronic disorders using biological and digital data from up to 5 million volunteers. Focus: • Managing chronic disease and cancer – combine health and other data with AI to accelerate diagnosis, preventative strategies and treatments • Early detection – link long-term volunteer data to NHS and health data to enable early detection and treatment	No	No
Data and Digital	Commercialising Quantum Technologies	Building on the UK's National Quantum Technology Programme, the Commercialising Quantum Technologies Challenge supports new products and technologies based on advances in quantum science. 4 focus areas: • Product and service innovations – funding research on new quantum-enabled product and service innovations • Industry-led technology development project • Supply chain – feasibility on innovative components and supply chain elements across the quantum sector	Yes	No

		• Investment accelerator – supporting early-stage, spin-out and start-up quantum technologies (QT) companies to secure venture capital.		
	Digital Security by Design	The Digital Security by Design (DSBD) Challenge supports projects that help the UK digital computing infrastructure to become more secure. Focus: • Creation of an updated hardware architecture in a physical prototype board • Developing the software and system development tools that will run on it • Demonstration in industry sectors, including automotive, e-commerce, defence, telecoms and operational technologies	Yes	No
	Next Generation Services	The Next Generation Services Challenge supports the UK's service industries to use technologies, such as AI and data analytics, to develop the next generation of services. The Challenge is focused on 3 priority sectors – the legal, accounting and insurance services. Projects focused on the following: • Research on barriers – examining the potential behavioural and socio-technical barriers to the use of the above technologies in the 3 sectors • Data Access – developing responsible data access/sharing methods and business models in the 3 sectors	Yes	No
	Audience of the Future	The Audience of the Future (AOTF) Challenge supports the development of immersive experiences and technologies in the UK-based creative sector, including research to better understand audiences for immersive productions. Focus: • Demonstrator programme covering 4 sectors: e-sports and gaming, performance, moving image, and visitor experience • Production innovation for creating faster, more efficient immersive content • Immersive technology investment accelerator to support early-stage businesses. • Design foundations support for projects exploring human-centred design	Yes	Yes

		• StoryFutures Academy as a national centre for immersive storytelling.		
	Manufacturing Smarter Innovation	The Manufacturing Smarter Innovation Challenge aims to help the UK's manufacturing industry become more productive and competitive through innovation and the adoption of the following digital technologies: • AI, ML and data analytics • Additive manufacturing • Robotics and automation • Virtual and augmented reality • Industrial Internet of Things (IIoT) and connectivity (5G, low-power wide area network (LPWAN))	Yes	Yes
	Robotics for a Safer World	The Robotics for a Safer World (RSW) Challenge supports the development of novel robotics and AI technologies and systems to reduce the number of people working directly in extreme environments. Supports projects across 4 main sectors: • Offshore wind energy - e.g. drones to maintain wind farms • Nuclear energy – e.g. assisting with nuclear decommissioning • Space – future AI and robotics for space • Mining – e.g. inspect subterranean mines In addition to these 4 sectors, the Challenge includes projects on automating fruit packing and has also evolved to include new needs, such as robotic sanitising of care facilities during COVID-19.	Yes	No
Clean growth	Transforming Foundation Industries	The Transforming Foundation Industries (TFI) Challenge supports the development of innovative technologies, collaborations and investment in the foundation industries in order to increase competitiveness, secure jobs and reduce environmental impact. The six relevant sectors are: cement, glass, ceramics, paper, metals and chemicals.	Yes	No
	Low Cost Nuclear	The Low Cost Nuclear Challenge aims to develop a compact, standardised nuclear power station product based around a UK-designed small modular reactor (SMR).This is to be achieved via modern mass production methodology. The first phase of the project saw the development of a	No	No

		concept design (Rolls-Royce), and the second phase will focus on development of this technology till a stage that attracts private investment.		
	Prospering from the Energy Revolution	The Prospering from the Energy Revolution Challenge aims to accelerate innovation in smart local energy systems. Focus areas: • Demonstrator projects – on transmission-connected eV charging network, integrated virtual energy system, local energy marketplace and intelligent grid • Detailed designs – developing designs for local energy systems at the level of towns, cities and regions. • Modernising energy data – projects focusing on new open software, hardware and data solutions for the energy sector • Key technology components for local energy systems • New knowledge and tools – research on uptake and impact of local energy systems	Yes	No
	Industrial Decarbonisation	The Industrial Decarbonisation Challenge aims to contribute to the UK's drive for clean growth across the six largest industrial clusters through development and deployment of such technologies as carbon capture, utilisation and storage and hydrogen fuel switching.	Yes	No
	Transforming Construction	The Transforming Construction Challenge aims to accelerate a shift in the construction via 3 central Challenges: • Moving to a manufacturing approach – from suppliers right through to site • Embracing digital technologies to provide assurance, efficiency of projects and performance feedback to design • Shifting to selling outcomes (what a building does rather than what it is) and maximising whole-life value of assets	No	Yes
	Transforming Food Production	The Transforming Food Production (TFP) Challenge supports the development and adoption of new ways to produce food, with a view to improving the productivity and resilience of primary food production while also reducing emissions and pollution.	Yes	No

		Focus areas: • Farming Innovation Programme – projects on productivity and sustainability in agriculture and horticulture while orienting towards net zero • Future food production systems – development of new, high-value food production systems • Science and technology into practice – development and adoption of precision approaches • International opportunities – accelerate shared international priorities and build export opportunities for agri-tech • Investment ecosystem – drive private investment in agri-tech via investor partnership		
	Smart Sustainable Plastic Packaging	The Smart Sustainable Plastic Packaging (SSPP) Challenge aims to tackle the challenge of plastic pollution in the environment by facilitating the development of a more sustainable plastic packaging value chain. Focus areas: • Sustainable plastic packaging materials and designs • Collaboration and innovation for integrated circular supply chains – including insights on systems change and consumer behaviour • Learning and knowledge dissemination from funded projects	Yes	No
Future of mobility	Driving the Electric Revolution	The Driving the Electric Revolution (DER) Challenge supports the UK's push towards a net-zero carbon economy and clean technology supply chains through investment in electrification technologies, including Power Electronics, Electric Machines and Drives (PEMD). 3 focus areas: • Industrialisation centres – creation of a network of regional centres to develop and scale PEMD technologies and manufacturing • Collaborative innovative funding – projects to help businesses grow PEMD supply chains and manufacturing capabilities • Talent and skills development	Yes	No

	Faraday Battery	The Faraday Battery (FBC) Challenge aims to drive the growth of a strong battery business in the UK through the development of battery technologies that are cost effective, high performing, longer range, faster charging, long lasting, safe and recyclable. The Challenge aims to support the UK automotive supply chain meet deadlines for zero emission vehicles.	Yes	No
	Future Flight	The Future Flight Challenge (FFC) aims to bring together technologies in electrification, aviation systems and autonomy to create new modes of air travel and capability by demonstrating along 3 areas: • Safe integration and operation of drones • Advanced air mobility and regional aircraft • Advancements in electrification and autonomy	Yes	No

Annex B. ISCF impact evaluation framework

This annex presents the framework and questions that have been used to conduct the impact evaluation of the ISCF.

Table 2. Impact evaluation framework

Impact evaluation theme	Impact subcategory	Evaluation question
Creating knowledge and innovation pathways	1.1 Innovation	To what extent has the ISCF advanced the readiness of new technologies, products and processes?
		To what extent have ISCF outputs (technologies, products, processes, services, approaches, etc.) been implemented/adopted within society?
	1.2 Knowledge creation (publications, data, etc.)	What has been the contribution of the ISCF to new knowledge addressing the Challenges, both within the UK and internationally?
	1.3 Stakeholder and public awareness and understanding	To what extent has the ISCF leveraged knowledge and insights to create increased awareness and understanding among key stakeholders of new technologies and outputs addressing the Challenges?
	1.4 Engagement with policymakers and informing policy	To what extent has the ISCF contributed to evidence-based policymaking surrounding the Challenges?
	1.5 Learning on mission-oriented research and innovation (R&I)	To what extent has the ISCF enhanced understanding of the effectiveness of mission-oriented R&I programmes and informed more effective policymaking for mission-oriented goals?

Capacity and investment	2.1 Investment	To what extent has the ISCF increased UK businesses' investment in R&D?
		To what extent has the ISCF increased overseas investment in R&D in the UK?
		How much additional public R&D investment has the ISCF contributed towards the R&D investment target of 2.4% of gross domestic product (GDP) by 2027?
		To what extent has research supported by the ISCF opened up new avenues of investment (de-risking)?
	2.2 Geographic distribution of investment/activities	While the ISCF is place-agnostic, to what extent have the Fund's investment and activities been widely distributed across the UK?
	2.3 Capacity (individual (skills, training) and infrastructural)	To what extent and how has the ISCF increased individual capabilities and capacities both in research and innovation?
		To what extent has the ISCF attracted additional talent and Challenge-associated skills into the UK?
		How and to what extent has the ISCF contributed to improved infrastructure to support future R&I investment?
	2.4 Diversity	How has the ISCF contributed to equity, diversity and inclusion?
	2.5 Employment, job creation and spin-outs	To what extent has the ISCF contributed to the creation and retention of new businesses and high-skilled jobs?
Connected innovation ecosystem	3.1 Collaboration and partnership	To what extent has the ISCF increased collaboration between businesses, including between younger, smaller companies and larger, more established companies up the value chain?
		To what extent has the ISCF increased business–academic engagement on innovation activities relating to the Challenge areas?
		To what extent has the ISCF increased Manufacturing Innovation Design and Research Institute (MIDRI) research around the Challenge areas?

	3.2 Recognition and prestige	To what extent have institutions and clusters participating in the ISCF Challenges been recognised for their expertise within the UK and internationally?
Economic impact	4.1 Economic impacts (turnover, gross value added (GVA), productivity)	To what extent have the ISCF Challenges supported the growth of UK businesses and created new markets, or enabled increase of UK's share in global market in their respective sector?
		What has been the increase in GVA (including the creation of new products and services in relevant sectors and/or the creation of new markets)?
		What has been the productivity change (capital, labour or combined)?
	4.2 Geographic distribution of investment/impacts	While the ISCF is place-agnostic, to what extent have the economic impacts of the ISCF been widely distributed across the UK?
Societal impact	5.1 Impacts on health	To what extent has the ISCF contributed to health and wellbeing benefits, including quality of life, life expectancy, reduced health inequalities and reduced healthcare costs?
	5.2 Impacts on environment	To what extent has the ISCF contributed environmental and sustainability benefits, including reduced emissions, progress towards net zero, and growth of the circular economy?
	5.3 Impacts on infrastructure and services	To what extent has the ISCF contributed benefits to infrastructure and service, including broadened access, increased resilience, and increased safety?
	5.4 Wider impacts	To what extent has the ISCF contributed wider societal benefits, including unexpected and unintended consequences?
Value for money	6.1 Value for money	To what extent does the ISCF represent value for money (VfM)?

Annex C. Impact evaluation methods

This annex provides more detail on the methods used to conduct the interim impact evaluation of the ISCF.

C.1. Review of Challenge-level impact evaluation reports

A total of 16 interim impact reports and 4 final impact evaluation reports were reviewed and thematically coded against the evaluation framework presented in Annex B. The study team developed a codebook with a list of the 19 impact subcategories mapped against the 6 evaluation framework themes. Each impact subcategory consists of multiple 'codes', which are a combination of key words and lead and lag indicators. We used MaxQDA qualitative data analysis software to code the Challenge-level reports against the codebook developed. Analysis of the coded material enabled the team to identify a range of evidence across the Fund, with varying levels of progress against the impact subcategories. The approach identified areas of common progress as well as areas of variation, where a handful of Challenges had led the way in realising impacts. Evidence in the Challenge-level evaluation reports was supplemented with Fund-level data from the Portfolio Performance Reports (quarterly) and Delphi dataset. However, an important caveat for this analysis is that it only represents completed responses from Challenge awardees and that some responses are likely missing; therefore, many Fund-level figures are likely underestimated.

C.2. Clustering approach for impact synthesis

The aim of this evaluation was to conduct a Fund-level assessment of impact across ISCF. However, when we were conducting the synthesis and analysis, it was also apparent that certain impact subcategories were more relevant to a specific group of Challenges, for instance health impacts or net-zero/environmental impact. Therefore, the team reviewed the impact subcategories and associated indicators through a cluster lens, grouping similar Challenges together in order to draw out key findings and themes across these groupings. To group the Challenges into clusters, the study team conducted an internal mapping exercise whereby evaluation indicators across all the Challenges, as well as their objectives, were compared to identify where there was significant overlap. The mapping was subsequently presented at an internal RAND and Frontier Economics workshop, to arrive at intuitive groupings for the Challenges supported by the objectives of the Challenges.

The workshop comprised two interactive activities. In the first, the Challenges were grouped based on the original Grand Challenge rubric, as a potential framework for consideration in the exercise. Referring to the objectives/scope of the Challenges and the preliminary network analysis, participants considered where else

a given Challenge could fit within the Grand Challenge clustering and/or whether new clusters could be added. The key aims of this first exercise were:

- To consider possible refinements to the Grand Challenge framework as a clustering of the Challenges from a conceptual perspective;
- To consider potential spillovers where Challenges grouped into one cluster may also have impacts on other clusters.

This discussion identified specific areas of impact of particular importance to a given grouping of Challenges and fed into the second activity.

In the second activity, participants were presented with a series of summary heatmaps (from the mapping exercise) to illustrate the consistency of metrics being collected across clusters using the Grand Challenge framework as a 'straw man'. Each summary heatmap presented an assessment of metric consistency for a specific area of the Fund-level impact evaluation framework, e.g. 'networks and collaboration'. For each heatmap, the following key questions were considered during the activity:

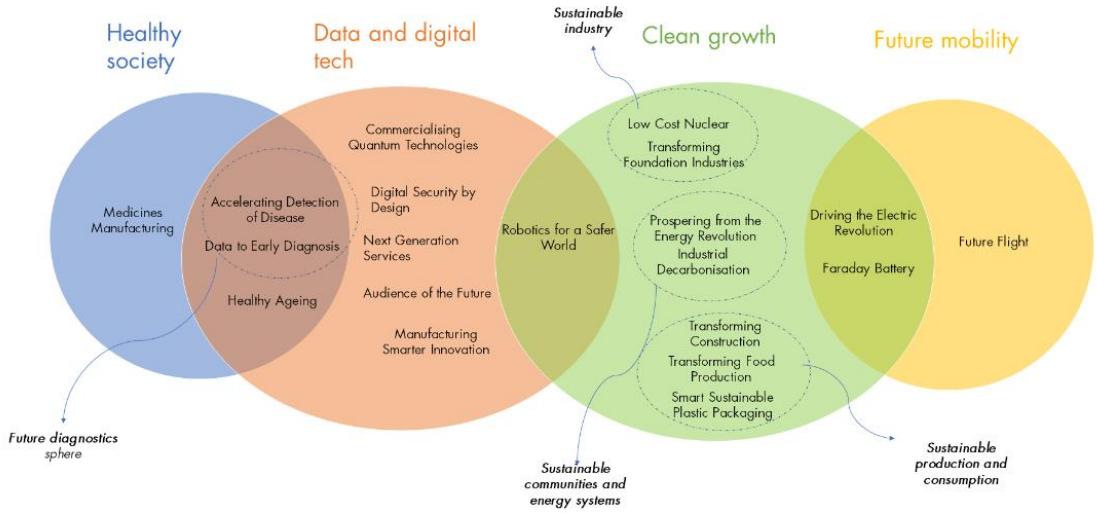
- Based on the summary assessment, is it likely that the Grand Challenge clusters will help tell a story of ISCF's impact in this specific impact area?
- Does the summary assessment suggest that a more aggregate Fund-level analysis would be more appropriate for this impact area, rather than a clustering approach?

The workshop clarified which Challenges naturally aligned more based on objectives and/or metrics being collected across impact subcategories and where Challenges could be appropriately grouped. The outcomes of the exercise revealed clusters that broadly mirrored the Grand Challenges, with some modifications based on the 'ground up' mapping of indicators exercise. The outcomes of these exercise were shared with UK

Research and Innovation (UKRI) and the ISCF Evaluation Steering Group for sign-off via an internal memo followed by a presentation.

The clusters were intended to help aggregate findings, where appropriate, beyond the level of individual Challenges to enable synthesis of generalisable comments on progress (or lack thereof) made by ISCF across sectors and at the Fund level. They have been used as such throughout the interim impact report.

Figure 1. Alignment of Challenges to various industrial clusters.



Validation workshops with ISCF stakeholders

To validate emerging findings from the Fund-level evaluation, we conducted a workshop with Fund stakeholders, including Challenge directors, Challenge evaluation managers, individuals from Innovate UK, project awardees, and industry representatives (N = 50). This workshop was conducted as the final analysis step prior to submission of the ISCF interim impact evaluation report. Those attending the workshop provided feedback on the findings, and these were used to refine and nuance the findings presented in the report.

Annex D. Economic and network analysis approach (Frontier Economics)

D.1. Overview

D.1.1. About this note

The econometric analysis to be conducted as part of the final phase of the impact evaluation of the ISCF in 2024 will focus on how the Challenge Fund programme has generated economic benefits for businesses supported by one or more Challenges.

Econometric analysis will be conducted to understand the impact of the Fund on business performance. The approach will use data linking to compare how businesses engaged by the Fund (the 'treatment group') perform compared with an objective counterfactual ('control group') of observationally similar businesses. Outcomes will include key business performance indicators such as headcount employment, business turnover, business survival, and a proxy for productivity (turnover per worker). This will give an indication of whether businesses grew quicker than they would have absent the support or were less likely to fail.

Rather than explore impacts at the Challenge level, the econometric analysis will seek to explore the impact of the ISCF as a whole and at clusters as discussed in this main body of this report.

This analysis will form a key input into the economic evaluation feeding into the 'growth of UK businesses' and 'increased productivity' parts of the logic model and into the VfM assessment. As well as corresponding to ISCF's mission-oriented structure, a key motivation for conducting the analysis at the wider ISCF level is that organisations may interact with multiple Challenges, which means attribution of impact is difficult when done in respect of only one Challenge in isolation. Pooling the data across multiple Challenges also gives larger sample sizes and more reliable estimates of an average treatment effect.

This note updates the scoping of the econometric analysis that was delivered as part of the original ISCF framework report and baseline report (both published in November 2022).[1] Since the baseline report, there has been further engagement with Challenges in relation to any Challenge-level data that may be relevant, and we have explored an additional central dataset, Innovation Funding Service (IFS), which includes both successful and unsuccessful applicants for grant funding, as well as data on application scoring. IFS also gives a more up-to-date view on grant funding to date and of the potential structure of the dataset to be used. We assess whether unsuccessful applicants can provide a counterfactual, exploring the coverage of this

[1] See in particular Sections 5.3.6, 6.2.2 and 6.6.5 of the evaluation framework report (available here) and Annex A of the baseline report (available here).

data, conceptual soundness of the comparison, and practical considerations for integrating and using the data in the analysis.

D.1.2. Summary of key findings

Overall, little has changed in the proposed econometric approach. We find that the central datasets already capture the vast majority of firm-level interaction and that only in a few cases is it appropriate to supplement this with Challenge-level data.

We assessed the feasibility of using IFS scoring data to implement a regression discontinuity design (RDD) approach in which outcomes for 'just-successful' and 'nearly successful' applicants are compared. The RDD approach assumes that firms close to a cut-off for funding support through ISCF are similar in terms of the quality of bids and other characteristics, such that those just missing out represent a good counterfactual for those just awarded funding. If ISCF funding is beneficial, we would expect to see those just successful improve on key performance metrics relative to those just unsuccessful, creating a 'discontinuity' in outcomes that would be attributed to ISCF support.

Relative to the approach proposed in the baseline report, which was to identify a control group based on propensity score matching from a wider pool of unsupported firms, the RDD approach, if appropriate, may be considered more robust in terms of the comparability of the treatment and control groups, giving additional credibility to the attribution of impact to ISCF.[2]

While the IFS data can be easily linked to the other datasets, our review suggests that an RDD approach is not appropriate for this evaluation. This is because scoring and awarding decisions do not always obey clear thresholds, due to considerations such as VfM or the need to bring about impacts throughout the supply chain portfolio. A key requirement for the validity of RDD is that the thresholds for treatment are strict. As a result, we conclude that an RDD approach is unlikely to perform well in this context.

However, the availability of unsuccessful applicants from IFS that can be readily matched into the analytical dataset does mean that the wider pool of unsuccessful applicants could be used as a counterfactual group to select from using a matching or difference-in-difference approach as outlined below.

This means we can build on and refine the approach proposed in the baseline report. This will include a **propensity score matching (PSM)** analysis, in which outcomes for treated firms are compared with those of a matched group with similar characteristics. The numbers of firms engaged in Challenges should allow the PSM to be done separately for each cohort of treated firms (by treatment year). We will also estimate a **difference-in-difference** (DiD) regression in which a treatment effect is estimated while controlling for various firm-level and time-varying effects, using the flexibility of this approach to explore whether the business impacts of ISCF support vary across dimensions, such as sector and geography.

Control groups will be drawn both from the wider business population and a more restricted sample based on unsuccessful applicants identified from IFS, allowing us to assess the sensitivity of findings to the choice

[2] A general weakness of RDD relative to matching, however, is that the RDD approach can only inform us about the impact of support for firms that are just successful; the resulting treatment effects would not necessarily be appropriate for firms that were well above any funding cut-off.

of control population. It may be that firms who applied for ISCF support but were not successful are a more appropriate counterfactual than the wider business population, as we know they are looking to grow and operate in similar sectors to those influenced by the Challenges.

D.2. Analytical approach

D.2.1. Baseline report proposed method

We propose to use quasi-experimental methods to measure the impact of ISCF support, where a control group acts as a counterfactual for how supported businesses would have performed in the absence of ISCF support. Methods differ in terms of how a control group is defined. In the baseline report, a combination of **PSM** and **DiD** approaches was proposed, summarised briefly below.

A key consideration is that rather than receiving support at random, businesses opt into applying for support. This means that supported firms are likely to differ systematically from non-supported businesses, so that simply looking at outcomes for non-supported businesses is unlikely to provide a robust counterfactual. For example, supported firms may be a different size on average, or be drawn systematically from specific sectors.

This problem is largely addressed by using PSM. The approach uses a first-stage regression model to estimate the likelihood of treatment ('propensity score'), which is then used to find, for each treated firm, a group of non-treated firms with similar likelihood of treatment based on observable characteristics. The average difference in outcomes between the treated firms and their matched controls is interpreted as a treatment effect. Statistical comparisons of the treatment and selected control group can be undertaken to validate that they are comparable in terms of observable characteristics. Where 'balancing' does not hold, alternative selections of matching variables should be tested until the groups are similar.[3]

PSM relies on two key assumptions. The first is that there is sufficient overlap between the modelled propensity scores for the treatment and control groups to identify sufficiently similar control firms ('common support'). Some treated observations may lack common support, which means it is not possible to construct a robust counterfactual for this group and they are necessarily excluded from the analysis.[4] This can limit the generalisability of findings. The second is that the model used to estimate the propensity score captures the key drivers of treatment and that there are no key unobserved drivers ('conditional independence'). Our previous experience applying this method in the context of business support interventions suggests that the common support assumption is broadly met, albeit that around a quarter of firms supported by Innovate UK in a previous exercise were not matched with a control firm in one study,

[3] Often this will entail using a more parsimonious selection of matching variables.

[4] This is most likely to occur for observations with very high treatment probability, which would occur, for example, if nearly all firms within a sector are treated, so that in that category implies a very high probability of treatment.

for example.[5] The conditional independence assumption is hard to test in practice, but such key drivers as sector, size, pre-treatment growth trends and markers of innovative businesses appear to be important factors of selection into treatment that have been used successfully in similar evaluation exercises.

PSM can only control for **observable characteristics**. If there are unobservable characteristics that are correlated with subsequent performance and that also affect whether or not a firm is supported by the ISCF, this could bias the results upwards. For example, we would expect firms with an unobserved 'appetite' for growth or innovation to subsequently grow more than other firms, whether or not they received ISCF funding. If it is not possible to control for this, it may be wrongly attributed to the effect of treatment. We believe much of this latent potential can be captured by proxy variables in the model, for example indicators of past innovative behaviour (such as inclusion in Business Enterprise Research and Development Survey as a proxy for firms being R&D active, as well as the pre-treatment growth trend, which is a strong predictor of subsequent growth).

DiD can further 'difference out' any pre-treatment differences between the treatment and control groups in terms of key metrics of interest, assuming that these metrics follow similar pre-treatment trends for the two groups.[6] DiD also allows multiple cohorts of treated firms to be easily combined, which improves sample sizes such that additional cuts of the treatment effects by different groups of supported firms (e.g. firm size, grant size, competition type or consortium size) can be explored.

In addition, DiD is very flexible in terms of how different treatment effects can be estimated in the model: multiple treatment terms can be used within one regression (e.g. estimating different effects for different project types), and interaction terms can also be tested (e.g. testing whether a particular project type has a different treatment effect to the average). This means that variation in treatment effects can be explored in great detail.

The additional step of running a DiD analysis only on the sample of firms with similar propensity scores (thus removing high-propensity and low-propensity firms) can improve commonality of pre-treatment trends and is a complementary econometric approach that can readily be deployed.

D.2.2. Additional considerations post-baseline report

Relative to the scoping conducted for the baseline report, the availability of the IFS dataset has enabled us to include consideration of RDD approaches as part of the overall econometric design.

RDD provides another potential way of identifying a counterfactual, by comparing successful and near-successful grant applicants. The rationale behind this approach is that application success thresholds are

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[5] Frontier Economics (2017), *The Impact of Public Support for Innovation on Firm Outcomes*, BEIS Research Paper 3 (available here). The scale of the issue will depend on the specific matching algorithms and 'callipers' of closeness in the propensity score chosen. The trade-off between comparability of match and lack of common support should be subject to sensitivity testing.

[6] In principle, the PSM process should lead to the treatment and control groups being observably identical in terms of e.g. pre-treatment levels of employment or turnover. In practice, there may be some differences remaining between the groups. See Frontier Economics (2017), *The Impact of Public Support for Innovation on Firm Outcomes*, BEIS Research Paper 3 (available here).

arbitrary, so applications graded 'just above' and 'just below' the threshold will be similar to each other and should be expected to perform similarly in future absent the effects of receiving any grant. If similarity can be established between the groups, observed differences between the groups post-treatment can be interpreted as an impact of the programme.

As we show below, the grant-awarding process does not produce the thresholds needed for sharp RDD, so ultimately this method is not proposed as suitable for the ISCF evaluation. However, the IFS dataset enables unsuccessful applicants to be used as a control group that can be used within the overall proposed PSM and DiD framework to complement the main analysis.

D.3. Data sources

D.3.1. Summary of key sources

The econometric analysis will be done using a linked dataset, containing administrative data on outcomes and business characteristics, together with data from the ISCF on which businesses were supported (including when support was provided, and which Challenge(s) supported a given business). The data will be linked using the Companies House reference number (CHRN), a unique company identifier.

In terms of outcome metrics, we propose to use the Business Structure Database (BSD), which is a snapshot of the Inter-Departmental Business Register (IDBR). The BSD covers all businesses that are registered for either VAT or PAYE, thus having very extensive coverage, with around 2.6 million firms included per year. It follows firms over time and is updated with turnover and employment data sourced from His Majesty's Revenue and Customs (HMRC). From this can be derived outcomes in terms of employment, turnover, turnover per worker and survival. It therefore has the longitudinal structure needed for the PSM and DiD techniques that will be implemented. It also contains data on foreign ownership, industrial sector, location and age, that can be used as control variables and matching variables (alongside the turnover and employment size metrics and, potentially, historical growth trajectories of these variables).

A key advantage of the BSD's almost exhaustive coverage is that unless treated firms are very small (i.e. below VAT and PAYE registration thresholds), they will appear in this dataset, as will a large number of potential comparators.[7] This maximises the sample sizes available, thereby increasing the robustness of the analysis and making various types of disaggregation of the analysis feasible. By contrast, many of the other business datasets considered for use lacked either the longitudinal structure, completeness, or sample sizes

[7] The Office for National Statistics has announced that, as part of the transition of the underlying data architecture from the Secure Research Service to the Integrated Data Service, the underlying IDBR will expand to include greater coverage of micro-businesses (as part of the move from IDBR to the Statistical Business Register. However, our understanding is that this will take place only in 2024 and will not include historical data, such that we do not anticipate this having a meaningful impact on the coverage of businesses that can be included in the econometric analysis for this impact evaluation. More details on the proposed business data changes are available here.

needed. A full summary of this was included in the detailed scoping work carried out as part of the baseline report.

In terms of characterising business support, the picture is more nuanced, as firms may interact with Challenges in different ways and the data characterising this are captured in multiple datasets. An important part of the baselining phase was therefore to collect and analyse the different business support datasets, to inform which analyses should be feasible once the evaluation takes place. This involved reviewing the coverage and completeness of the variables included in the data, the extent of overlap between different types of support, and how easily they can be linked to the business data or to specific challenges. This is assessed in detail in the following section, with a brief description of the datasets below:

- **Delphi** is a central UKRI dataset largely populated from the Innovation Funding Service Post Award (IFS-PA). It contains data on all funded projects, with unique identifiers for the projects and organisations involved. Organisation-level data include participant type, size and location. Project-level data include the Challenge, programme and competition it falls within; the application number and awarding date; the project name, identifier, start and end dates; the grant amounts; and the costs and grant claimed to date by the awardee. The CHRN identifier provides a way to link organisations in Delphi to their respective entries in the BSD, and the funding dates and Challenge field clearly allow supported firms and the supporting entity to be defined and the period of support to be identified. This is provided across the range of Challenges and the Delphi BSD provides the most straightforward frame in terms of defining an analytical dataset.

As part of the scoping work for the baseline report, we were provided with a Delphi dataset running up to mid-2021. An updated version would be needed at the point at which the evaluation takes place to capture more recent grant funding, and to allow for longer-term post-treatment effects to be estimated.

- **Innovation Funding Service (IFS).** This dataset contains applications for grant funding, with successful applications then passing through into Delphi. The inclusion of unsuccessful applicants provides an alternative approach to defining a counterfactual group, beyond drawing on non-supported businesses in the wider BSD. Crucially, IFS includes CHRNs in a large majority of cases, allowing linking to the BSD and Delphi. IFS usually, though not always, contains assessment scores. This can allow just-successful and just-unsuccessful applicants to be compared, following the RDD literature. However, the task is complicated by the fact that assessment and scoring systems vary across competitions. Determining what is meant by 'just successful' would therefore need to be done separately for individual competitions, adding considerable complexity to the approach, with a risk of some arbitrariness or lack of comparability. In addition, grant awards do not always follow clear scoring thresholds. This is discussed further in Section 0, below.

For this update note, we were provided with an IFS dataset covering a period to mid-2023. While an updated version would capture more recent grant applications, we would be unlikely to be able to use this

within the econometric part of the evaluation, as the corresponding outcome data would not yet be ready at the time of analysis.[8]

- **Knowledge Transfer Network**. Established by Innovate UK, the Knowledge Transfer Network (KTN) is a central hub for connecting innovators, running events that bring together people, companies, government agencies, universities and research organisations. Many Challenges have events run through the KTN, and attendance data are generated through the customer relationship management (CRM) software. Data include the organisation and event name and identifier, enabling us to identify organisations that have interacted with Challenges through attending events and thereby providing another potential measure of support.[9] More generally, these data give a rich overview of the interaction of firms attending Challenge-run events. These data were explored in detail in the 'Connected Innovation Ecosystem' section in the baseline report in the context of network analysis.

As part of the scoping work for the baseline report, we were provided with a KTN dataset up to September 2021. An updated version would be needed for the final evaluation, to capture more recent events.

- **Challenge-level data**. We also considered the possibility that Challenges may interact directly with organisations in ways that do not appear in the Delphi, IFS or KTN datasets. For example, they may run competitions outside of the ISCF system, run events independently, or provide other types of support. It was not possible within the baseline report to conduct a full assessment of the scale of such data. As part of this update, we engaged with Challenges directly using a data-request template. This is described in further detail below, in Section D.3.3. Having followed up in detail, we found that most of the support data are indeed collected through central databases, such as Delphi, IFS and KTN, described above. Very few Challenges hold significant additional data that would be desirable to incorporate in the main analysis.

D.3.2. Review of central data sources

This section contains further discussion of Delphi and KTN, to help inform the scoping of the econometric analysis. This section replicates and extends the discussion as part of the scoping work contained in the

[8] Depending on the exact timing of the econometric analysis, the BSD 2024 (which runs from April 2023 to March 2024) would only become available in Autumn 2024. This means that it is only feasible to analyse firms supported by ISCF up to 2022, to allow at least 1 year of post-treatment impact data to materialise.

[9] Note that organisation identifiers are internal to KTN and do not map directly to CHRNs. Linking to the BSD data outcomes data can therefore only be done through business name, which is less accurate than the CHRN. To do this linking, we propose to use the ONS IDBR 'matching service', who can use fuzzy matching on name and location to derive CHRNs and thus enable linking to the administrative data.

baseline report. An overall summary of all the data sources considered is shown in **Error! Reference source not found.**, below.

Table 3. Summary of data sources

Data source	Coverage	Identifier	Uses in analysis
Delphi	All grant awardees (firm + academic)	CHRN + organisation name	Identify treatment group in econometrics; treatment type; network analysis of awardees
IFS	All project applications (firm + academic)	CHRN + organisation name	Identify counterfactual group for econometrics; network analysis of applicants
KTN	All event attendances (firm + academic)	Organisation name	Network analysis of attendees
Challenge level	Additional awardees	CHRN +/or organisation name	Additions to treatment group
Business Structure Database	All firms above VAT threshold / paying PAYE income tax	CHRN	Employment, turnover and survival outcomes; business characteristics

Source: Frontier Economics. CHRN = Companies House Reference Number

Delphi

The extract we were provided with contains 3,752 observations overall, where each observation is a participant organisation in an ISCF project. Participants may be in multiple projects, and a project may have multiple participants. The dataset contained details of projects starting from 1 June 2017 to 1 June 2021.

We first focused on the completeness of the CHRN data in Delphi, as this is of crucial importance in being able to reliably link the data to business data. CHRNs were included for 2,895 observations (77%). Of those observations missing CHRNs, 711 had keywords within the organisation name to suggest it is not a company.[10] This would mean they are excluded from the scope of the econometric analysis. This left only 146 remaining observations without CHRN.[11]

The 3,752 observations relate to 2,171 unique participant organisations, as some are involved in multiple projects. Among this group, 1,827 have CHRNs, 216 lack CHRNs but appear not to be companies, and

[10] This is using the following acronyms, keywords and parts thereof: univ, college, school, centre, catapult, nhs, institute, borough, authority, council.

[11] During construction the final dataset, effort will need to be expended to manually match such observations, looking up the company name in the Companies House database and using other criteria, such as sector, location and

128 appear to be companies but lack CHRNs. This suggests we have CHRN information for at least 94% of unique companies in the dataset, which is high. The figure could be higher still if some of the 128 are not companies.

The data are complete in terms of linking to Challenges and providing start and end dates for the support. In a small number of cases, the amount of the grant offered is missing or zero. The 71 cases for which the amount is missing are projects that were withdrawn after approval. The 293 cases for which the grant offered is zero are almost all projects with multiple participants, where another organisation is the lead bidder. The non-funded participant often appears to be a large collaborating organisation, and in half these cases makes a co-investment. We propose to exclude such observations from the econometric analysis, on the basis that the treatment intensity is likely to be low relative to the overall size, meaning that any effect will be hard to detect.

Delphi contains a number of additional variables, such as sector, size band and organisation type. These are largely complete. The key data on firm characteristics should largely be captured in the BSD, so it is not, in our view, necessary to draw this additional information from Delphi.

Project-specific information, such as Challenge, wave, competition, funding amount, lead organisation and 'product type' (feasibility study, research, collaborative research & development (CR&D)), are also contained in Delphi and are complete in around 98–99% of cases. It would be useful (and, in our view, feasible) to link this information to BSD, as this will allow for exploration of the variation of treatment effects by some of these key characteristics of projects.

Innovation Funding Service

IFS contains records of applicants for funding, both successful and unsuccessful. An observation is an organisation in a project application, which relates to a competition run by a Challenge. Organisations can make multiple applications, and applications can feature multiple organisations.

The IFS dataset was provided to us in June 2023 and contains applications for competitions with start dates ranging from August 2017 to September 2023.[12] The file includes 160 competitions, 12,263 project applications and 22,879 observations (i.e. an organisation in an application). Of these, 2,612 applications

uniqueness of name. High-quality matches can be used in the treatment group. Low-quality potential matches will be excluded from the analysis, as there is a risk of treated firms wrongly being included in the control group and of non-treated firms wrongly being included in treatment group, all of which would bias downward the estimated impact.

[12] The competition start dates could be after the application process, which explains why some competitions began after the dataset was provided.

are funded (6,641 observations). Funded applications tend to be larger consortia (2.5 organisations on average per successful bid) than unfunded applications (1.7 organisations per unsuccessful bid).

CHRN coverage is good, enabling easy linking to the BSD and Delphi. At the observation level:

- 85% of records (19,552 observations) had a CHRN;
- 9% of records (2,042 observations) did not have a CHRN, but the organisation name contains keywords (analogous to the Delphi dataset) suggesting they are not a business;
- 6% of records (1,285) observations did not have a CHRN and appear to be businesses, based on organisation name, i.e. are genuine cases where CHRN is 'missing'.

Excluding the non-businesses, coverage of CHRN is therefore around 94% across observations, which is high.[13]

As should be the case, we see projects approved in IFS subsequently appear in Delphi.[14] However, Delphi contains some projects (entire competitions) that are not found in IFS. Of the 1,202 projects in Delphi, 948 are funded by Innovate UK (IUK) and appear in IFS; 107 are funded by organisations other than IUK and do not appear in IFS; and 147 are funded by IUK but could not be linked to predecessor applications in the IFS system.

On closer inspection, it was found that most of these were due to 'Blue Zone' funding, where previously unfunded but high-scoring applications were subsequently offered funding (106 cases). In other cases, the 'projects' are funded through an IFS subsidiary, such as KTN or a Catapult (outside of the competitive structure) or the funding is a Direct Award with funding decision made outside of IUK or UKRI. These cases do not correspond easily to the successful / unsuccessful distinction used to define an alternative counterfactual, so there is no need to add applicant data for these cases.

Where CHRN data are available, the identity of supported companies is consistent between Delphi and IFS datasets in more than 90% of cases.[15] Inconsistency appears to mainly be due to the CHRN being recorded in one dataset and not the other, as well as different CHRNs being used, which can occur in particular between holding companies and trading companies.

In terms of combining the data, we would prioritise Delphi on the basis that it is closer to the 'true' post-award identity of firms. In case of missing CHRNs, fuzzy matching within project (on organisation name, address or unique funding values) may fill some gaps. Where multiple CHRNs for the same organisation

[13] The corresponding figures in terms of organisations rather than observations are 12,079 with CHRNs (90%), 418 non-businesses (3%), and 930 missing (7%).

[14] An exception to this is a round of COVID-triggered projects that are in IFS but not in Delphi, and which are not relevant to the analysis. Otherwise, all approved IFS applications will appear in Delphi.

[15] For projects found in both Delphi and IFS, where a CHRN is found in IFS, in 92% of cases it is also found in Delphi, and where a CHRN is found in Delphi, in 90% of cases it is also found in IFS.

name are observed, the additional IFS-based CHRN would also be presented to the Office for National Statistics (ONS) IDBR matching service in case it is useful to support data linking.

An important component of the dataset is the assessment scores. Of the 160 competitions included in the IFS file, 79 have complete scores, 53 have no scores and 28 have partial coverage. In addition, higher scores do not necessarily translate into funding decisions. The reasons for this are discussed in the box below, based on discussion with Innovate UK.

Competitions and assessment of applications

Grant funding applications are made and evaluated in relation to specific competitions. A competition typically sets a number of distinct but interlinked themes that together aim to unlock benefits for a sector. Competitions therefore have a 'portfolio' aspect in that a broad range of benefits need to be achieved by the individual projects in combination. This need can take precedence over the quality of any one bid. The applications are also scored on quality before consideration of VfM, which can subsequently feed into funding decisions. As a result of these portfolio and VfM considerations, assessment scores do not mechanically determine whether a project is approved. For example, a high-scoring bid might be similar to other bids in the portfolio and deliver insufficient benefits relative to a lower-scoring bid that is the 'last piece of the puzzle'. There may also be lower-scoring but lower-priced options that are preferable.

A variety of assessment techniques are used across competitions. Competitions are often based on distinct phases, with a competition for the early development phase, and without more advanced phases to follow. The early phase often follows an 'expression of interest' format, which allows the Challenge to create a streamlined application with minimal financial outlay that can be taken forward if appropriate. In these situations, the applications will not be formally scored. There are also cases where the assessment scores are used to determine eligibility for interview but the subsequent interview process is not run through IFS, so the scores do not appear in the dataset.

As a result, some competitions do not have any scores, and higher-scoring bids do not automatically take precedence over lower-scoring bids. RDD is typically focused on the 'sharp' case, where a threshold in the running variable perfectly predicts treatment assignment, for example, if all applications that scored above 70 are funded and all applications below are unfunded. The funding of projects in IFS is more nuanced than this. Rather than there being a jump in grant award rates at a threshold, the correspondence is a smooth upward slope between scores of around 65 (almost none approved) and 85 (almost all approved). This makes application of RDD challenging, as there is no discontinuity to speak of.

A more proportionate approach use of the IFS data is as an alternative control group in a PSM or DiD setting, rather than in a formal RDD.

Knowledge Transfer Network

KTN data are generated through attendees registering for and attending events. The file we analysed contained 25,257 entries, where an observation is an individual (pseudonymised and linked to an organisation) registered for an event. It covered 260 events, running from August 2017 to July 2021.

The events are not directly linked to Challenges, but the names of the Challenges often appear in the event name. This allowed us to use keyword searches to link to Challenge, searching for the Challenge name in

the event name. This process led to 158 events matched to a Challenge and 102 unmatched. The remaining cases required manual matching (e.g. 'battery' would indicate a link to the FBC), which enabled a further 57 matches of reasonable quality and 45 cases where we were not confident which Challenge an event belonged to. Given the relatively small number of events, a more intensive manual matching would be feasible, including a validation process with Challenges and UKRI to confirm or negate each of the manual matches.

KTN contains data on attendees from 4,424 organisations. Because information on attendees and organisations is captured as it is entered into registration systems, there is no link to CHRNs, and instead fuzzy matching must be used. This presents problems for linking KTN to the BSD, as we may link to the 'wrong' business. Moreover, the lack of geographic address is problematic, as that is used in performing the fuzzy match and assessing its accuracy. We therefore note the potential for errors in linking the KTN database to BSD, though have not so far been able to validate with ONS whether fuzzy matching entirely on the basis of company name is feasible.

We assessed the overlap between KTN and Delphi by standardising the text of the organisation name fields in both datasets.[16] This resulted in only 652 of the 4,424 organisations in KTN finding a match in Delphi. A more formal fuzzy matching procedure using Stata software returned very few additional matches. Manual examination of a selection of these unmatched cases suggested that this was a genuine lack of overlap between the datasets rather than a failure to match entities that were the same.

We therefore conclude that only a small proportion of event attendees have participated in projects funded and recorded in Delphi (652 of 4,424) and likewise, that only a small proportion of awardees have attended events run by KTN (652 of 2,171). This finding was somewhat surprising, but it would indicate that the grant funding recipients and event attendees are relatively distinct groups. This has implications for how different treatment subgroups may be defined, with an obvious first delineation being 1) grant awardees; 2) event attendees; and 3) the overlap group.

The overall breakdown of grant-awarded projects and organisations and KTN events is shown below. This shows most Challenges being present in both datasets, although some have fairly low numbers of events despite funding many projects and organisations. This may explain some of the lack of overlap between which organisations are included in the respective datasets.

Table 4. Numbers of grant awardee projects and KTN events by Challenge

Challenge	Delphi projects	Delphi organisations	KTN events
Accelerating Detection of Disease	1	1	0
Audience of the Future	73	133	28
Commercialising Quantum Wave 3	39	118	9
Data to Early Diagnosis and Precision Medicine	41	140	10

[16] This is done by converting to lowercase; removing multiple spaces; removing extraneous characters, such as '.' or '&'; and removing certain text, such as 'plc' or 'limited'.

Digital Security by Design	25	24	7
Driving the Electric Revolution	44	88	5
Faraday Battery	78	148	18
Future Flight	50	148	12
Healthy Ageing	40	54	19
Industrial Decarbonisation	25	102	6
Low Cost Nuclear (Phase 1)	1	9	0
Manufacturing Smarter Innovation	55	183	14
Medicines Manufacturing	190	342	6
Next Generation Services	51	107	11
Prospering from the Energy Revolution	81	232	1
Quantum Technologies Wave 2	4	37	16
Robotics for a Safer World	145	211	1
Smart Sustainable Plastic Packaging	31	51	3
Transforming Construction	67	209	13
Transforming Food Production	100	235	12
Transforming Foundation Industries	38	94	17

Source: Frontier Economics analysis of Delphi and KTN data.

D.3.3. Challenge-level data

This section outlines the process for engaging with Challenges and summarises the overall findings. Engagement took place both to inform the previously published baseline report and, as a follow-up, to inform this update note.

Process for engaging with Challenges

An Excel-based data template was developed and sent out to each Challenge. The requests were directed at the Challenge-level evaluation leads, based on a contact list provided by UKRI. The requests were made in August 2021, by email, and further reminder emails were sent in September.

The data template requested information about the contact lists or databases held within the Challenge about the organisations engaged, the type of information held, and the completeness of the records. The overall aim was to understand how Challenges characterised the nature of their support and the full range of beneficiaries in an unprompted way, as well as identify the most suitable data sources to inform any

further data collection efforts. Specifically, the template requested data around the availability and completeness of the following data:

- company name, address and CHRN fields;
- any business-demographic data;
- information on the type and value of support provided and the start and end dates;
- details to identify academic and third-sector organisations (in particular to inform the potential network analysis);
- contact information for the key contact point within the respective organisations;
- numbers of successful and non-successful applicants.

If significant amounts of data were found to exist outside of the central databases, this would entail additional effort to gather and combine such data from the respective Challenges in order to provide a comprehensive assessment of organisations treated by ISCF as a whole.

Where Challenges did not indicate that central databases would hold all the required information, they were subsequently re-contacted in November 2022 to follow up on the availability and coverage of any Challenge-level data. This took into account the prevailing finding from Challenge-level engagement that most data would be captured in central databases, that this would largely cover identification of recipients of grant funding, and that the value of piecing together additional data for some Challenges and not others would be very limited for a Fund-level analysis. Thus, the follow-up engagement sought only a minimal level of additional data.

Summary of findings from Challenge-level data request

In total, detailed template responses were received from 19 of the 22 Challenges, and we were able to follow up with other Challenges as part of the subsequent engagement process to understand the information available in more depth.[17]

Challenge-level data

Regarding the use of Challenge-level as opposed to centrally held data, we found that the large majority of Challenges reporting using centrally held datasets, with Delphi cited in 9 cases and IFS in 12. In other cases

[17] Of the other three Challenges, Low Cost Nuclear gave a detailed response outside of the template, owing to its different circumstances (covering only one specific project), whereas Medicines Manufacturing and Manufacturing Made Smarter were unable to respond at the time of initial engagement in 2021 due to resourcing constraints. It was subsequently clarified in the later engagement that Medicines Manufacturing data would be adequately captured in IFS and Delphi. The outcomes of the engagement with Manufacturing Made Smarter are summarised below.

there was reference to the UKRI/IUK data warehouse, central databases or multiple databases. The only areas where centrally held data were *not* mentioned were as follows:

- **Creative Industries Clusters** referred to having data on Higher Education Institutions through Siebel / Salesforce and fragmented internal data on indirect beneficiaries. It was subsequently determined that Creative Industries Clusters was not in scope for the ISCF evaluation.
- **Next Generation Services** reported that the Singapore Global Business Innovation Mission 2019 uses a Challenge-held spreadsheet on beneficiaries. This data was subsequently shared with Frontier to inform the scoping.
- **Transforming Construction** reported that the Active Building Centre held data on their own CRM. It was subsequently clarified that the key relevant data would be captured in IFS and Delphi.
- The other cases where Challenge-level data sources were reported were:
- **Prospering from the Energy Revolution** reported that the EnergyRev has a project database on Higher Education Institutions. These are already listed on the EnergyRev website and on grant records, so no further data was required to be shared.[18]
- **Transforming Foundation Industries** referenced a TFI Team database, alongside IFS and KTN. It was subsequently clarified that the key relevant data would be captured in IFS and Delphi.
- **Future Flight** referenced a TIBCO database, alongside IFS and Delphi. It was subsequently clarified that the key relevant data would be captured in IFS and Delphi.
- **Manufacturing Smarter Innovation** clarified that the majority of participating organisations are captured on Delphi. The Challenge also funds the Smart Manufacturing Data Hub, run by University of Ulster, and the Digital Supply Chain Hub, run by the Digital Catapult. The Manufacturing Smarter Innovation (MSI) Challenge is running until 2025, and much of the funding has not yet been disbursed, which means outcomes will largely fall outside of the evaluation window.

Business demographics

The Challenges reported holding very little data on business demographics. The data either are described as incomplete or are confined to a very limited set of basic characteristics that are already captured in the central datasets. Therefore, additional data on business demographics from Challenges is unlikely to be available or add meaningfully to the data available to inform any econometric assessment. As noted below, the BSD already captures this information, containing employment and turnover trajectories, as well as

[18] EnergyRev (accessed January 2024), Energy Revolution Research Consortium - Core - EnergyREV (accessed January 2024).

sector, location, age and ownership structure. Therefore, the lack of this data at Challenge level is not problematic for the evaluation.

Description of support

Where Challenges report holding support data at the business level, this relates overwhelmingly to grant funding, which is already captured in the central datasets. Several Challenges also gave general descriptions of wider support activities carried out (i.e. non-financial), but there was no indication that there would be any systematic data showing which recipients received specific types of non-financial support.

As a result, we consider that while it will be useful to attempt to supplement the Delphi and KTN databases with other support data from a limited number of Challenges, as set out above, we may only be able to define binary (0/1) treatment indicators from these additional Challenge-specific databases rather than more granular definitions of support type.

Unsuccessful applicants

Around half of Challenges reported that data on unsuccessful applicants would be available. Where data sources were described, this description referred back to IFS or to central datasets (which we interpret as referring to IFS). On this basis, we concluded that Challenge-level data on unsuccessful applicants above and beyond what is captured in IFS is unlikely to be available for the evaluation.

D.4. Implications for econometric analysis

The review of data sources in the baselining phase, subsequent Challenge-level engagement and review of the IFS dataset has largely reinforced the approach set out in the evaluation framework report. The additional engagement since the baseline report has confirmed that central datasets will form the overwhelming focus of the econometrics and clarified that the IFS data will be a useful and relevant additional source of data to support the analysis.

The core econometric analysis will use Delphi to identify treated firms (supplemented by a limited amount of Challenge-level data), as well as outcomes and firm characteristics from the BSD. Our intention remains to use PSM and DiD approaches. While IFS allows for unsuccessful applicants to be used as a control group, RDD is not appropriate given the smooth correspondence between scores and treatment assignment.

D.4.1. Data sources

The proposed use of data sources is discussed below:

- The longitudinal structure, almost exhaustive coverage, and completeness of variables support using the BSD as the data source to use for business outcomes and characteristics. Other business survey datasets bring significant difficulties in terms of incomplete coverage, which would affect the clarity of analysis. While the BSD's advantages in terms of coverage are noted, there are, nevertheless, issues with the timing of the data contained therein, as a result of the data sources used to populate

it.[19] These will require careful consideration when building the dataset and interpreting findings. As discussed above, the BSD is also relatively limited in the number of business-demographic characteristics contained, although previous use of BSD for similar exercises suggests that the variables included, such as sector, age, growth trajectory and location, are key drivers of performance and selection into treatment.

- Delphi and KTN capture the large majority of data available around which organisations have been supported, and together these databases can be used to characterise treatment. However:
    - Delphi will be the main treatment variable of interest, as we would expect grant funding to be the most material aspect of business support for a firm. In practical terms, it is straightforward to link Delphi with the BSD, as CHRNs for businesses are largely complete, so this gives a reliable signal of treatment.
    - KTN requires both fuzzy matching on names to link with the BSD, as well as manually identifying which Challenge an event belongs to. Both of these steps are prone to error, which reduces the accuracy of any estimated effect and may make detection of an effect more difficult, particularly given that event attendance may be considered a more 'light touch' form of support compared with grant funding. Given the potential errors, we would propose to only use KTN involvement as a secondary treatment variable in DiD or simply as a covariate.[20]
- IFS data on unsuccessful applications can easily be linked to Delphi and the BSD by CHRN, as this field is largely complete. This allows an alternative counterfactual group to be defined using unsuccessful applicants.
- Challenge-level data are useful only in several cases (see Section 0), as the measurable data are largely captured in Delphi and KTN.
- The low overlap between event attendance and grant funding means these types of support can be assessed quite distinctly from each other.

D.4.2. Econometric methodology

Different types of econometric approaches lend themselves to different structures of dataset and levels of disaggregation. PSM is normally conceived of in terms of a 'baseline' year, in which treated firms are treated and from which comparator firms are drawn, so that both groups face the same temporal shocks.

Given that firms may undergo repeated interaction (participate in or apply for multiple projects with one or more Challenges), in this context it is appropriate to focus on how outcomes change relative to the *first*

[19] For example, employment data sources include Business Register and Employment Survey and HMRC PAYE, which can relate to different time periods.

[20] PSM allows only one treatment variable to be used at a time. Given that grant funding is expected to have a much larger impact, and given the data linking issues identified, a PSM focused on KTN is unlikely to yield a reliable measure

episode of treatment, to avoid conflating the effects of multiple episodes of support. **Error! Reference s ource not found.** shows the number of unique firms receiving treatment by year, split out by whether this is the first year of treatment or a subsequent year. It is important to focus on the point of first treatment for baseline purposes, as otherwise we may also be measuring the effects of previous treatment episodes.[21]

Table 5. Number of firms receiving treatment in year, by whether first treatment or subsequent treatment

Year of treatment	No. firms that were first treated in year	No. firms treated in year that have received treatment in a previous year
2017	53	0
2018	527	19
2019	327	105
2020	541	137
2021	356	195
2022	372	195
2023	196	103

Source: IFS

From 2018 to 2022, the numbers of firms receiving their first treatment ranges from 327 to 527. Based on prior experience, we consider that this should be a large enough number to allow for year-by-year cohort analysis for PSM at the level of the Fund as a whole.

In considering variation of impacts across observable characteristics of firms, sample sizes may be too small in a year-by-year analysis to provide robust estimates. An option here is to pool successive cohorts of treatment and control firms, which allows further disaggregation and exploration of how impacts vary along key dimensions, such as firm or programme type. Some care is needed in doing this, however, as pooling requires treatment effects to be stable across cohorts (i.e. the effect of being treated from two years post-treatment is the same regardless of whether a firm was treated in 2018 or 2021) or for cohorts to have a similar mix across these dimensions. Otherwise, there may be biases due to different subgroups falling into different cohorts that experience different conditions post-treatment. The various macroeconomic shocks of the past few years may be problematic in this regard.

Based on past experience, we suggest that for the purposes of exploring variation in treatment effects, a DiD approach is more flexible (and straightforward to implement computationally), as it allows multiple treatment variables to be tested directly within the same model. For example, the model can include separate

of the variable's impact. The variable could be added to a DiD analysis, with Delphi grant funding being the primary treatment indicator.

[21] We may also wish to distinguish firms receiving one-off treatment from those receiving multiple rounds of treatment, to avoid attributing impacts of later rounds to the first round.

treatment variables for large firms, small firms, collaborative R&D, or technology maturity. Whether there is a differential response on any such dimension can be tested directly through interaction terms. If these terms are small and insignificant, we can conclude there is no difference in effect for that subgroup.

To operationalise this approach, we will first assess whether the results from a DiD specification are similar to those from the 'core' PSM approach. If so, we will explore differential treatment effects using the DiD approach.[22]

A further advantage of DiD, assuming it appears to give similar estimates of treatment effects to the PSM method, is that it allows for more flexible exploration of how treatment effects change as we look at more distant post-treatment periods. DiD allows cohorts to be combined into one long panel dataset. This includes all firms in the sample and allows us to define variables for the number of years post-treatment that an observation is observed. For example, the effect at t+1 (one-year post-treatment) is seen in 2017 for those treated in 2016, in 2018 for those treated in 2017, and so on. This increases the power of the estimates relative to estimating the model for each year in turn.

However, the literature has noted econometric difficulties with this 'staggered panel' setting in which treatment occurs in different years. These difficulties arise because the treatment effects observed a certain number of years after treatment occur at different times, which can bias the results if these time effects differ between the treatment and control groups. DiD estimators to deal with this problem have recently been developed, and we would investigate the use of these in the evaluation.[23]

We would also envisage using IFS to give a control group base on unsuccessful applicants, rather than identifying the control group based on a propensity score. This would follow the above approach in terms of using PSM to explore the core result, and if appropriate to use DiD to explore variation in the treatment effect across firm or project type.

The key interaction of interest for the PSM and DiD approaches using unsuccessful applicants, as the control group is the first point of application. A breakdown along these lines is shown below based on IFS data, with firms counted by year of first application and showing further splits in terms of application and success in following years. This shows reasonable numbers of unfunded control firms corresponding to the

[22] A key challenge for DiD relative to PSM is establishing the validity of the parallel trends assumption. This can be violated if, for example, the control group is drawn very widely and includes many non-comparable firms who exhibit different pre-treatment trends. A practical measure in this case is to first run a propensity score model and then retain only those firms in the sample whose propensity score distribution overlaps, to increase comparability of the treatment and control groups.

[23] For a broad discussion of the issue, refer to Roth et al. (2023), 'What's trending in difference-in-differences? A synthesis of the recent econometrics literature', *Journal of Econometrics*. Specific estimators that could be used are explored in Callaway and Sant'Anna (2021), 'Difference-in-Differences with multiple time periods', *Journal of Econometrics*, and Borusyak et al. (2023), 'Revisiting Event Study Designs: Robust and Efficient Estimation', arXiv:2108.12419.

treatment firms. A complication is that some firms may be unsuccessful at first application and then subsequently gain funding. These would be removed from the control group.

Table 6. Count of firms by year of first application and funding success status

Year of first application	One application – funded	Multiple applications – first funded	One application – unfunded	Multiple applications – first unfunded, but later funded I	Multiple applications – never funded
2017	10	43	54	11	13
2018	271	256	751	222	238
2019	177	150	663	123	162
2020	278	263	830	136	139
2021	263	93	577	74	104
2022	304	68	610	35	77
2023	181	15	340	6	12

Source: Analysis based on IFS

D.5. Network analysis

This note has focused on the implications of the additional data review for the econometric analysis.

In the baseline report, we also conducted a network analysis drawing on the Delphi and KTN datasets, with a suggestion to revisit the analysis to look for changes in the networks supported by the ISCF as part of the final evaluation.

Here we provide a brief assessment of the additional data review for the network analysis.

The baseline report included separate network analyses of KTN and Delphi, looked at through the lens of both networks of organisations and networks of Challenges. KTN and Delphi were analysed separately because:

- there was a low overlap in terms of organisations interacting through the two channels;
- KTN is difficult to link to Delphi due to lack of CHRNs; and
- it is not clear how event attendances should be weighted relative to project collaboration to derive a single 'network'.

The availability of IFS allows for a richer characterisation of networks. Since it aligns closely with Delphi, it presents an application-based view of networks. This would allow additional network maps and connectivity metrics to be estimated in the final evaluation.

The additional analyses would be:

- An **application-based network** view based on organisations that apply for support from different Challenges, regardless of the success of the applications; and
- A **weighted network** in which unsuccessful applications are given less weight in establishing the links in the network.

However, while we would consider that actual funded projects should carry more weight than unsuccessful applications, there is no objective basis on which to derive these weights. As a result, the Delphi analysis based on networks of successful applicants would still be the priority focus of the network analysis conducted for the final evaluation.

Nevertheless, the additional, application-based networks would yield additional insights about the nature of collaboration networks supported by the ISCF. Given that around half of applicant organisations in IFS are never successful, we anticipate that an application-based view would be sparser and contain more isolated nodes, which could play out differently by Challenge.

Annex E. Challenge-level impacts

The following tables contain evidence gathered from the Challenge evaluation reports. The evidence is presented as a mix of direct quotations (indicated by quotation marks) from the reports, supplemented by our own summaries of the reports.

E.1. Creating knowledge and innovation pathways

Table 7. Summary of innovation at the Challenge level

Challenge	Impact in scope?	Summary of innovation at Challenge level
Audience of the Future	Yes	There was evidence of new intellectual property (IP) as a result of the Challenge. A total of 10 companies reported having been granted IP rights, and a further 3 organisations said they were considering applying for IP. The granted IP included 8 trademarks and 6 instances of copyrighted material. Looking across the portfolio, we note that 44% of participants (base:21) had produced new IP and/or exploitable trade secrets. For the Story Futures Academy (SFA) programmes, just over 1 in 10 participants said they had produced new IP. Most of the projects resulted in at least one new creative immersive product and/or service. The majority of participants had progressed by at least one Technology Readiness Level (TRL), and one third had progressed from TRL1–2 (feasibility) to TRL9 (commercialisation). In comparison, unsuccessful applicants reported an average increase from TRL3 to TRL4. The programme has helped accelerate the development of early-stage products and experiences. There is evidence that the Challenge has supported new products, services and technologies. 'Most participants had developed at least one new creative immersive product (79%) and or service (56%) through participation in the Challenge.'

		71% of the 48 surveyed participants had developed new working processes. 50% had improved existing working processes. 'Respondents also noted they had developed new, or improved, methods (60% and 52% respectively)'. Most participants had developed at least one new creative immersive product or experience because of their AOTF project (79%, 38/48). The evaluation survey findings found that the SFA contributed to developing new and improved production methods, prototypes, working processes, and products and services. In terms of implementation of approach, participating organisations reported changes to their organisational strategy. An example of this was Marshmallow Laser Feast having changed their approach to the potential of digital-first projects and the type of work they want to develop in the future. In addition, two demonstrators focused more on creating reusable assets and scalable processes and have both attracted follow-on interest and investment.
Medicines Manufacturing	Yes	In some cases, new IP has been generated and associated regulatory licences have been granted as a result. Most of the projects funded through the CR&D have met their technical objectives and advanced one or more TRLs. A total of 11 projects had led to increased knowledge and a jump in TRLs but are likely to need further investment to commercialise. A further 2 projects have commercialised products or processes among the case studies, and a further 2 are in line to commercialise their outputs from their CR&D projects. In terms of the projects supported by the DHTC, there has been rapid progress in developing the maturity of their innovations. On average the technologies had progressed from an average TRL of 2.5 to one of 5.3, but 10% of projects completed the technical development process and reached TRL9. An example includes a project that built a fully functional hardware device that can record open procedures in the operating room to improve surgical support and performance and that is now a full commercial product and achieving sales. The programme has strengthened UK capability in the development of advances in medicines manufacturing technologies. There was an indication that within the investments through the viral vectors manufacturing competition, the Oxford AstraZeneca vaccine would not have been produced at the same scale. The DHTC portfolio of projects had a high rate of success in delivering against their objectives. Most projects made considerable progress in the development of the technologies, with a high proportion of projects developing a prototype of the technology.

		The Advanced Therapy Treatment Centres (ATTC) have supported the administration of advanced therapies. An example of this is the standard operating procedures for managing a pipeline of patients eligible for advanced therapy medicinal products (ATMP) treatment. The ATTC have also produced significant outputs around the creation of systems for traceability and tracking of ATMP. There has also been advancement in terms of patient monitoring. 'Aptus Clinical and Datatrial are now able to offer a comprehensive clinical trial data management service owing to the validation work undertaken by iMATCH with over 100 clinical and commercial users.' Where clinical evaluations are available, the technologies under development have demonstrated net health benefits or cost savings to the NHS. Other impacts include market validation through feasibility studies, which enabled firms to validate the market for their technologies; the development and validation of prototypes; and clinical evaluation. Some firms had completed a clinical evaluation of their technology. Where results were available, they demonstrated substantial benefits associated with adoption of the technology. For example, one technology supporting the remote management of patients with chronic obstructive pulmonary disease (COPD) reportedly reduced admissions by 28%, reduced occupied bed days by 38%, and achieved a per-patient cost saving to the NHS of £8,500 per annum. There has been evidence of implementation and adoption of ISCF products. The Cell and Gene Therapy Manufacturing Innovation Centre (CGTMIC) was found to be an effective mechanism to allow ATMP developers to access manufacturing capability. The centre was being used by companies, primarily by cell therapy developers. This was facilitated by the centre's module on viral vector production. Most of the firms occupying the modules are small and medium-sized enterprises (SMEs) producing or aiming to produce for clinical trials. The facilities provided by the centre were seen as important to supporting the companies to commercialise products. There were also support services available, which were regarded as valuable. The Manufacturing Innovation Centre has been instrumental in supporting development of a cluster of ATMP) developers in Europe. 'This was reflected by the choice by Rentschler – a multinational CDMO – to develop its new Advanced Therapy Medicinal Products operation from an initial base within the Centre.' There is some evidence to suggest that within the investments made through the viral vectors manufacturing competition, the Oxford/AstraZeneca vaccine could not have been produced at the same scale in the UK and that the UK would not have had such early access to it. Most therapy developers supported through the ATTC attributed an acceleration of their development programme to their participation. The support provided by the Catapult around the Manufacturing and Innovation Centre has contributed to structuring the supply chain needed to serve the Stevenage cluster and as well as ATMP manufacturing sites elsewhere in the UK. In addition, the business model established by the Catapult through its manufacturing centre has provided a blueprint for similar commercial and government-sponsored facilities and has been replicated outside of the UK. The ATTC have resulted in processes, guidance and best practice. These have included aspects around supply and logistics, clinical training, clinical pathways, patient monitoring, patient engagement and the development of novel commercial products and services. The

		ATTC and the ATTC network have also enabled wider adoption of these results in NHS Trusts not funded through the programme. For example, the centres have been involved in the coordination of debates related to clinical adoption of ATMP. An example includes the network's Industry Advisory Group, which actively engages NHS England and therapy developers, and several specialist working groups sitting within the Industry Advisory Group. For the DHTC, 14 of the 43 projects had been successfully demonstrated in the NHS, which included 10 projects that provided evidence of their efficacy in enabling cost savings and 4 projects that provided evidence of their health benefits for patients. 'Twelve technologies had been adopted in an NHS context on small scale or widespread basis, and seven firms had been able to exploit their technologies overseas.'
Data to Early Diagnosis and Precision Medicine	Yes	There is limited evidence of IP in the Data to Early Diagnosis (also referred to as D2D) Challenge – 1 project had improved IP protection through creating a more robust evidence base for a patent. Several projects had created new technologies or validated existing tools or technologies. This has included developing AI tools and diagnostic technologies for use in the NHS. In terms of services, 'five centres had made good progress in setting up infrastructure and facilities'. A total of 3 centres – Industrial Centre for Artificial Intelligence Research in Digital Diagnostics (ICAIRD), National Consortium of Intelligent Medical Imaging (NCIMI) and PathLAKE – had successfully established new data storage facilities and platforms. It was also noted that a lot of time and effort had gone into establishing new processes, guidance and contractual arrangements for data processing and sharing across the consortia, including ethics frameworks. In terms of datasets, the Health Data Research Innovation Gateway signposts to 699 datasets, and the Hubs have also made 100 datasets discoverable through the Gateway. The WGS UK Biobank project has made several advancements in the provision of genomics data. At the time the evaluation was undertaken, the project had achieved the first milestone of sequencing 150,000 whole genomes. 'These data (along with that of the 50,000 genome sequences from the vanguard study phase) had been made available to the industry partners, ahead of wider availability for public research in the following months.' 'As well as datasets, there has also been provision of software platforms. For example, LMIA has successfully delivered and deployed two major software platforms. These are the Federate Learning and Interoperability Platform (for R&D) and the AI Deployment Engine (a platform for delivery of models into clinical care).' In terms of implementation and adoption of ISCF products, through the UK Biobank, the creation of infrastructure and analytical pathways to handle large-scale genomic information was considered a real accomplishment. Using AI and data-mining techniques, industry partners had undertaken genomic data analysis through the Biobank.

Commercialising Quantum Technologies	Yes	In terms of IP, the number of quantum tech patents granted to QT organisations (both in the UK and worldwide) has increased from 3,804 in 2020/2021 to 3,825 in 2021/2022. However, this was lower than the targets for those years, which were 4,000 and 4,250, respectively. The number of filed patents by QT organisations was 45 in 2021/2022. 'Significantly more patents were filed than granted in 21/22 indicating that not all filed patents translated into granted patents.' Across the companies, there was a mix as to the extent to which they were engaged with patent activity. Some companies filed patents that had not done so previously (Nu Quantum), some were very active in filing patents (Arqit), and some slowed down (BT and Toshiba). Patenting was the favoured mode of protecting IP among grant holders compared with other modes, such as copyright or trademark. Nevertheless, half of the projects did not plan any formal protection of their IP. As a result of the ISCF QT programme, six companies reported new products, and at least seven products and services based on QT launched in 2021/2022. Examples of quantum component projects that have been released include a cold atom source (Coldquanta) and an operating system for quantum computers (Riverlane).
Digital Security by Design	Yes	The evaluation noted that it is early for new products and services to have been created using the Challenge technology. However, there had been several advancements. The Technology Platform Prototype has been implemented in silico, in the form of a Morello Board, which can be shared with academic and industrial partners. It is available for use by projects and partners to investigate the technology and the potential impact or benefits of this technology for new products and services. The technology is now being investigated by funded projects and the Technology Access Programme. 'The technology and supporting ecosystem are at too early a stage yet for any development of products and services based on the Morello Board. The Technology Access Programme, however, offers a pathway to introduce companies to the DSBD technology and interest them in the prospect of developing products and services based on it. While the number of companies involved so far is small, the proportion viewing DSBD technology as 'important to future products and services' and the relatively high amount of time and resource allocated to TAP [Technology Access Programme] projects are positive indicators.'
Next Generation Services	Yes	Over the course of the Challenge, those involved with the programme produced more IP and exploitable trade secrets on average, reporting an increase from 1.0 to 2.2. This was higher than unsuccessful applicants, who reported a decrease from 1.6 at the point of applying to 0.8. There was evidence that the programme supported the development of IP (and exploitable trade secrets) relevant to the areas within scope. Since applying to the programme, four participants have entered discussions to obtain licence agreements. The Next Generation Services (NGS) CR&D projects progressed their project by an average of 4 TRLs and a median of 3 TRLs, with all projects having progressed by at least 1 TRL. At the end of the projects, one fifth had reached TRL9 (commercialisation).

		The programme has supported the development of new products, services and processes. A total of 84% of participants (26 out of 31) have developed new, improved products/services, and a further 10% of participants expected it to happen in the future. 'To date, participation in the programme has supported organisations to develop a total of 31 new or improved products or services.' In addition, participation in the programme also led to new or improved internal processes, and participants were also significantly more likely to have trialled or tested new business models while participating in the NGS programme. For example, '64% of participants said AI solutions are currently being implemented as part of their business models.' In terms of the implementation and adoption of ISCF processes, services and approaches, programme participants reported an increase in the adoption of their current products and services that made use of AI solutions. 'The programme also supported increased adoption with 62% (8 out of 13) end-user participants reporting programme participation had led to new or improved internal processes.'
Manufacturing Smarter Innovation	Yes	There have been some examples of new and improved products, technologies, services and processes through the rounds of CR&D competitions. 'Fourteen projects have produced a demonstration of a new/modified technology, service or product and another two are on track to do so'; 'six projects have developed products or prototypes'; 'three projects have achieved proof of concept, and another is on track to do so'. From the Digital Supply Chain Hub (DSCIH) outputs, 12 technology solutions, 10 use cases and 12 demonstrators had been developed.
Robotics for a Safer World	Yes	In terms of IP activity, three projects applied or are in the process of applying for patents. The evaluators suggested that there may not have been enough time for patents to have materialised from the projects. There is also evidence that projects had progressed up the TRL levels. Successful applicants had progressed their projects towards TRL 4.6 from TRL 3.3, compared with unsuccessful applicants, who had remained at 3.6 at both baseline and interim. On average, funded projects had progressed by 1 TRL level, moving from specifying proof of concept to demonstrating proof of concept at a test site. The use-inspired research hubs are predominantly focused on TRLs 3–6. The programme has supported new and improved technologies and services, including the development of more RAI systems and solutions. Successful applicants had on average developed 2.9 new RAI systems and solutions, tested 2.8 and demonstrated 2.5 to potential customers and end users. This was more than the unsuccessful applicants, with numbers 1.6, 1.6 and 1.3, respectively. There was very little evidence on implementation of project outputs at this stage of the evaluation, but project awardees felt that their involvement in the programme (RAI-EE (Robotics and Artificial Intelligence in Extreme Environments)) had led to improved understanding of the potential for applying RAI solutions to their operations and processes and believed their involvement led to new plans and strategies to increase the adoption of robotics and AI in their operations and processes.

Transforming Foundation Industries	Yes	There were no examples of IP, but those involved in the CR&D 2 projects anticipated that they would be applying for IP (10 out of 39 survey respondents). There is little evidence from the evaluation on the progression through TRL levels, but there are some isolated examples of projects producing commercially viable products, including Concretene. There were limited examples of new products or services created, but 90% of the project awardees anticipated that there would be eventually (35 out of 39 survey respondents).
Prospering from the Energy Revolution	Yes	'The projects involved in the programme had, on average, progressed their technologies by one or two TRLs since being awarded the funding. Innovations which were supported by the Key Technology Components competition were at a higher technical maturity due to higher starting levels. Indeed, there has been strong technological progress on the Key Technology Component projects, with projects reaching high TRLs towards commercialisation. There has been moderate commercialisation of the technologies developed through the various competitions within the Prospering from the Energy Revolution (PFER) programme. Approximately 22% of projects funded through the Demonstrator and Innovation Accelerator competitions had commercialised their technology offering. For the Key Technology Components, one third of the projects commercialised their technology. For the projects that had reached prototype development and demonstration, there was evidence of market acceptance and demand, demonstrated by direct sales or the leverage of further investment. The ability to commercialise was dependent on the technical maturity of the innovation. Over the course of the Challenge, Demonstrator projects have been able to successfully progress the technologies that underpin delivery of their smart local energy system. For example, the Energy Superhub Oxford (ESO) Demonstrator launched its Optimisation and Trading Engine and is beginning to generate revenue. The knowledge and toolkits produced by ERIS (Energy Revolution Integration Service) have been adopted beyond the Challenge, by local authorities planning actions towards progressing net-zero initiatives. The business models had been validated for local energy systems. For example, 620 households were signed up to the Demonstrators.'
Industrial Decarbonisation	Yes	It was noted that it was too early to establish the extent to which projects had demonstrated decarbonisation technology deployment. 'However, it was found that the Challenge was on track to support progress towards deploying decarbonisation technologies at an industrial scale in one cluster by the mid-2020s, with another four clusters to be established by 2023. There was limited evidence that the Challenge was encouraging wider take-up among industry. However, there was some interest – for example within the Black Country there was interest from industry leaders involved in the industry advisory board for the project, and in the Scotland cluster there were signs of engagement from smaller emitters interested in feeding their CO_2 emissions into the transport and storage infrastructure being developed by SNZI [Scotland Net Zero Infrastructure].'

Transforming Construction	Yes	There is some evidence that there were impacts on procurement, with a change to procurement strategy to consider a wider range of impacts, including on people and on the environment, as opposed to inputs alone. However, it was suggested that this could not be directly attributed to the TCN [Transforming Construction] due to other factors. Despite this, government interviewees stated that the TCN had a 'clear, strategic impact on procurement'.
Transforming Food Production	Yes	There is limited evidence that the Challenge has led to the filing or securing of patents. Some have been filed, but the exact number was not provided. There is evidence that projects across the Challenge had made technological progress, with all 31 project leads consulted reporting progress. There is evidence that projects have moved up the TRLs towards 'real-world solutions'. An example of this is the STiP Demonstration project, which had reached TRL7-8 and is expected to be fully commercialised by the end of the project. Projects focused their funding on several components, including making technologies more accessible and scalable. This included reducing the costs of production, optimising compatibility, and adapting existing technologies to UK contexts. There have been encouraging signs towards commercialisation, with some examples of full commercialisation across the projects. There is evidence that projects are taking appropriate steps towards commercialisation, including end-user engagement, market testing and demonstration. The Challenge funding supported firms to identify routes to market and provided firms with confidence around their product. Through backing by the Challenge, there was also broader support for commercialisation in terms of 'placing emphasis on market testing, promoting awareness of projects.' There were also examples where the Challenge had supported business development, further accelerating the firm's progress towards commercialisation. There were several examples of new or improved technologies through the Challenge, including around the use of green fertilisers, the trialling of bacteriophage (viruses of bacteria), and the use of robotics in fruit production.
Smart Sustainable Plastic Packaging	Yes	There is minimal evidence of IP from the programme. From the projects making use of 'smart' technology that participated in the survey (8 out of 21), 1 reported that it had a patent in progress. From the projects focused on understanding environmental impacts, 5 completed the online survey, and there were no patents in progress or submitted from these projects. From the projects focused on understanding consumer behaviour, 11 completed the online survey. None of those had patents in progress or accepted.

Driving the Electric Revolution	Yes	For the Driving the Electric Revolution Challenge, there were some promising signs of the Challenge accelerating innovation and commercialisation of PEMD (Power Electronics, Electric machines and Drives) technologies. 'There was evidence that competition winners were able to increase the MRL (manufacturing readiness level) and accelerate commercialisation of their products within the UK. Out of the 54 firms involved, 17 were expecting to be at an MRL of 7 or higher at the end of their engagement with the Challenge, compared with only 1 reporting that level at the start of their involvement with the Challenge. An example of project increasing its MRL was the Challenge-funded project that developed a novel die attachment process for next-generation power electronics, allowing the consortium to increase the MRL of the technology to level 9. An enabling factor to support commercialisation was the ability of firms to utilise the DER-IC (Driving the Electric Revolution – Industrialisation Centres) facilities to test manufacturing techniques and processes while waiting on their own equipment, supporting capacity. For example, there was evidence that the equipment at the Midlands DER-IC site was being used by firms at all stages of development, including design and piloting products and processes. There was, however, some concern that commercialisation was not equal among the different sectors.
Faraday Battery	Yes	There is some evidence of the generation of IP, with 16 patenting opportunities identified across seven projects. Of the 16, 5 had led to official IP disclosures. For the CR&D collaborations, 20 of the collaborations were considering applying for IP protection via patents, 9 had already applied, and 5 had been granted patents. '77% of respondents reported that the Challenge had supported projects to reach a later stage of technological development, primarily at the low-mid TRLs. The survey results suggested that progress through the TRLs had taken place. Most of the progress at the lower TRLs was thought to be because both Faraday Institution (FI) and CR&D focus on the lower levels. Of the 66 collaborations captured by the CR&D project close-out reports, 27 reported that their expectations of commercial opportunity had moderately increased as a result of this project, and 20 reported that it had greatly increased. (Three reported no change, and the remainder did not provide an answer).'
Future Flight	Yes	There is evidence to suggest that the majority of development-phase projects were considering applying for IP protection, with four projects that had applied or been granted IP protection. There was evidence to suggest that projects had increased their technological readiness, with a particular increase in the projects towards the higher end of TRL levels (5+). For TRL 7, the proportion increased from 5% at the start to 31%. Stakeholders suggested the FFC had played a major role in this. The FFC was also seen to play an important role in accelerating technological development, something that was confirmed by government and industry stakeholders.

Table 8. Summary of knowledge creation at the Challenge level

Challenge	Impact in scope?	Summary of knowledge creation at Challenge level
Audience of the Future	Yes	There have been several knowledge outputs produced as a result of the programme. This has included conferences and academic festivals, industry engagement through demonstrations of the work, industry-facing media and industry-wide steering groups. The Challenge also resulted in new and improved courses, modules, content and teaching methods. 'The programme has resulted in 50 new or modified courses and 2680 students benefitting from new teaching or courses (Train the Trainer cohorts 1 and 2)'.
Medicines Manufacturing	Yes	There has been evidence of several types of knowledge output from the Challenge. The ATTC have produced standards and protocols for safe clinical administration, with several clinical pathways established by the centres, which are expected to help scale the clinical trial activity and administration of ATMP into clinical care. The centres have also supported the establishment of best practice for manufacturing and preparation of ATMP. 'Standard Operating Procedures, best practice guides and toolkits were also developed to cover the entire pathway of Advanced Therapy Medicinal Products manufacturing.' 'The ATTCs developed training and educational initiatives to address training needs related to advanced therapies across a wide range of areas. They have also developed novel solutions to address supply chain and logistical challenges.'
Data to Early Diagnosis and Precision Medicine	Yes	'Several projects had produced or were expected to produce academic papers. The production of research papers had raised the national profile of the digital pathology and radiology Centres of Excellence. Alongside publications, several projects have made data resource available; the successful creation of a Cloud-based Research Analysis Platform (RAP) and the public release of data from the first 200,000 genomes in September 2021 were significant milestones'.
Commercialising Quantum Technologies	Yes	In terms of publications, ISCF projects have resulted in publications in peer-reviewed journals, with the publications including both academic and industrial authors. The number of CQT-related publications in peer-reviewed journals increased from 707 in 2020/2021 to 784 in 2021/2022. However, this was lower than the target of 750 and 900 for those years, respectively. The evaluation highlighted that the pandemic may have had an impact on the publication targets not being met, due to limited access to laboratories for conducting the experiments.
Digital Security by Design	Yes	'The projects have successfully fostered collaborations between industry and academia, leading to the publication of research findings. However, there is a need to further connect large and small companies and strengthen the supply chain in the UK. Two projects have already published research from the Manufacturing Innovation Design and Research Institute (MIDRI) in academic journals. Three other projects are either in the process of doing so or have published MIDRI research through alternative academic channels like conference papers. Three projects have published research in journals that involve both academic and industrial partners. One project is working towards achieving this, and another project has independently published their work with a private research firm.'

Next Generation Services	Yes	The programme resulted in the generation of new knowledge. 'Academic researchers involved in the programme produced a total of 101 academic publications.' This included journal articles, books and book chapters, policy briefings and consultancy reports. 'Programme participants increased their publication think pieces (including blogs), reporting an average of 9.7 outputs.' In addition to the publications, there were 20 other forms of knowledge and research output, including databases and models, and research materials.
Manufacturing Smarter Innovation	Yes	Through the MSI Challenge, there have been a number of events around knowledge exchange, including 28 events, workshops and webinars.
Robotics for a Safer World	Yes	There is some evidence of publication outputs. 'Analysis of Researchfish shows that the research projects undertaken by the Use-inspired research hubs are starting to generate (codified) new knowledge and publications, with each hub reporting a large number of publications related to the ISCF-RAI-EE grant, and a total of 395 publications (including peer-reviewed articles, conference proceedings and working papers).' 'This is 317 more than the publications recorded at the time of the baseline (where 78 publications were recorded raising concerns on whether or not they could had indeed emerged from the Use-inspired research hubs activities.' There have also been other forms of knowledge output generated by the Challenge; the use-inspired research hubs have generated knowledge, including the development of new open-source computer models and algorithms for robotic path planning and simulation, contributions to existing software toolboxes, collection and provision of field trial datasets to support validation of Hub activities, integration of software with a robotic platform to support testing, and wider dissemination activities.
Transforming Foundation Industries	Yes	There was limited evidence on publications because of the Challenge. For the project Transfire, three academic papers had been published. For the network (WS4) one academic paper had been prepared (and another one contributed to). There is limited evidence of other knowledge outputs produced as a result of the Challenge. It was stated that the Challenge had improved the knowledge base for foundation industries by bringing representatives and researchers together.
Prospering from the Energy Revolution	Yes	There were 36 publications in total, and in addition to this, work undertaken via the Modernising Energy Data Access (MEDA) competition led to the creation of an open energy data architecture and platform. Stakeholders across the energy supply chain signed up to this initiative.
Industrial Decarbonisation	Yes	There was limited evidence of research papers. In terms of knowledge outputs from the Challenge, we note that knowledge has been generated as a result of the projects, which has supported further activity in the sector. There have been some examples of policy and research briefs.
Transforming Construction	No	The activity led to research publications and to wider dissemination through conferences.
Transforming Food Production	Yes	There was limited evidence of academic publications associated with project activity. There were some examples of knowledge-exchange activities, including webinars, virtual talks, farm open days, social media, and investor engagement activities. Moreover, 'the Challenge team had also been proactive in attending conferences and trade shows'.

Smart Sustainable Plastic Packaging	Yes	There is minimal evidence of publication outputs from the programme. From the projects making use of 'smart' technology that participated in the survey (8 out of 21), there were 2 reported academic papers that had been accepted for publication, with 1 paper published. From the projects focused on understanding environmental impacts, 5 completed the online survey. These projects had resulted in 13 papers published and 3 accepted for publication. From the projects focused on understanding consumer behaviour, 11 completed the online survey; 14 papers had been published and 3 papers had been accepted for publication.
Driving the Electric Revolution	Yes	Innovate UK KTN events have played a crucial role in raising awareness about the DER-IC, facilitating industry engagement and showcasing the potential use of DER-IC equipment in funded projects and commercial applications. Innovate UK KTN keeps track of the number of PEMD contacts and their engagement levels over time. These data reflect the size and engagement within the PEMD ecosystem, though they do not directly measure specific collaborations. The data show an increase in contacts, from fewer than 500 in mid-2019 to more than 3,000 by spring 2022, indicating growth in the ecosystem, albeit with a slowing pace over time. Notable spikes in contact numbers correspond with major competitions, such as the Catalysing Green Innovations and Supply Chains for Net Zero competitions. The Challenge and Innovate UK KTN have conducted various knowledge-transfer activities to spread awareness about the Challenge's aims and supported projects. These include promoting competitions, scoping workshops, and a series of 'Engage with' online and live sessions aimed at fostering collaboration and knowledge exchange within the PEMD sector. These activities have seen significant participation and interaction, demonstrating their effectiveness in engaging the industry and facilitating collaboration opportunities. Innovate UK KTN offers sessions to assist with proposal writing and forming consortia. It is recommended that this support be more widely publicised to both SMEs and academic institutions to enhance awareness and utilisation of these resources.
Faraday Battery	Yes	'Indicators supporting this include a significant rise in publications resulting from collaborations within the UK and internationally. Survey results indicate that 92% of respondents believe that industry-academia collaboration has grown since the launch of the Challenge. Data on publications demonstrate the increasing influence of FI research, indicating a wide range of research spanning various categories relevant to batteries. Stakeholder interviews also underscore the enhanced translation of academic research into practical industry applications. The indicator for this is the sustained academic collaboration within the UK and internationally, as measured by joint publications and the number of research institutions receiving awards. Collaboration among UK academic institutions on publications related to batteries serves as an indicator of the strengthening of the research landscape.'
Future Flight	No	'Stakeholders acknowledged that the FFC was playing a role in shaping regulatory frameworks to bolster the future flight sector in the UK by facilitating collaboration between industry and regulatory experts. They believed that the FFC had expedited the development and release of certain regulations and guidance materials through the CAA's [Civil Aviation Authority] interactions with competition winners, such as the publication of guidance for remotely piloted aircraft system (RPAS) operators handling dangerous goods.'

		Regulatory stakeholders noted that the speed of developing and publishing specific regulations and guidance had been enhanced by the CAA's engagement with competition winners during the development phase, exemplified by the published guidance on the carriage of dangerous goods by RPAS. Successful consortia highlighted that the FFC had motivated them to showcase their projects through publications and presentations at conferences to enhance visibility beyond the FFC. They also pointed out that the networks available to senior FFC leadership played a crucial role in supporting this effort.

Table 9. Summary of stakeholder and public awareness at the Challenge level

Challenge	Impact in scope?	Summary of stakeholder and public at Challenge level
Audience of the Future	Yes	There was mixed evidence on awareness among industry stakeholders. There were examples of activities around 'industry engagement including demonstrations of the work, industry-facing media and industry wide steering groups', at the interim evaluation stage, but it was felt that while there was general awareness of the programme, there was little knowledge of specific projects. There was engagement with academic stakeholders through the programme. As a result of the programme, 78 educational and skills programmes and courses were developed, which included 50 courses developed through the Train the Trainer project. Academics who participated in the Train the Trainer workstream also reported changing attitudes towards and greater recognition for immersive within their institutions as a result of their participation in the programme. 'SFA had a positive impact on attitudes towards immersive among participants: 92% said their SFA involvement made them convinced or enthusiastic about the future of immersive storytelling (SFA Annual Report, 20/21).' 'External stakeholders from the immersive sector (investors, industry professionals, trade bodies and other higher education institutes) recognised the level of demand for skills development in the creative immersive vertical and praised the impact SFA has had in meeting this need.' Within the Challenge, each demonstrator had targets for audience numbers, and two of the four met the target. 'In total the four Demonstrators reached a total audience of 2.38M. This was heavily driven by the eSports Demonstrator.'
Medicines Manufacturing	No	'The Challenge has supported awareness raising among industry and business stakeholders. Through the programme there has been a variety of collaboration among pharmaceutical firms, CDMOs, therapy developers and the NHS. Collaboration has been enabled in part by the creation of the ATTC network, and in part through the efforts of the Challenge Director and programme team. Through the apprenticeship programme, 'the Catapult has undertaken engagement and proof of concept activities to demonstrate the validity of apprenticeships as a mechanism to deliver a skilled workforce for the Advanced Therapy Medicinal Products sector.' This has involved several engagement activities, including the National Apprenticeship Week, with companies and apprentices involved championing the scheme. The Catapult also works to attract and recruit early adopters for apprentices and new standards to enable organic growth in demand and penetration across industry.'

Data to Early Diagnosis and Precision Medicine	Yes	Examples of improved awareness among academic, industry and wider public stakeholders include the following projects: 'PathLAKE where they held a conference in September 2021 with c. 170 attendees; NPIC [Northern Pathology Imaging Collaborative] has held two public engagement events, one was a citizen's jury and the other an exhibition on AI in healthcare; and ICAIRD has a role advising the Scottish Government.'
Commercialising Quantum Technologies	Yes	N/A.
Digital Security by Design	Yes	There was evidence of improved awareness among industry and business stakeholders. Collaboration between academia and industry was built into the workstreams, resulting in a mixture of academic- and industry-led investigation of the technology. Engagement with industry had worked well in terms of building an ecosystem for early testing. The Challenge was involved in raising awareness of cyber security issues and the role of the Challenge in combating these issues through a campaign. There was some evidence that the engagement activities worked well in building an ecosystem that was involved in adoption of DSBD and testing the Morello Board. However, it was stated that more needed to be done to increase awareness of issues around cyber and digital security. The use of search terms related to the Challenge has grown over time, showing increasing awareness of new security capabilities and of the ecosystem more broadly. There is limited awareness of the Challenge by the public due to the stage of the programme, particularly as there are no available products or services for business-to-business or business-to-consumer purchase. Media tracking from 2021 to 2023 shows increasing awareness of new security capabilities, with LinkedIn, Twitter and website page views increasing over the timeframe.
Next Generation Services	Yes	The programme resulted in awareness raising among industry and business stakeholders. Research projects delivered 199 engagement activities to disseminate knowledge, and this included presentations and webinars in collaboration with the AI for Services network. Programme participants reported an increased understanding of the sector challenges and opportunities, the opportunities relating to AI and data and the potential for applying AI solutions to their sector. 'The majority of participants reported their participation had led to further thinking around the skills needed in their organisation going forward (85% of participants, base:20) and increased the likelihood their organisation will undertake a project to develop or implement AI & Data solutions (67% of participants, base:20).' While not related to projects directly, members of the AI for Services network found the network valuable, particularly in understanding commercial opportunities in applying AI and data solutions. In addition, involvement in the research projects helped improve awareness and influenced the training of practitioners and researchers. An example of this was the AI in English Law project, which contributed to the establishment of a new interdisciplinary master's level course for law and computing science at the University of Oxford.
Manufacturing Smarter Innovation	Yes	In terms of increasing stakeholder awareness, the Challenge has delivered several events involving engagement with industry. For example, InterAct delivered 17 events, with 557 attendees, and had 442 members, including 112 from industry and 274 from academe.
Robotics for a Safer World	No	'94% of 115 surveyed [awardees] believed their involvement in the programme had led to improved understanding for the potential for applying RAI solutions in their operations and processes.' 'Four in five (81%) also believed that their involvement had led to new plans and strategies to increase the adoption of robotics and AI into their operations and processes.'

Transforming Foundation Industries	No	There is some evidence that TFI contributed to increasing 'willingness amongst companies and academics to innovate and collaborate'. It was also stated that the Challenge informed the debate within industry, academia and government around the types of the challenges facing foundation industries and the need to address them, although there was limited evidence for this.
Prospering from the Energy Revolution	Yes	Through the ERIS programme funded by the Challenge, there has been a wider uptake and understanding of a systems approach. The team involved in the Challenge played a role in repositioning some of the ERIS activities in recognition of the capacity gaps at local authority level. Current activities focus on supporting local authorities to help implement systems-based approaches to local area energy planning. An example of this is the work done with Oxford County Council to apply the Smart Local Energy Asset (SLES) toolkit and the Local Energy Asset Representation model for local area energy planning.
Industrial Decarbonisation	Yes	The Challenge was felt to establish a clear programme to advance industrial decarbonisation, which provided a clear signal of government commitment. This was felt to increase industry confidence in investment in industrial decarbonisation. There was some evidence that projects involved with the Industrial Decarbonisation Research and Innovation Centre were embedding in industry. For example, 'one project used an industrial site at one of their industry partners as a test bed which allowed them to prove applicability and scalability of their technological solution'. However, there was also some evidence that engagement with industry partners could be greater across the projects within the Industrial Decarbonisation Research and Innovation Centre (IDRIC) as a whole.
Transforming Construction	Yes	The evidence highlighted that the demonstrator elements of the TCN engagement worked well, and it showed how TCN elements could work in practice. The survey provided evidence of high awareness of TCN concepts by large-scale construction businesses. 'There was evidence to suggest that individuals had a high level of awareness of concepts prior to engagement with the TCN.' However, it was noted that the TCN had helped to increase knowledge of specific concepts and their potential. This was particularly true of government stakeholders, in relation to who it was expressed that the TCN had helped increase their knowledge of specific concepts. There was an increase in use across the TCN concepts since the baseline survey, particularly for information-management frameworks, digital compliance and improving the whole-life value of buildings. The activity case studies found that organisations that had engaged with the TCN tended to have had high awareness of TCN concepts prior to engagement. There has been limited dissemination of the outputs of TCN activities across wider industry; however, the evaluation still found that the TCN was providing a valuable role.
Transforming Food Production	Yes	There is some evidence showing that Challenge has led to improved awareness among industry and business stakeholders. Most projects engaged in knowledge-exchange and demonstration activities, although the extent to which this happened differed across projects. These activities involved engagement with end users to test and demonstrate technologies and generate customer interest, as well as engagement with research communities to validate findings. Commercial partners also facilitated knowledge exchange for some projects through their contacts across supply chains. The quality and pace at which technologies were developed was thought to be improved by the strengthened relationships between project partners. There was some evidence of awareness raising among the wider public. Some of the knowledge-exchange activities led to national media coverage (for example on the BBC). In some cases, the knowledge-exchange activities also enabled projects to engage with a wide range of users (including in other countries) to help test and validate the research.

Smart Sustainable Plastic Packaging	Yes	In terms of awareness among industry and business stakeholders, the Challenge actively promoted the use of behavioural science and behavioural change research in supporting decisions around plastic production, use and reuse. Project leads for the behavioural change projects have seen academics, retailers and plastic manufacturers show an interest in the research. Overall, projects recognised the importance of behavioural change to the success of their activities. More than three quarters of the projects references the importance of behavioural change to the success of their work. In addition to supporting specific projects with a behavioural focus, the Challenge organised and chaired behavioural change sessions at the conference Global Research and Innovation in Plastics Sustainability (in 2021 and 2022). The Challenge was also able to benefit from the series *Blue Planet 2*, which facilitated raising public awareness on the reuse and recycling of plastics, and this momentum was continued by the projects themselves.
Driving the Electric Revolution	No	N/A.
Farraday Battery	Yes	In terms of raising awareness, the targets set by the FBC, together with the Council, were 'seen to be a good basis for global discussion on the topics of battery safety, performance and efficiency'. 'On testing, the FB[C] is generally perceived to be developing the right ecosystem to aid UK battery production in the long term, including by attracting investment from companies with testing experience. Two of the 16 patent opportunities reported relate to testing protocols, and the commencement of operations at UKBIC [UK Battery Industrialisation Centre] could further enhance testing capabilities. No evidence was found to link the intervention to awareness among the public.'
Future Flight	Yes	There was some evidence of activities to increase awareness among the public. The FFC undertook social science research activities on understanding and influencing public acceptance for future flight technologies. This included appointing a team of academics, articulating priorities and gathering evidence on public attitudes. However, there was limited evidence of overall changes in public perception between baseline and interim evaluation surveys.

Table 10. Summary of informing policy at the Challenge level

Challenge	Impact in scope?	Summary of informing policy at Challenge level
Audience of the Future	Yes	COVID-19 accelerated shifts to digital products and services. Creating scalable processes or reusable assets worked well to get follow-on investment. Challenges in consortium and project management were noted, although they were patchy across demonstrators, with some working better than others.

Medicines Manufacturing	Yes	In terms of engagement with policymakers and regulators, the Vaccines Manufacturing and Innovation Centre (VMIC) team, alongside the Challenge Director, supported the work of the Vaccine Taskforce. The VMIC CEO was a workstream lead for the taskforce and fed into discussions around vaccine development technologies and the UK and wider landscape. 'The Advanced Therapy Treatment Centres network has enabled engagement with the UK regulatory community including NICE [National Institute for Health and Care Excellence], MHRA [Medicines and Healthcare Regulatory Agency], HTA [Human Tissue Authority] and HRA [Health Research Authority] as well as the Regulatory Advice Service for Regenerative Medicine.' 'Regulatory stakeholders highlighted the value of a single point of contact provided by the Centres network.' There were also contributions to national initiatives, including the Innovative Licensing and Access Pathway for medicines, the Accelerated Access Collaborative and the Novel NHS commissioning specification. In addition, the Challenge supported regulatory guidance around exporting ATMP. This was through the Pharmacy Working Group. The evaluation also found evidence that the Catapult played a valuable role in coordinating sector input to major regulatory reviews, such as the ongoing NICE review of health technology assessment methods of ATMP. 'Interviewees were overwhelmingly positive about the support they received from Innovate UK noting it was constructive and supportive, adaptable to the difficult environment (Brexit and COVID-19 and related challenges). In particular, Innovate UK Technical Leads and the monitoring officers were frequently mentioned. The role of the monitoring officer as a "liaison" with Innovate UK was highly valued by respondents who found they were knowledgeable and ambitious for the projects. One area of support that respondents found very helpful was in facilitating contacts and assisting with navigating the grant funding landscape in the UK.' The COVID-19 pandemic has reinforced the importance of the Medicines Manufacturing Challenge in several key aspects: sovereign manufacturing, the importance of national coordination, capacity constraints, and digital health and demand. 'The absorption capacity of the NHS for new Advanced Therapy Medicinal Products trials could be at risk without further investment once higher-prevalence indications reach later stage clinical research.' Some companies funded through the CR&D competitions reported that they reverted to using manufacturing partners based overseas, mainly for reasons relating to cost and capability. 'Regulatory barriers in registering medical devices given the different nature of the products, firms faced challenges with regulations on the registration of products as medical devices. For example, a firm developing real-time evidence gathering platform for mental health professionals noted the difficulty of the work to register the platform as a medical device, which was done through the development process thanks to dedicated resources, but that could have significantly delayed the adoption and commercialisation of the platform at the end of the development phase.' 'Addressing barriers for host companies: Smaller, less mature companies reported they were less able to fund structured internal training programmes including apprenticeships due to time, resource, support, and infrastructure needs, although the apprenticeship levy transfer was seen as being an enabler for addressing this barrier.'

Data to Early Diagnosis and Precision Medicine	No	Local management teams and structures were highlighted as having worked well by Innovate UK monitoring officers during quarterly monitoring meetings. 'The collaborative approach to shaping and developing the Digital Innovation Hub (DIH) programme has been effective with a range of academic, clinical and commercial partners now involved in the Hubs and Health Data Alliance.' 'For the UK Biobank WGS project, there was a strong consensus that the creation of a collaborative space where partners from different sectors could work together was the key enabler of the project.' Most of the delays to the projects were related to the COVID-19 pandemic; however, delays to the establishment of the COE occurred due to delivery complexity. Delays to the projects also occurred due to complexity around the University/NHS Trust governance structures and processes.
Commercialising Quantum Technologies	No	N/A.
Digital Security by Design	Yes	The Challenge was seen to have good links with government through the Programme Board and advisory group. In addition, the technology features in recent strategies suggest that DSBD was on the UK research agenda. The Challenge has attracted funding from government departments and agencies (for example Department for Business, Energy & Industrial Strategy (BEIS)), and 'featured in several Government strategies, suggesting that awareness in Government is relatively high, at least in certain key departments.' For example, the 'Integrated Review 2021 – a five-year government's Strategic Framework on national security and international policy – now focuses on Sustaining Strategic Advantage through Science and Technology as one of its four key themes. MoD [Ministry of Defence] has committed matched funding to DSBD and there is a senior fellow of the MoD's Defence, Science and Technologies Laboratory on the DSBD Advisory Group.' In addition, the National Cyber Strategy 2022 features a section on Digital Security by Design under an objective on fostering and sustaining 'advantage in the security of technologies critical to cyberspace'. There were positive perceptions of the Challenge, and stakeholders involved in the Challenge suggested that the impact on government strategy was more significant than the impact on early development of the ecosystem. Barriers to the project, such as challenges in the recruitment of early career researchers, were noted, as well as COVID-19 pandemic–related issues.

Next Generation Services	Yes	The programme delivery team engaged with policymakers and regulators. Examples of this include involvement of the Challenge Director in the steering group for the Law Tech UK Sandbox activity, funded by the Ministry of Justice. There were also connections with the former department BEIS; this was embedded in the structure of the programme. The programme activities have informed policy within the UK. This has been through the knowledge from the research projects, which has resulted in activities including evidence to a government review/consultation, participation in an advisory committee or citation in policy documents. The projects have also ' 'reported wider policy influence in Europe, in terms of providing written and expert stakeholder evidence to European consultations and committees.' The programme also benefits from knowledge gained during implementation. The knowledge gained helped inform UKRIs understanding of the needs and interests of three professional services sectors that were in scope of the programme.
Manufacturing Smarter Innovation	No	N/A.
Robotics for a Safer World	No	'There are also early signals of positive spillovers in terms of policy influence. Three of the research hubs are members of two British Standards Institution committees and to two IEEE Standards Association committees. These committees are working to provide national and international methodologies and tools for the development, implementation, use, and assessment of robotics and autonomous systems. RAIN [Robotics and AI in Nuclear] Hub has also been working with Office for Nuclear Regulation and Culham Fusion regarding future regulation of nuclear robotics. According to Researchfish, the ORCA [Offshore Robotics for the Certification of Assets] Hub has been very active in developing wider policy links. For example, researchers within ORCA were involved in the planning and development of the proposed Robotics Sector Deal, and have also been active in providing evidence and meeting with government ministers and civil servants around the UK Maritime Strategy and drone legislation. Representatives of ORCA also sit on two international advisory committees'.
Transforming Foundation Industries	No	N/A.
Prospering from the Energy Revolution	Yes	Through the programme, there has been regular engagement with key stakeholders at Ofgem, which has led to Ofgem and UKRI partnering on the Strategic Innovation Fund. 'The Energy Data Taskforce (EDT) was launched as a working group building on work undertaken by the ERIS team. Ofgem are now obliging networks to abide by best practice as developed by the taskforce, and the work has also led to Ofgem requesting and publishing digitisation strategies to facilitate development of novel services and business models using energy data.'

		The Challenge has influenced policy and regulation. Examples include work resulting from the EDT (coordinated by ERIS and Innovate UK) that has been cited as a critical input into several policy and regulatory initiatives. BEIS and Ofgem have committed to implementing five recommendations from the work, and the Energy Digitalisation Strategy was based on the work. Following up on the EDT, BEIS launched a new Energy Digitalisation Taskforce (known as EDiT). The work undertaken by the Challenge was highlighted as influential in the drafting of strategies, and the Challenge has also led to engagement with the National Infrastructure Bank with a framework developed by the Investment and Finance Working Group feeding into the Bank's work to develop eligibility and financing plans for energy projects. Results from the Challenge have influenced Ofgem regulation and initiatives by BEIS on sharing and accessing data in the energy sector.
Industrial Decarbonisation	Yes	Some engagement activities with policymakers are planned, but it is unclear what has been delivered or achieved at this stage of the evaluation. There has been fragmented delivery; more formal mechanisms for collaboration and knowledge exchange would be better.
Transforming Construction	Yes	There was limited engagement with policymakers and academia, and it was highlighted that 'the links between the TCN and wider government were not as effective as they could have been.' In terms of the Challenge influencing policy, there are isolated examples. One example is that as part of the GenZero project Construction Innovation Hub (CIH) influenced the Department of Education to improve design standards for school buildings. The importance of the Construction Playbook in changing public sector procurement was noted, which supported the incorporation of TCN concepts. However, views on whether the TCN had engaged in its development were mixed. Barriers, such as skills shortages, were also identified.
Transforming Food Production	No	Through the Challenge, there were several engagement activities with policymakers and regulators. This involved projects' engagement with Department for International Trade (DIT), local Growth Hubs, Defra and other sector organisations, such as the John Innes Centre. 'Two of the projects set up advisory boards as a mechanism to engage with the wider agri-food sector. There was some evidence of the Challenge delivering positive strategic effects in relation to informing policy and cross-departmental partnership working with Defra.' There was evidence that TFP had played a critical role in raising awareness and demonstrating the benefits of investment in innovation with those in Defra, which was reported to have helped secure Defra's financial commitment to the Farming Innovation Programme. Defra's involvement on the TFP Programme Board has also encouraged better alignment of policy priorities.

		There were also links between projects and the wider UKRI/DIT offer, which raised the profile of TFP-funded projects. The TFP team also engaged with regulatory bodies to support TFP projects and other agri-tech firms to commercialise new products (e.g. the Food Standards Agency). This also played a role in setting the 'strategic direction for parts of the sector' (e.g. the collaborative development of Alternative Proteins Roadmap), although it was noted that it was early to assess the impact of these strategic activities. There were mixed views on the Challenge's strategic influence. It was noted that there was limited awareness of TFP across the sector as a whole, and there was still scope to raise the influence of the programme. 'Several features of TFP's design and implementation have facilitated progress, including its scale, flexibility, strong management, collaborative approach, prioritisation of industry/end-user engagement and dedicated funding for demonstration, dissemination and market engagement. The rationale for intervention remains valid and highly relevant.' One hindering factor was capacity among the Challenge team. Other barriers included COVID-19, Brexit and the war in Ukraine and rising costs. In terms of the design and delivery of the Challenge, there were barriers relating to the loss of programme budget (loss of GBP 13m from the TFP budget). Bureaucracy within UKRI, especially in terms of the competition processes, was viewed as being a hinder. The timing of Challenge competitions was a particularly important for this sector as it was heavily impacted by growing seasons, so small delays can result in having to wait until the next growing season.
Smart Sustainable Plastic Packaging	Yes	One hindering factor was the impact of the COVID-19 pandemic, due to the delays it caused to projects and due to limitations around face-to-face research and engagement. Other factors included Brexit and increasing costs, and supply chain difficulties making access to equipment challenging.
Driving the Electric Revolution	No	There were several barriers that hindered the Challenge making impacts to environmental policy relating to the lack of a high-level government industrial strategy. It was also noted that the Challenge spread quite thin across areas.
Farraday Battery	Yes	The Challenge played a role in establishing a policy framework for investment. There was evidence of the FBC bringing together influential and informed senior leaders, which gave credibility to the conversations held with government departments. It was noted that the FBC provided a model that supported the development of UK technologies from concept through to production, which is attractive to potential investors. In addition, the Challenge's progress in building a platform of work with low TRLs was seen as helping provide government with the confidence to invest.

		'There was evidence that the Challenge played a significant role in strengthening the policy landscape for batter technology through the research and outreach activities conducted by the FI and CR&D.' The FBC, Advanced Propulsion Centre (APC), Automotive Transformation Fund (ATF) and government departments, such as the DIT and BEIS, work together to ensure that 'the policy and investment profile for batteries is raised'. The FBC was seen to showcase the UK's strength in applied research, and FBC outreach was influential in developing the policy landscape for batteries. For example, 'its research into eV and battery production out to 2040 (undertaken in 2019 and updated in 2020) was influential in leading to the establishment of the Automotive Transformation Fund (ATF).' There was some evidence that the FBC helped to secure continued investment post-Brexit. The ATF provided a platform for automotive companies and stakeholders in UK battery manufacturing to communicate with government on issues related to the battery value chain. The ATF was considered as a 'key attractor for UK battery manufacturing and provided a basis for global discussions on related topics'.
Future Flight	Yes	There was evidence of engagement with government stakeholders. Government stakeholders reported that the FFC provided a useful link with industry to support coordination and participation. This was also reported on the industry side, where they found the channel with government useful to communicate priorities. The Challenge also led to the creation of a ministerially chaired Future Flight Industry Group. In terms of the outcomes of engagement with policymakers and regulators, there was evidence from regulatory and industry stakeholders that the Development Phase of projects was 'useful to build experience between future flight companies and the CAA' in order to support successful trials and demonstrations. Stakeholders also agreed that the FFC was contributing to the development of regulatory frameworks to support the future flight sector in the UK by bringing together industry and regulatory expertise. Stakeholders thought the FFC had 'accelerated the development and publication of some pieces of regulation and guidance as part of CAA engagement with competition winners (e.g. publication of guidance for remotely piloted aircraft system (RPAS) operators carrying dangerous goods)'. It was also felt that the FFC had informed government policy across a range of other initiatives (Future Flight Vision and Roadmap, Aviation Council, Drones Industry Action Group, ADS AAM Advanced Air Mobility Market Group). In terms of stakeholder perceptions, those involved in the consortia felt that the FFC had 'bridged a communication gap' between industry and government by acting as a contact point and intermediary. The consortia valued receiving FFC advice on navigating processes, permits and approvals, as well as the ability to communicate rapidly with government on priorities. Government stakeholders valued the FFC gathering and distilling information from the varied and diverse industry stakeholders. There was evidence pointing at the usefulness of industry workshops and events for facilitating consortia engagement.

E.2. Capacity and investment

Table 11. Summary of Investment at the Challenge level

Note: While impacts could be in scope in the Challenge-level evaluation frameworks, Challenges looked at investment through different lenses (e.g. looking at investment broadly or more granularly, looking at private and public investments separately, and looking at reasons for increased investment).

Challenge	Impact in scope?	Summary of investment at Challenge level
Audience of the Future	Yes	Successful applicants reported increased levels of investment in R&D for immersive technologies and increased R&D intensity, higher than those reported by the unsuccessful applicants. UK government departments also showed substantial additional public investment. The Challenge cemented strong relationships with global technology partners (e.g. Apple), and it has led to a variety of relationships with content holders (i.e. Disney, Netflix), indicating future avenues for further investments. The interim report noted that 'access to finance, and investors' perception of risk in XR [extended reality], was still perceived to be a significant constraint in the development of new creative content'. Although the AOTF evaluation did not report any international investment, it did, in fact, engage with global organisations. 'The programme has invested £39.9m in supporting the development of creative immersive content. Of this, £36.4m of AOTF funding has been allocated to its primarily work strands and secured a further £13.5m in matched funding from project participants.'
Medicines Manufacturing	Yes	Investments are anticipated to exceed private investment targets (£14m) over the next three years. 'Notable overseas investments include a £31m Series B fundraising by Big Health', 'and £27m raised by Perspectum Diagnostics – a developer of non-invasive digital diagnostics.' 'In December 2021 Fujifilm Corporation announced that it is expanding its UK gene therapy capacity with a £400m addition of viral vector process development and GMP [Good Manufacturing Practice] manufacturing services at Diosynth Biotechnologies in the Northeast.' Investments and support attracted further public funding of £8.6m to the centre for Process Innovation to create a new Centre of Excellence in mRNA vaccine manufacture, increasing the 'capabilities of NHS sites to deliver ATMPs to patients which in turn has anchored manufacturing investment in the UK.' This received significant attention by the government's Vaccines Taskforce following the COVID-19 pandemic, leading to an additional £135m of funding from BEIS to accelerate the initial build and expand filling-line capacity.
Data to Early Diagnosis and Precision Medicine	Yes	New industry-funded collaborations resulted from the project. More than £175m was leveraged in matched funding and a further £49.5m was committed in public investments from the Office for Life Sciences (OLS). The delivery of globally renowned research assets led to international companies paying for remote data access and was particularly attractive to private companies wishing to establish commercial–healthcare research partnerships. 'Key achievements of the London Medical Imaging and AI project have included the launch of the AI Deployment Engine, and the ongoing development of the Federated Learning Platform (FLIP). The first AI-enabled MRI scanner has also been procured.'

Commercialising Quantum Technologies	Yes	Private matched funding was more than five times the ISCF requirement, reaching more than £65m. While the programme may not have created many start-up companies, it has provided vital support to these start-up companies, helping them to get venture capital (VC) investment.
Digital Security by Design	Yes	The current level of private investment in the programme is above the 2023 target of £50m (final target of £800m by 2027), with a total of £22.7m committed to organisations involved with DSBD by other government departments. The private sector co-investment has opened up new routes to market.
Next Generation Services	Yes	Each business invested around ca. £209k in the project 'post-grant'; if this were to continue across each participating business, then the total cumulative investment would equate to around £14.8m. Public funding bodies (EPSRC, UKRI, SRA, ERC) contributed a further £1.9m to projects involved in the Challenge. The majority of successful applicants thought that the NGS programme made the solutions developed more ready for further investment from the private sector. 'With this in mind, our analysis used an indicative total cost of £33.2m, which includes £20.3m in value of grants, £1.67m in administrative costs (calculated as the difference between grants and the total value of the programme), £9.4m in matched funding and £1.83m in in-kind contributions, both from participants.'
Manufacturing Smarter Innovation	Yes	Additional match funding of £162m from industry sources is anticipated; the current value realised is £380,000.
Robotics for a Safer World	Yes	Programmed has leveraged £76.2m in leveraged funding from businesses, primarily those involved in the programme, where R&D spend for RSW projects remained constant at £2.7m compared to the counterfactual of unsuccessful projects (reduction in spend). Growth in the RSW is particularly strong for the offshore energy and nuclear sectors. Private investments included Astroscale raising £61m, as well as funding from European Space Agency, China and Horizon 2020, amounting to just under £0.5m. Other public sector funds amounted to £9.0m. The Challenge led to new avenues of investment: the mechanisms that have allowed R&D activity and private investments to occur have primarily been via the ISCF funding instruments, such as use-inspired research hubs working as sector aggregators improving the visibility and coordination of the field. The funding also allowed companies to prioritise R&D in areas that have been marginalised. The Challenge was seen as an important factor in the formation of the partnerships (Chapter 2), providing credibility and financial leverage and reducing burden and risk to consortium partners.
Transforming Foundation Industries	Yes	Additional investment of £83m is expected from the private sector. 'Feedback from businesses has indicated that they value the support for innovation as it de-risks their own investment in these projects, by providing pilot facilities for companies to trial new technologies, project-funding or access to skills and expertise. The demonstration of the government's commitment to innovation for the FI is likely to have played a role in events such as Modern Karton's £600m investment in a new paper mill at Shotton Mill.'

Prospering from the Energy Revolution	Yes	'PFER funded firms have been able to collectively raise £874.3m in funding from external investors. 40% of the £2.2bn total equity investment in the UK between 2019-2021 was generated by firms funded by PFER, further highlighting the influence of the programme on UK investment competitiveness. This is also true internationally, particularly within the European smart energy systems market (UK holds 7% of the market share). Beyond the investments into firms supported by PFER, the work of the Investment and Finance Working Group has led to fruitful engagement with the novel National Infrastructure Bank, and conversations on how the Bank could support SLES initiatives in the future.'
Industrial Decarbonisation	Yes	'The Challenge looks set to leverage over three times its target with a total of £837.6M in co-investment. In addition, HyNet has secured £40m of funding from other public sector grant funds, partners and Network Innovation funding.' There is some promising early evidence on reducing commercial and technical or technological barriers and additional impacts in industrial decarbonisation investments, with early indications of Industrial Decarbonisation (sometimes shortened to IDC) projects and their progress encouraging the unlocking of funds for further activities or projects. The Teesside Deployment project Net Zero Teesside showcases how the IDC has catalysed further activity: project leads claim an expected '£1.7 billion in private sector investment to incorporate blue hydrogen, biomass, biofuels, industry and energy-from-waste to contribute to a net zero industrial cluster'.
Transforming Construction	Yes	At the time of Challenge-level evaluation, the Challenge was on track to meet its 2023 co-investment target (£250m by 2027). 'De-risking activities through providing matched funding and resource has allowed organisations to collaborate in "high-risk" areas. The TCN has enabled organisations to pool risk both with the TCN and across other organisations involved in the activity, giving a positive signal to investors, and success in demonstrating the commercial viability of innovations.'
Transforming Food Production	Yes	Over half of project leads consulted reported increased investment in R&D as a result of the project, with one project having successfully crowdfunded more than £2m from more than 600 investors. A £3.5m international equity investment was also secured. De-risking technologies and providing evidence for business cases provided technical credibility for further investment. 'Private investments accelerated progress by, for example, enabling firms to scale-up testing and demonstration activities, build manufacturing facilities, and accelerate business development alongside the R&D more generally.'
Smart Sustainable Plastic Packaging	Yes	Co-investment totalled £209.9m to date (140% of the £149m co-investment target), with an additional £7m in public investment for one project. Challenge funding has been 'crucial in reducing the inherent financial and resource risks associated with research and innovation and proof of concept activities.' These investments have led to new investment opportunities and activities, supporting new capital build projects for new plants.
Driving the Electric Revolution	Yes	The Challenge reached approximately £195m in co-investments in 2022, exceeding the £154m target for the lifetime of the Challenge. The Challenge helped Custom Interconnect Ltd (CIL) to attract a further £1.4m of capital investment for a follow-on project. In addition to this, the Challenge enabled successful DER applicants to receive further public funding and international private investment. 'The UKRI funding has de-risked direct-dispense manufacturing and has raised interest from customers and investors alike, thereby attracting the private finance needed for further scale-up.'

Farraday Battery	Yes	There has been a noted positive impact on investment in the battery sector due to the Challenge. While there is international interest in battery technologies, there are not enough incentives for foreign investments given overall R&D trends showing a decline in foreign investment, which may mask any positive effects of FBC. 'The Challenge improved perceptions of the UK as an investment location coupled with announcements regarding Gigafactory establishment also raise the prospects of positive headline economic outcomes in the medium term. Stakeholders stressed the need for long-term commitments from government given the time required to earn a return on major investments, and the FB[C]'s progress in building a platform of work with low TRLs was seen as helping to provide government with the confidence to invest.'
Future Flight	Yes	FFC estimated that realised pledged co-investment as of June 2022 was £13m – or 59% of the £22m that consortia committed to spend on the Development Phase FFC projects. Non-UKRI public investment stands at £45m. 'Multiple industry stakeholders felt that functions of the FFC would continue to be needed post 2024 in order to support UK competitiveness.'

Table 12. Summary of the geographic distribution of investment and activities at Challenge level

Challenge	Impact in scope?	Summary of geographic distribution of investment and activities at Challenge level
Audience of the Future	Yes	Regarding geographical distribution, and focusing on the DCMS Creative Industries (CI) sector subgroup, London has the largest workforce (7,586). This represents an increase of 12% (~800 more people). Furthermore, the London workforce accounts for almost 58% of the total UK creative immersive content workforce (equal to the baseline position). 'Although the absolute numbers are large, the size of the creative workforce in London means that the employment in the capital in Creative Immersive Content currently accounts for 0.56% jobs in the CI sector in the region. The highest penetrations – for cities with a workforce of 100 or more – are instead to be found in Sheffield (231, 0.87%), Cambridge (247, 0.82%), and Brighton and Hove (306, 0.77%).' In these three cases, workforce and penetration is slightly higher in comparison with the baseline. This signals the growing importance of the sector in these cities.
Medicines Manufacturing	Yes	The effect of the ATTCs in upscaling capacity outside of London and the Southeast was viewed as critical in encouraging ATMP developers to commit to larger-scale programmes of trials in the UK. 'The programme has led directly to growth outside of the core COE.' 'Examples include Orbsen's investment into the West Midlands to take advantage of upscaled NHS capacity.' However, despite the success of training interventions supported by the programme, the supply of skills outside of London is an ongoing issue that could act as constraint in balanced regional growth.
Data to Early Diagnosis and Precision Medicine	No	N/A.

Commercialising Quantum Technologies	No	N/A.
Digital Security by Design	No	N/A.
Next Generation Services	Yes	The geographical distribution of the project team throughout the UK facilitated engagement with regional institutions (e.g. Institute of Chartered Accountants of Scotland (ICAS)); however, the project noted that engagement was often challenging due to the London-centric nature of accounting and law.
Manufacturing Smarter Innovation	Yes	'Enterprises involved in CR&D projects are reasonably well distributed across the UK. London and the South East represent the largest number of collaborators (48 and 37, respectively).'
Robotics for a Safer World	Yes	Outputs were generated from multiple organisations involved, notably the University of Southampton produced the highest volume of publication-based outputs, whereas the University of Sheffield and Natural Environment Research Council (NERC) British Antarctic Survey produced the most international impactful outputs in terms of their field-weighted citation impact.
Transforming Foundation Industries	Yes	'The location of the majority of FI businesses means that efforts to support the sector align with levelling-up priorities: Yorkshire & Humber, Northwest and Wales are the most represented regions in terms of partners involved in CR&D projects.'
Prospering from the Energy Revolution	Yes	N/A. – No information was found on geographical distribution of investments, despite the Detailed Design project's aims to trial platforms across regions.
Industrial Decarbonisation	Yes	The diversity of projects that exist within the IDC portfolio served as 'blueprints across different industrial and geographic settings, including onshore (e.g. Northwest) and offshore sites (e.g. Scotland), estuaries (e.g. Humber), large industrial complexes (e.g. Teesside), large dispersed industrial sites (e.g. South Wales) as well as industrial settings with small but energy intensive businesses (e.g. Black Country).' There is evidence that some projects are attracting significant interest, e.g. the Black Country has seen interest within the region from industry leaders involved in the Industry Advisory Board for the project, and the Local Enterprise Partnership is extending to the wider West Midlands. 'The Scotland cluster is also seeing signs of engagement from smaller emitters interested in feeding their CO_2 emissions into the transport and storage infrastructure being developed by SNZI.'
Transforming Construction	No	N/A.
Transforming Food Production	No	N/A.

Smart Sustainable Plastic Packaging	No	N/A.
Driving the Electric Revolution	Yes	'The DER-IC are also outside the Southeast, located in Scotland, the Northeast, the Midlands and the South West & Wales. These regions have a larger share of industries and skills that risk becoming obsolete in the transition to net zero. By locating projects and DER-IC in these regions, the Challenge indirectly contributes to retraining (and levelling-up). Challenge data suggests that the distribution of funding is largely outside of London and the Southeast, in line with wider "levelling-up" objectives to increase investments across the country. Only 10% of funding is estimated to have gone to London and the Southeast, compared with around 27% to the West Midlands, 15% to both the Northeast and Wales, and 12% to Scotland.'
Farraday Battery	Yes	N/A.
Future Flight	Yes	'Seven in ten of UK headquarters were in the South of England (69%, including 28% in the South East, 18% in London and 16% in the South West), and around one in ten were in the Midlands (10%), the North of England (9%) and the devolved nations (11%, including 8% in Scotland).'

Table 13. Summary of the capacity (individual [skills, training] and infrastructural) at the Challenge level

Challenge	Impact in scope?	Summary of capacity at Challenge level
Audience of the Future	Yes	Almost all participants agreed that the programme had supported the development of new skills among their staff and improve the internal capabilities. 'The programmes also developed technical skills, with over half of participants reporting increased skills in development with real time game engines (53%); creative art direction (57%) and writing for Immersive experiences (57%).' 'In terms of embedding knowledge and capacity, 78 educational/skills programmes and courses were developed or modified across participating UK higher education institutions as a result of SFA activity, which includes 50 courses developed through the Trainer the Trainer (TTT) project.' Freed from the requirement for team members to be physically present in Bristol, Fictioneers were able to hire from a much more geographically dispersed (and therefore larger) labour pool. People were recruited through LinkedIn and other platforms from other parts of the UK, from Sweden and even from South America; this meant they were able to source specialist skills more easily and cost effectively.

Medicines Manufacturing	Yes	'The ATMP Apprenticeship Programme exceeded its targets and has led to 118 apprentices commencing training.' Many participants emphasised that the project led to the development of new technical skills and knowledge directly related to the technology being developed, through upskilling existing employees as well as recruiting new employees with the needed skills. 'The capital investment competitions have made important contributions to growing UK capability for viral vector manufacturing and the digitalisation of medicines manufacturing processes.' 'Supporting the creation of new GMP manufacturing facilities in the UK with specialised manufacturing solutions (e.g. in bacteriophage products, oral formulations, antibody biologics). In turn this will build the UK capabilities and reputation as a leader in specialised manufacturing areas, create additional jobs and revenue for the UK.'
Data to Early Diagnosis and Precision Medicine	Yes	'Improved skills capacity and capability for genomic technologies has been achieved within industry but is expected to evolve further as researchers from other sectors begin to use the new data.' 'Digital skills are being improved through the use of new digital technologies deployed by the programme in NHS labs and amongst clinicians.' 'The Digital Pathology Tutor training platform continues to grow and by end of Q10 had 219 registered users (an increase of 57% during Q10).' 'The funding was seen as the catalyst for investing in new equipment.' 'Challenge funding (and the inferred government commitment to the UK Biobank as a national research resource) was key to the additionality of the activities, i.e. making the genomic sequencing work and infrastructure development possible.' 'Challenge funding has been enabler for fundamental infrastructure investment to improve data linkage and visibility/ discoverability, as well as being the impetus to encourage further investment to develop these projects.' 'Consultees stated that without the OLS programme there would not have been the funding for new scanners and digital equipment and therefore there would not have been the same level of collaboration around procurement.' 'The refurbishment and fitting out of the National Training Centre had been completed, though the new facilities had not been used due to COVID-19 social distancing measures.' In addition, 'two scanners had been installed at the Royal National Orthopaedic Hospital and one at the NPIC Centre in Leeds as planned with the majority of scanners expected to be installed from October 2021 to July 2022.'
Commercialising Quantum Technologies	Yes	The Challenge reports around 1400 skilled workforce for developing and commercialising QT.
Digital Security by Design	Yes	'Nine out of 11 interviewees connected with DSBD-funded projects felt that DSBD has led to new skills development and capacity to adopt new technology.' In terms of skills, 'the evidence from academic-led projects shows that there has been a small amount of direct improvement in the researcher skill base due to engagement of early career researchers, funding 2 PhDs, and leading training sessions.'
Next Generation Services	Yes	'We have found evidence of uptake of programme learning. Participants believe they have gained increased skills and capabilities as a result of participating in ISCF NGS grants, with participation leading to a better understanding of the challenges, issues and potential of AI/data, as well as a better awareness of challenges and issues across different sectors. In addition, all participants reported developing new or improving their technical skills through their NGS project, with significant contributions to other organisational skills including problem solving, project management, strategic thinking, and business planning'.

Manufacturing Smarter Innovation	Yes	N/A.
Robotics for a Safer World	Yes	Compared with a baseline of 84%, 94% participants felt that participation in the programme has led to improved skills and capabilities. The funding enabled collaborative R&D and establishment of demonstrator projects, in turn enabling companies to strengthen internal capacity, especially by strengthening their tech roadmaps and accessing state-of-the art facilities and expanding their existing networks. For example, 'securing ISCF funding enabled the co-founders of HyBird to work on the business full-time, as well as build a strong technical team to achieve key milestones and outputs that was essential to the success of the project and for future business development and growth.' Multiple international universities and some businesses have been involved, indicating international talent engaging or coming to the UK; this has not been clearly explained in the report.
Transforming Foundation Industries	Yes	Skills and training courses include the Women's Leadership Programme, which received applications from 95 individuals, with 40 successfully funded. '85% of CR&D 2 beneficiaries who responded to the inflight survey, stated that new skills will be attained by their team as a result of the project, ultimately addressing skills shortages.'
Prospering from the Energy Revolution	Yes	N/A.
Industrial Decarbonisation	Yes	N/A.
Transforming Construction	No	'The facility can create different scenarios, replicate conditions and standards of existing buildings, and create digital twins of buildings – so ideas can be quickly remodelled and refined in the lab and re-tested in real life.'
Transforming Food Production	Yes	'Strong and consistent evidence of progress in terms of improved R&D capabilities, knowledge and skills. skills/knowledge gained as a result of TFP has not only aided technology development and project progress but has also helped to de-risk longer-term internal investment in R&D and led to changes in business models. Commercial skills: through testing, demonstration, market engagement and partnership. Working, consultees reported they have also improved their understanding of the market and how to commercialise new products.'
Smart Sustainable Plastic Packaging	Yes	'Five new jobs have been created in the plastic packaging value chain and 96 people have been trained or upskilled stemming from SSPP-funded projects.'

Driving the Electric Revolution	Yes	'The Challenge has provided £6 million of funding for skills-related projects which have developed high quality training programmes, from vocational to postgraduate, with the aim of producing a more skilled workforce. Through partnering with the Midlands DER-IC site and relying on the University of Nottingham's extensive training experience, ECS is currently offering live training to much larger groups than it would have previously. DER activities to upskill industry professionals and to educate and inspire interns and school students through: The PEMD Skills Hub45 (total budget of £1 million); and the building talent for the future competition (total budget of £250,000). The DER-IC has received funding of £33 million from the Challenge. The bulk of this funding (£28.5 million) is dedicated to investing in new equipment, with the remaining funding covering staff costs, marketing, and other business activities. Access to equipment has encouraged SMEs to innovate and expand their activities and has enabled larger organisations to improve their manufacturing techniques with minimised risks and costs. In the 2020/21 financial year, an additional £3 million was allocated to the DER-IC as an opportunity had been identified to purchase additional equipment to fill an important gap in the supply chain. In terms of recruiting engineers or PhD physicists, nine of ten applicants were not based in the UK; unfamiliarity with visa application processes was cited as a limiting factor.'
Farraday Battery	Yes	'The FI also operates a PhD training programme which aims to help meet an estimated demand for 4,500 trained battery researchers in the UK to support battery manufacturing. In addition, funding for training programmes is provided to grow a talent pipeline for UK energy storage R&D. The emergence of R&D skill clusters in the UK is another sign of growth in the UK's research ecosystem. This stands to be of particular benefit to battery R&D in the aerospace sector, for which the technical demands are significantly higher than comparable automotive R&D. The case studies revealed that, in general, OEMs [Original Equipment Manufacturers] believed that the FI had substantially enhanced technological capabilities in the R&D space, and that CR&D projects had accelerated OEMs' understanding of future technologies. Several OEMs reported that they had integrated the FBC R&D programmes to bolster their own R&D capability. One vehicle OEM had its own internal facility for cell development and looked to the FBC to enhance its own capability. Another OEM operating in testing and recycling said that support for R&D would allow it to undertake a wider range of projects than it might otherwise not be able to.'
Future Flight	Yes	'From Development Phase project close-out data, 66% of respondents reported that they had developed new skills from their project, and the most frequently cited skills were technical skills/knowledge (53%), collaboration and planning, business planning and problem solving (all 27%). Other skills that projects mentioned were fundraising, leadership, project management and strategic thinking.'

Table 14. Summary of impacts on businesses and job creation at the Challenge level

Challenge	Impact in scope?	Summary of business and job creation impacts at Challenge level
Audience of the Future	Yes	There are fewer companies working in this sector compared to pre-pandemic, but in contrast there is a 29% increase in workforce and more retention of experience staff. Two Design Foundation participants reported creating a new spin-out companies, with a further four expecting to do so in the future. There are 6 instances of realised IP and 11 instances of IP reported to be realised in the near future.
Medicines Manufacturing	Yes	'Econometric analyses suggest that the DHTC led to an overall increase in employment across firms of three to four percent, equating to 320 to 530 jobs. Firms participating in the ATTCs attracted around £1.6bn in private investment since 2018, creating around 800 new R&D jobs.'
Data to Early Diagnosis and Precision Medicine	Yes	For NPIC CoE metrics measured to date (to July 21) reported 25 new jobs created (vs project target of 29).
Commercialising Quantum Technologies	Yes	'Start-up companies are leading. Two start-up companies have the most employees working on Quantum Technologies: Arqit 120 and Quantinuum (UK) 70 people.' The skilled workforce for developing and commercialising QT is around 1400. The creation or retention of jobs was achieved through the establishment of 2 companies and 1 in pipeline.
Digital Security by Design	Yes	'[As]s of 2022/23, 270 jobs have been created on the back of the several DSBD projects. This is greater than the entire programme's target of 100 new jobs.' 'Businesses have reported that 52 employees have been involved in DSBD, and 22.5 more positions are expected to be created to support further DSBD-related activities.' '11.5 new FTE [full-time equivalent] staff employed on the back of the DSBD programme.' There is limited but positive evidence of commercialisation supported by the Challenge.
Next Generation Services	Yes	'Participants in the CR&D projects reported increased employment due to their NGS project, indicating they had retained an average of 3 FTE and created a further 1.5 FTE (median).' There have been six spin-outs and there are more on the way.
Manufacturing Smarter Innovation	Yes	'14 organisations (78%) reported a total of 49 people had developed new skills (via formal or on-the-job training)', 'almost half of the businesses reported that employment had increased; in total, this amounted to 17 new jobs across the sample – more jobs were created within manufacturing firms than technology developers.'
Robotics for a Safer World	Yes	The 'average R&D employment on RAI in EE has increased by 5.1 FTEs, on average, among participants in the programme, up from 9.6 to 14.7.' 'In the long term it is estimated that the project will generate 35 new jobs 5 years post commercialisation. This estimate is based on the realisation of revenue estimates and the assumption that one job will be created per £200k in revenue.'
Transforming Foundation Industries	Yes	Employment by sector was reported through the '[c]reation of 41 FTE jobs within Glass Futures. Creation of 20 jobs via Transfire.'

Prospering from the Energy Revolution	Yes	More than 55% of firms have increased by at least 1 FTE.
Industrial Decarbonisation	Yes	There has been an overall increase in recruitment across the businesses and partners working on the Challenge, with some organisations reporting increases of up to 2% in FTEs. CSAC has increased the number of project managers, both at junior and senior levels (for more in-depth projects). The number of skilled semiconductor engineers has also increased – by a surprisingly high number given the strength of global competition for these skills.
Transforming Construction	No	Improvements are in processes for promoting spin-off projects. There was an example of a spin-off project to GenZero, which was a classroom prototype.
Transforming Food Production	Yes	There has been creation of highly skilled jobs, evidence of new job creation, and some retention, with roles becoming embedded.
Smart Sustainable Plastic Packaging	Yes	'The online survey with 24 successful projects has shown that to date: > 5 new jobs have been created in the plastic packaging value chain.'
Driving the Electric Revolution	Yes	One specific project reported a 50% staff increase as a result of the Challenge.
Farraday Battery	Yes	There has been a positive impact on jobs, but this impact is not quantified. Skills retention was a challenge, however, and there was a call for more efforts to be made here by the UK government as individuals were unlikely to remain upon completion of their study or contract. There have been 5 spin-outs.
Future Flight	Yes	There has been creation of new enterprises and spin-outs. There are more companies undertaking R&D in this sector compared with 5 years ago, but it is difficult to make direct attributions and assess impact on recruitment and retention.

Table 15. Summary of the EDI at the Challenge level

Challenge	Impact in scope?	Summary of Equity, Diversity and Inclusion (EDI) at Challenge level
Audience of the Future	No	'SFA also pledged that 50% of the people engaged through the programme would be female and at least 20% from BAME [Black, Asian minority ethnic] backgrounds. SFA consistently met these targets throughout the programme, reaching 52% female participants and 23% BAME participants.' 'The project was conceived as a national collection of UK immersive content – the first of its kind – showcasing 20 years of British works incorporating VR (virtual reality), AR (augmented reality) and XR (extended reality). This was then used as a tool to engage with the wider sector, with a particular view to engage more women aged 18–25 (due to their low presence in the industry workforce). The mentoring within the project focused exclusively on this age group, but also this demographic was strongly reflected in the branding of the Arcade and in the work that was chosen to include within it.'
Medicines Manufacturing	No	N/A.
Data to Early Diagnosis	No	'In general, EDI was not a significant consideration for the genomics strand projects, since they largely drew on pre-existing patient cohorts with limited scope to enhance EDI; partners acknowledged the limited diversity of datasets, especially UK Biobank itself. EDI was also not seen has being fundamentally embedded within the Challenge, although most corporate partners have their own EDI values and priorities.' 'Most respondents referred to the HDR UK Health Data Science Black Internship Programme as a positive EDI initiative.' 'PPIE (Patient and Public Involvement and Engagement) across the Centres of Excellence had built on routine processes, with some examples of specific additional activities. These had included ensuring lay representation on ethics committees and outreach to promote the use of digital pathology and radiology.'
Commercialising Quantum Technologies	No	N/A.
Digital Security by Design	No	N/A.
Next Generation Services	No	N/A.

Manufacturing Smarter Innovation	Yes	'The CR&D workstream is trying to encourage projects to think more about EDI issues without being prescriptive. EDI is being considered in the CR&D workstream in two ways: • a question about what the project proposed to do in relation to EDI was included in the most recent competition application form • where possible, the Challenge has tried to include more diverse groups on assessor panels, in interview groups, and on presentations; however, feedback suggests that this has been challenging at times because of the limited diversity found in the manufacturing sector.' 'Issues around Equality, Diversity and Inclusion (EDI) have been considered across all five of the Research Centres, although the extent to which actions have been delivered varies. While some Research Centres considered EDI as a delivery priority, others were less aware of the issues and only loosely understood EDI as an area they should work towards.' 'Actions taken by the Research Centres around EDI have included: • Appointing an 'EDI champion' and/or setting up an EDI committee • Ensuring representations from all career stages on all the research centre boards • Engaging in discussions with the social enterprise Inclusioneering to develop an EDI framework • Engaging with Transforming Foundation Industry's (another UKRI industrial challenge fund programme) Network+ around EDI issues and designing policies to complementary to theirs • Undertaking an EDI analysis of all research centre outputs'
Robotics for a Safer World	No	N/A.
Transforming Foundation Industries	Yes	EDI is recognised as a crucial component of the Challenge due to historical employment patterns and limited labour availability that have hindered diversity and skills development in the sector. EDI plays a vital role in the planning and execution of the TFI, with assessments integrated into project monitoring. It has become a central theme in sector strategy studies, events and research under WS4. Notable initiatives include: • A report from a March 2022 EDI workshop within Network+ that addressed various EDI issues in sub-sectors and provided recommendations • Establishment of an EDI working group within Transfire in June 2022 to develop an EDI best practices playbook tailored for the FI • Launch of a Women's Leadership Development programme in May 2022 to support 40 women in the FI sector in attaining senior and technical roles • An upcoming apprenticeship recruitment programme with an EDI focus, aiming to attract underrepresented groups

		Stakeholders have praised the Challenge's commitment to advancing EDI, noting its alignment with best practices. Feedback from businesses indicates an increasing consideration of EDI, partly due to existing policies and partly due to the influence of the TFI programme. While early impacts are positive, it is acknowledged that addressing deep-rooted issues will require sustained effort: 'You can't change the world overnight, but progress can be made towards better practices and awareness.' Key outputs include a workshop report on EDI in foundation industries, as well as academic papers and reports contributed to under WS3 and WS4. Thirteen respondents (33%) anticipate or have already experienced positive impacts on their EDI initiatives from the project.
Prospering from the Energy Revolution	No	N/A.
Industrial Decarbonisation	Yes	'In 2020, the majority of businesses within wider industry surveyed reported having measures in place to promote EDI. Mainly via focusing on talent/the best person for the role and positive discrimination.'
Transforming Construction	No	N/A.
Transforming Food Production	No	
Smart Sustainable Plastic Packaging	No	N/A.
Driving the Electric Revolution	Yes	'A second component of EDI – racial diversity – is increased by the practice of recruiting PEMD talent from abroad to meet the increasing demand for skills, which arises partly from the Challenge's work to grow the UK PEMD supply chain. While interviewees did not mention specific EDI targets, there was agreement that efforts had been made to embed ED&I into the Challenge's activities, particularly around CR&D and skills competitions. These included having courses designed with skills competition funding that could be accessed by disabled people and targeting individuals from disadvantaged backgrounds, encouraging a diversity of presenters at "Engage with" sessions and having ED&I questions at CR&D competition interviews.'
Farraday Battery	No	N/A.
Future Flight	Yes	'The FFC surveyed Development Phase projects about whether their technology or service would benefit protected classes. A couple of projects noted that automating tasks so that they were conducted by drone operators had potential diversity benefits for the end-user workforce. For example, one project noted that infrastructure inspection was traditionally manual work, which had historically been conducted by male inspectors and required physical strength. The project contributed to the objective of conducting inspections remotely, and the consortia member noted: "this will enable people [of older] age [or with a] disability to conduct the required tasks. We would also expect more female engineers/ inspectors to conduct such work". A free-to-users programme to provide mentorship to female participants in the Challenge was recently launched with the University of the West of England.'

E.3. Connected innovation ecosystem

Table 16. Summary of collaboration and partnership at the Challenge level

Challenge	Impact in scope?	Summary of collaboration and partnership at Challenge level
Audience of the Future	Yes	Collaboration in the Challenge has taken place through the Design Foundation projects, which have provided a valuable platform for participants to build new collaborations, particularly with micro-companies. These collaborative efforts have been supported through dissemination activities where potential partners could meet and through the Department of International Trade, whose promotion of immersive at events has been seen as a 'bridge for collaboration'. Across the interim and final stages of the evaluation for AOTF, the composition of the similarity of organisations not only in terms of their size, sectoral background and ownership structure, but also in terms of their structural organisation and working modalities, was a key factor in determining the successful collaboration. The Challenge developed new models for delivering training and facilitating collaboration, both online and using VR tools, which were particularly useful during pandemic restrictions. There is consensus that AOTF project enhanced collaboration. An example of a successful collaborative output in this Challenge is the Moving Image Demonstrator – a joint venture company in a collaborative partnership with Fictioneers and Aardman, who are providing the Wallace and Gromit IP and writing a new story for an immersive, cross-media adventure for the characters.
Medicines Manufacturing	Yes	Collaboration in this Challenge took place through a mix of existing and new collaborations, with CR&D grants playing a key role in enabling joint working with industry partners. The Challenge Director and the programme team have made significant efforts in increasing collaboration of national strategic significance, through the creation of the ATTC network. The programme has allowed for the further development of pre-existing partnerships. There are several examples of successful collaborative outputs in this Challenge imcluding two major R&D collaborations with large pharmaceutical firms (GSK and AstraZeneca) aiming to address key manufacturing challenges (the 'Grand Challenges' GC1 and GC2); 'data trial have been able to deliver updates to their Nucleus product ahead of schedule, and the collaboration in iMATCH has led several Aptus Clinical clients to choose Nucleus as their electronic trial master file (eTMF) solution'; and there have been projects involving collaborations with the Cell and Gene Therapy Catapult, which may enable spill-over benefits by making the capabilities developed available to other firms under licensing arrangements. 81 out of 135 organisations involved partnerships, with the majority of partnerships being between micro- or small firms, or academic partners.

Data to Early Diagnosis	Yes	Strong management and delivery teams were cited as a driver to collaboration, with the introduction of the Challenge Director playing a key role in driving collaborative activity. Hubs had initially established collaborations due to mutual interest and geographical proximity; however, the project increased partnerships and collaborations even among major industry players that are competitors, with platforms and pipelines for commercialisation, Challenge funding and data access and availability being instrumental factors. Challenge outputs include new cross-sector collaborations, new products and evidence to enhance existing tools or technologies, skills development, and increased investment in genomics and other omics research. An example of successful collaboration includes the commercial–healthcare research partnerships with INSIGHT and AstraZeneca. There were a reported 150 commercial and 170 academic contracts in place across the programme.
Commercialising Quantum Technologies	Yes	There were 90 new collaborations recorded.
Digital Security by Design	Yes	Collaboration mechanisms between business consisted of a combination of formal project collaboration mechanisms and informal opportunities with core delivery partners that were crucial the programme's success. Although these collaborations included a mix of various types of partners in all their workstreams, the collaborations did not give rise to consortia involving large and small companies. There were 19 software ecosystem development projects, only one of which met the criterion for collaboration between businesses of different scales.
Next Generation Services	Yes	The application process and community-building activities funded by the programme have fostered new collaborations, as have the continued national and international outreach activities. More generally, the NGS programme design, 'including the Challenge activities, governance and UKRI management, has facilitated the development of collaborations'. The NGS Challenge 'has fostered new engagement opportunities through participation in networking events and other activities', which may, in turn, lead to further collaborations in the future. Examples of these engagement opportunities include the 2019 Global Business Innovation Programme Singapore mission and the numerous AI for Services network in-person and online events. Collaborations have resulted in new partnerships, access to further funding, skills and knowledge acquisition and the development of new products. An example of a successful collaborative output is Genie AI having built working commercial relationships with Barclays and Withers and established long-term plans with many partners to carry on various activities. 'The AI for Services network had facilitated 495 introductions and 15 collaborations' since 2021. There have been an average of 2.9 new partnerships with customers or end users.
Manufacturing Smarter Innovation	Yes	Collaboration has occurred through flagship projects, including the Logistics Living Lab, which aims to explore and develop delivery resource collaboration to tackle the costly delivery. Collaboration has also occurred through Global Scoping Workshops that have brought together UK businesses and stakeholders in specific technology areas.

Robotics for a Safer World	Yes	The programme has facilitated collaboration between smaller and larger established companies, with 57% of the projects under the CR&D strands and 21% of those under the demonstrator strand displaying collaboration across different-sized organisations. However, challenges remain, as collaboration was cited as a key challenge in the development of the CARMA platform despite successful commercialisation. Output of collaborations between business include an increase in R&D employment in RAI – EE by 5.1 FTES and an increase in collaboration between younger, smaller companies and larger, more established companies, connecting up value chains. Flagship collaborative outputs are Total's ongoing JARVIS project and the HyBird project by ISCF RAI. The Hub comprises of 11 UK institution in collaboration with more than 30 partners from across a range of stakeholder groups across the value chain.
Transforming Foundation Industries	Yes	A collaborative mechanism used in this Challenge has been to involve industry in the programme design: 'a workstream focused on engaging the sub-sectors and bringing them together.' Progress has been made in the objective of accelerating innovation and new collaborations, with reported increases in opportunities to collaborate with other businesses and increased skills-acquisition opportunities across partnerships.
Prospering from the Energy Revolution	Yes	Collaboration for the PFER Challenge has been facilitated by engagement activities, including the collaborative work for demonstrators during the lifetime of their projects. Since 2019, there have been 64 reported outputs from the PFER consortium that have demonstrated successful models for scaling up SLES. A significant collaborative output has been the development of a due diligence framework, which is now being used to engage with potential investors for SLES projects.
Industrial Decarbonisation	Yes	'The IDRIC Challenge promoted collaboration between business by signalling government commitments to investment in decarbonisation, speeding up communication and decision-making processes and reducing technical, technological and commercial around decarbonisation.' 'This collaboration took place with stakeholders at all levels and comprised of a combination of new partnerships and the consolidation of pre-existing partnerships. However, progress on collaboration has been impacted by the BEIS Cluster Sequencing Competition and the need for greater cross-cluster collaboration has been acknowledged.' Collaboration between business supported by the IDC has resulted in ongoing collaboration between clusters, increased collaboration between larger companies and/or SMEs, strengthening of working relationships and optimising the response to new issues and opportunities. In 2020, 2 projects were engaging with smaller businesses and 1 had a project led by an SME.
Transforming Construction	Yes	Collaboration has been driven by wider factors within the construction industry and was spurred in part by COVID-19-accelerated access to digital tools. The TCN has been successful in promoting collaboration in some instances (e.g. Behind the Meter Billing and Trend Basin), but in others it has been suggested that the collaboration would have happened in some form without the involvement of the TCN (e.g. Aquila, Digital Accelerator and FASTtruss).

Transforming Food Production	Yes	Collaboration has occurred through prioritising industry–end-user engagement, providing dedicated funding for demonstration, dissemination and market engagement and creating a focus on collaborative R&D through providing access to partner expertise and networks. The results of this collaboration have been the strengthening of relationships between partners, with examples of ongoing R&D collaboration and/or plans to continue collaborating in future and strengthened relationship with potential customers/end users. An additional output has been increased company profile and reputational benefits for partners involved in TFP projects. An further output has been increased commercial benefits.
Smart Sustainable Plastic Packaging	Yes	Pre-existing relationships seems to be a significant determinant of collaborative success; however, more evidence needs to be collected to verify this finding. 'The Challenge is most likely to have impact against Plastics Pact targets where funds have been allocated to build fully operational plants or processing facilities in the SSPP Demonstrators Rounds 1 and 2 competitions.' 26 collaborations have been recorded in Rounds 1 and 2 competitions, with 4 collaborations initiated or enhanced between SMEs and large organisations.
Driving the Electric Revolution	Yes	The main mechanism for collaboration between business were the competitions that mandated collaborative research by winners and, in so doing, fostered immediate collaboration, with the intention of building on these relationships to ensure future follow-on collaboration. The outputs of collaboration between businesses include increased investment and co-investment associated with each competition. This investment has allowed smaller firms to demonstrate their capabilities and increase their confidence, subsequently resulting in further collaboration, including collaborations with larger companies. An example of this is Ricardo's collaboration with the Midlands DER-IC site, which gave them the confidence to continue working with other DER-IC centres, potentially exploring the manufacturing of an invertor with Newcastle in 2024.
Farraday Battery	Yes	As with other Challenges, collaboration is a prerequisite of FBC funding. The level of collaboration is heightened by more frequent and repeated interaction with the FBC funding processes. Collaborations have resulted in a reported increase in commercial opportunities as a result of reduced fragmentation and harnessing of spillovers, as envisaged by the Challenge. Close collaboration between the FBC and the APC has facilitated the further development of UK automotive-focused battery supply chain to support the transition to electrification. As of September 2020, CR&D reported the existence of 66 new collaborations.
Future Flight	Yes	'Challenge was structured in a way that facilitated collaboration between future flight sector organisations as well as across different sectors.' The Challenge additionally implemented activities that encourage collaboration between different stakeholders in the sector, including knowledge-exchange events, workshops and webinars, networking events, working groups, newsletters and cross-government forums. Collaboration has been responsible for bridging the communication gap between industry and the government, for driving the development of future flight technology clusters and for increasing the contribution of the sector to the UK economy. 'Collaboration was also expected to contribute to government policy and to the development of regulatory frameworks in the sector.'

Table 17. Summary of recognition and prestige at the Challenge level

Challenge	Impact in scope?	Summary of recognition and prestige at Challenge level
Audience of the Future	Yes	'In the baseline report, the UK's reputation in international markets was benchmarked via an analysis of the number of awards that UK creative immersive products or productions (or coproductions) have won at key events. In the approximately two and a half years between September 2019 and May 2022, 207 awards were made to creative immersive productions of which 20 (9.7%) were produced or co-produced by companies based in the UK. This compares with 13 (7.7%) of the 169 awards awarded between January 2017 and August 2019. Some of the UK companies and products that received international awards between September 2019 and May 2022 have been supported through the AOTF programme. These include: • CUTECIRCUIT's SoundShirt, which won Biggest Societal Impact at the US-based Auggie awards, was awarded AOTF funding through the Design Foundations competition. • Wallace & Gromit: The Big Fix Up, created by the Moving Image Demonstrator consortium, won Best in Augmented Reality Apps/Games and Best in the World (across all categories) at Australia-based Qld XR Festival 2021 Awards. • Wallace & Gromit: The Big Fix Up was also overall winner of the Digital category at the international Blooloop Innovation Awards 2021. • Another winner, Passion Animation, winner of the 'Animation: Immersive and mixed reality video – people's voice' category at the Webby Awards, has been supported by the StoryFutures Academy.' External stakeholders still see the UK's strength as being in content creation, although they characterise the global market as increasingly competitive. ISCF AOTF is viewed as unique in terms of government support for creative immersive tech. Stakeholders also expressed their view that the AOTF programme is relatively unique in terms of government support across the immersive industries internationally and that, given the level of global competition, it would be detrimental to UK's market position not to maintain the momentum gained through the programme through further support. 'UK's reputation in the Creative immersive Content sector was already high at the outset of the programme, and there is no evidence to suggest this has changed. There was consensus among external stakeholders (investors and industry representatives) interviewed for this research that the UK is internationally recognised for its content creation, specifically its ability to take new technologies and develop attractive content.'
Medicines Manufacturing	No	The 'hotelling' business model established by the Catapult through its Manufacturing Centre has been recognised internationally as a blueprint for similar commercial and government-sponsored facilities, and the ATTC network has attracted significant interest from international pharmaceutical and biotechnology firms.
Data to Early Diagnosis	No	The UK Biobank has aided the UK's reputation internationally and was viewed as a flagship project globally and regarded as the gold standard for population genetics research.

Commercialising Quantum Technologies	No	N/A.
Digital Security by Design	Yes	'The UK generally scores well in international rankings of cybersecurity performance: for example, in the 2020 Global Cybersecurity Index18 the UK ranks joint second behind the USA. As the programme matures, it can begin to have an impact on the UK's reputation. The delivery team have investigated international markets through government-led missions to key countries: The US have a long-standing relationship with the Cambridge University team that developed CHERI [Capability Hardware Enhanced RISC Instructions] (which has had support from DARPA [Defense Advanced Research Projects Agency] since 2010) and the US is a significant target market. Missions have also been to India, Japan, and Australia. The relationship with Australia is significant because of the Five Eyes global security partnership and AUKUS [Australia-UK-US] trilateral security pact; some Morello boards have been delivered to Australia and have the potential to be used in the supply chain for Five Eyes security initiatives. Interviews with stakeholders suggest that the UK is well-regarded with respect to: its cyber strategies; its publicly funded programmes and the published evaluations and surveys which accompany these; its approach to regulation and codes of practice; and its research and development. What is less clear is whether this translates into support for innovation and creating commercial success. There is a risk that, since the global players in IT are multinational, research and development that is funded by the UK ultimately becomes a source of revenue for a small number of overseas companies that dominate the market.'
Next Generation Services	No	National recognition has been received by NGS-funded law firms which won awards such as the 2016 Legal Technology Team of the Year at the Legal Business Awards, the Legal 500 UK Firm of the Year for insurance (regional) and transport (travel), and the 2017 the UK Law Firm of the Year Award at British Legal.
Manufacturing Smarter Innovation	No	N/A.
Robotics for a Safer World	No	N/A.
Transforming Foundation Industries	Yes	'The early evidence suggests that programme activities have led to key outputs and some early outcomes as set in the TFI logic model. For example, there has been an increased willingness (and actual) collaboration and innovation among FI companies – and between FI companies and academia. Crucially, there is now a perception amongst all consultee groups that there is a more recognised/established shared FI identity because of TFI.'
Prospering from the Energy Revolution	No	EnergyREV papers have been cited by international organisations, such as the Stockholm Environment Institute.
Industrial Decarbonisation	Yes	'Net Zero Humber has been showcased by the World Economic Forum as part of their international cluster initiative and the Humber region has received the attention of USA International Trade officials, who visited the region.'
Transforming Construction	No	N/A.

Transforming Food Production	No	'The qualitative evidence points to a number of other benefits arising from TFP at a project level: Increased company profile and reputational benefits: association with project partners (notably those who are "sector champions" and well respected in the sector) and the credibility of having UKRI funding was reported to have helped to raise the profile of 28 Transforming Food Production firms involved. There have also been reputational benefits for project partners – for example, one consultee said that taking part in the development of a leading technology has helped them become the "go-to" for stakeholders wanting to keep abreast of progress in that area.'
Smart Sustainable Plastic Packaging	Yes	The British Plastics Federation has gained national recognition by being tasked with developing online courses on designing and manufacturing sustainable plastic packaging products.
Driving the Electric Revolution	Yes	'The Midlands DER-IC site has facilitated a greater interaction between industry and universities within the PEMD sector. Due to the Midlands DER-IC site's network and reputation, one SME interviewed stated that firms were more likely to approach academic institutions when they were part of the DER-IC. Most stakeholders do not see the UK as the world leader in terms of innovation in PEMD technology, but businesses are expecting more focus on PEMD compared to the baseline results. The Challenge aimed to promote the UK as a centre of innovation and excellence in PEMD manufacturing processes. In order to gauge stakeholders' perceptions of the UK's current position, survey respondents were asked whether they considered the UK to be a leader or ahead of most countries in terms of being a centre for innovation in PEMD technology. The evidence from the survey shows that 29% of survey respondents considered the UK to be the world leader and the majority of stakeholders (58%) considered the UK to be ahead of most countries but behind the world leaders (Figure 34). Compared to the baseline results, there was a decrease of 24 percentage points in those that considered the UK to be the world leader (29% cf. 53%), and this decrease was accompanied by an increase in those who believed that the UK was ahead of most countries but behind the world leaders (58% cf. 40%).'
Farraday Battery	Yes	The FBC is playing a burgeoning role in influencing government policy and collaboration, although more still needs to significantly impact the agenda. 'The responses suggest that the UK is doing well in what have long been recognised as its traditional areas of strength (notably, the quality of its academic institutions) but that weaknesses at the more applied, closer to market end are still current.'
Future Flight	Yes	N/A.

E.4. Economic impact

Table 18. Summary of economic impact at the Challenge level

Challenge	Economic Impact	Summary of economic impact at Challenge level
Audience of the Future	Yes	**Economic impact:** The AOTF Challenge has positively impacted turnover for participating organisations, generating new avenues for revenue through development of new products, services or customers, with 'almost half of participants reported that they had already generated revenue from new product/services 46% or customers'. 'Programme participants had gained a larger absolute increase in the median turnover than unsuccessful applicants (£128,000 vs £20,000)', particularly for immersive content or technologies. In addition, 'the average percentage increase in turnover was also much higher for participants (175%) compared to unsuccessful applicants (75%).' The Challenge has contributed to increased revenue from exports of new products and services. At the time of the final Challenge-level evaluation, the average value of exports had increased from £145,000 at baseline to £304,000 for participants (although there is an outlier of £3m), while for unsuccessful applicants the average increased had been less (from £21,000 to £76,000). The Challenge is also contributing to market positioning, with 58% of survey respondents stating that the project was contributing to protecting the current market position, 32% to expanding their market position in the UK, and 21% to expanding the market outside the UK. 'Only 5% of participants did not expect their AOTF to have an impact on their capacity to expand their market position in the UK.' The UK has increased investment in immersive creative content following the AOTF programme, from US$121m at baseline to US$183m at programme completion. However, the EU has increased investment further, from US$75.6m at baseline to US$269m at final stage. There is evidence that the Challenge has contributed to opening new markers for participants. For example, one company has secured a contract to deliver the PlayStation Gran Turismo World Championships for Japanese games company Polyphony, bringing this work to the UK for the first time. **New products/services:** The AOTF Challenge has led to the development of new products and/or services. At the end of the programme, 79% of participants had developed at least one new creative immersive product, and 56% has developed at least one new creative immersive service. In addition, 40% of participants had improved an existing service. Products and services have reached worldwide audiences, with reports of 16,000-68,000 users engaged from across the globe for two different products.

		GVA, productivity and geographic distribution: The Challenge has positively impacted productivity for participating businesses as the Challenge has progressed. The Challenge led to an absolute increase in productivity for participants, of more than double that of unsuccessful applicants (£25,000 vs £10,000). The median value of GVA at programme completion had increased from £36,000 to £100,000 for participants (£32,630 to £75,300 at interim stage), while unsuccessful applicants reported a smaller absolute increase, from £25,000 to £35,000 (£37,650 to £41,666 at interim stage). This translates into an average percentage increase in GVA of 183% for participants and of 52% for unsuccessful applicants at the end of the programme.
Medicines Manufacturing	Yes	**Economic impact:** Participation in the Medicines Manufacturing Challenges led to increased annual turnover, equating to approximately £74m per annum across all firms supported by the Challenge. At an interim stage, the average annual turnover of firms increased from £0.5m to £1m, equating to £79m per annum if aggregated over the 128 firms supported. This was slightly lower at a final evaluation stage, with average annual turnover of firms increasing from £430,000 to £980,000, equating to £74m per annum if aggregated over the 136 firms supported. The impact of the Challenge on export volumes is unclear due to the effect of the COVID-19 pandemic. It is likely that the Challenge has increased manufacturing capacity and solutions that could be exported. However, much of the manufacturing capacity created by the Challenge was absorbed by production of COVID-19 vaccines, which were mainly directed at meeting domestic needs. There is some evidence that the programme has strengthened the UK's unique capabilities in the development of advanced medicines manufacturing technologies. The Challenge-level evaluation found that the programme had strengthened the skills base in manufacturing and clinical administration of ATMPs and had supported investments in production capacity as well. However, there was a lack of quantitative evidence to support this statement. There is no information on new markets and other areas of economic impact. **GVA and new products/services:** There is little evidence to assess the impact on GVA of the Challenge, with a single statement available on estimated economic impact of one campus, of £34m in net GVA. The Medicines Manufacturing Challenge has led to the development of new products and services, which have already been adopted to varying degrees. The final Challenge-level evaluation found that 3/5 products created through the Challenge already had wide-scale adoption and the remaining 2/5 had small-scale adoption. Three projects had led to production that are now on the market or manufacturing processes that are being implemented, creating revenue for the companies. In addition, 12 technologies had already been adopted in an NHS context, and a further seven firms had been able to exploit their technologies overseas. At an interim stage, one firm had their technology adopted in 60-70 sites in the UK and more than 100 sites overseas, and another firm was under contract to deploy its technology in 16 sites, including two in the United States. **Productivity and geographic distribution:** N/A.

Data to Early Diagnosis	Yes	**Economic impact:** There is insufficient evidence to assess the economic impact of the Data to Early Diagnosis Challenge. While the interim report stages that the project has 'already increased the UK's profile and reputation for whole genome sequencing, expected to deliver better and more targeted medicines over the next 10 years', the statement does not have strong evidence to support this claim. **GVA and new products/services:** The Data to Early Diagnosis Challenge has led to the development of new products and services. At an interim stage, the Challenge had already development four AI tools and a further 28 were in development. Projects had built new technologies and tools, including a new portal for data storage and analytics, or generated evidence to validate or enhance existing technologies. **Productivity and geographic distribution:** N/A.
Commercialising Quantum Technologies	Yes	**Economic impact:** There is strong evidence that the commercialising QT Challenge has led to increased revenue. However, it is important to acknowledge that the Challenge-level evaluation did not include a counterfactual to allow full interpretation of the data. The value of revenue generated by UK QT organisations increased year-on-year by £63.25m (from £31m to £94.25m), with an increased revenue of QT products/services by UK QT organisations of £57m (from £31m to £88m). 'Most revenues are derived from selling products and services enabling quantum technologies (approx. £47M), followed by sales of quantum systems (£ 8M), quantum components (£ 2.5M) and revenues from using quantum systems (£0.1M).' There is some evidence that the Challenge is contributing to increased exports, with the Challenge-level evaluation stating that several companies are exporting their products. There is no supporting evidence in the Challenge-level evaluation to accurately assess the achieved impact. According to Challenge participants, the Quantum Programme has enabled companies to move their technologies and products forward, creating a UK supply chain and working with future customers. There is some evidence that the sector is maturing, although the UK needs to continue investing in and building international relationships to keep its market share in an increasingly global market. There was no information on new markets and other evidence of economic impact. **GVA and new products/services:** There was no information on GVA. The Challenge has led to the creation of new products and services. At the moment of the Challenge-level evaluation, 27 new products and services had been launched across 16 companies, reaching 150 new customers. **Productivity and geographic distribution:** There was information on productivity changes or geographic distribution.
Digital Security by Design	Yes	**Economic impact:** The opportunity for market entry of DSBD technologies comes from adoption of the technology by the major operating systems rather than from creating a new market. It is expected that adoption of these technologies by any two of the three major operating systems would lead to 60% market share. However, this is an expected impact rather than achieved. **GVA and new products/services:** The DSBD programme is expected to have create 11.5 new FTE, equivalent to £1m GVA. However, this is expected impact rather than achieved. **Productivity and geographic distribution:** It is perceived that there is a productivity advantage in adoption of DSBD technologies, mainly by reducing working days lost to cyberattacks. However, the actual impact on productivity is yet to be determined.

Next Generation Services	Yes	**Economic impact:** Participation in the NGS Challenge has had a significant positive impact on annual turnover. The average value of annual turnover for participants increased £47m between baseline (£69m) and the end of the programme (£116m). While the average annual turnover for unsuccessful participants also increased from baseline to the end of the programme, this increase was significantly less, at £15m. As other uses for new services are brought to market, revenues are likely to continue to grow, which will also impact business valuation. It is expected that 'the total commercial benefits accrued over the next six years will be £719m in total across the 44 companies who have provided subjective views on the future commercial potential of their innovations'. While there is the expectation that the NGS Challenge will positively impact exports, there is no evidence that this has been achieved. While most participants (70%) claimed their projects had increased the likelihood of exporting goods or services, there was no evidence on actual exports. The vast majority of Challenge participants (83%) expected their projects to expand their position outside the UK as well as maintain their market position in the UK (77%). The Next Generation Services Challenge has supported companies in exploring new markets in terms of geography and sector, with 58% of participants stating that the project had greatly increased their commercial opportunities. At an interim stage, one company was exploring opportunities to expand their technology to Africa, while another company was focused on the UK but with a view of expanding to the United States in the near future and other countries in the farther future. The final report does not provide evidence of whether this was achieved, although one company has reported working with the United States. Similarly, new sectors had been opened for Challenge participants at an interim stage, with one company working with the police force and another acknowledging the use of their new solution for internal training and knowledge management. **GVA and new products/services:** The Next Generation Services Challenges has led to the development and adoption of new or improved products or services. At an interim stage, the programme had already supported the development of new products and solutions for 53% of participants, and at least one product was scaling up in the United States. At the stage of final evaluation, 31-43% of participants' products and services had adopted AI solutions, implying improved products and services. **Productivity and geographic distribution:** N/A.
Manufacturing Smarter Innovation	Yes	**Economic impact:** There is limited evidence to suggest that MSI has led to increased revenues. While SMEs involved with the programme reported improvements in business performance, the Challenge-level evaluation only provides details for a single company. **GVA and new products/services:** N/A. **Productivity and geographic distribution:** N/A.
Robotics for a Safer World	Yes	**Economic impact:** The Robotics for a Safer World Challenge has led to increased revenue of participating companies. Successful applicants had seen a slight increase in their mean turnover, of £0.2m (including grant income), while unsuccessful applicants had seen a considerable decrease, of £0.6m. 'Initial estimates for one consortium forecast revenue and gross profit of £7.9 m and £4.3m respectively five years post-commercialisation, representing a 1% global market share'. Another company was expected to 'introduce a product within a year and processes and services within three years, generating an anticipated £5m in sales revenue and £250,000 in cost reduction per year'.

		There is evidence to suggest that end-user businesses are also able to exploit results from the Challenge, with turnover of non-applicant business associated with the Challenge increasing significantly, from £2.6m to £12.8m. There is little evidence to support that the Challenge has positively impacted exports to date, with increases seen for both successful (12%–23%) and unsuccessful (22%) projects. **GVA and new products/services:** It is expected that the Challenge will have a positive impact on GVA, although to date this has not yet been achieved. RADBLAB 'Initial estimates forecast consortium revenue and gross profit of £7.9m and £4.3m respectively 5 years post-commercialisation from the sale of 16 units (at £440k per robot, excluding commissioning costs and renewable software license), representing a 1% global market share.' The Challenge has supported development of new products and services. One project managed to progress their technology from TRL1 to TRL9, with many developments resulting in securing new IP. The company now has one product on the market (Shield XS), which provides end users with a safer, faster and cheaper solution to inspecting confined, extreme and challenging spaces. Another company was expected to introduce a product within 1 year and processes and services within 3 years, generating an anticipated £5m in sales revenue and £250,000 in cost reduction per year. **Productivity and geographic distribution:** It is anticipated that the Challenge will have wider economic impacts on the sector, including contributions to cost savings, productivity and increase global competitiveness. However, these have not yet been achieved and it may be a long time before they are.
Transforming Foundation Industries	Yes	**Economic impact:** N/A. **GVA and new products/services:** While it is too early to assess the economic impact of the Transforming Foundation Industries Challenge, there is evidence that the Challenge has led to the production of commercially viable products, such as Concretene. **Productivity and geographic distribution:** N/A.
Prospering from the Energy Revolution	Yes	**Economic impact:** N/A. **GVA and new products/services:** While the Challenge is still at an early stage, there is evidence that new products and services have been developed and commercialised. One project (Icebreaker One) has led to the creation and implementation of an open energy data architecture and platform that has created momentum across the energy sector and government, attracting key players in the energy supply chain to the initiative. Three projects from the CR&D portfolio have already been commercialised, including a battery optimisation solution, a wireless household metering solution, and a technology that maximises grid services from electric vehicles. In addition, a contract is being agreed with Oxford Council and charge point operators to implement a battery storage solution developed through a Challenge project. **Productivity and geographic distribution:** N/A.

Industrial Decarbonisation	Yes	**Economic impact:** There is little evidence to support the impact that the Challenge has had on turnover, with a single company providing data on increase in their turnover for two financial years. There is little evidence to support the impact that the Challenge has had on exports and global markets, with few companies reporting on turnover and the proportion of turnover attributable to exports. **GVA and new products/services:** N/A. **Productivity and geographic distribution:** N/A.
Transforming Construction	Yes	**Economic impact:** There impact of the Transforming Construction Challenge on annual revenue is unclear, with different values provided in the Challenge-level evaluation. 'One figure states that while 50% of participants stated that their revenue had gotten significantly better or slightly better following engagement with the TCN, compared with 22% of unsuccessful applicants, 41% of successful applicants reported their annual revenue had stayed the same and a further 9% that their revenue had decreased. A second statement mentions 49% of participants reported no change in their annual revenue since engagement with TCN, 32% reported increase in annual revenue, 16% reported significantly better annual revenue, and 6% less revenue. A third statement says that overall, 43% of businesses reported that TCN had a positive impact on annual revenue, including 15% that reported a large positive impact. 45% reported that the TCN had no impact on their annual revenue. Lastly, 76% of successful applicants in the TCN reported a positive impact on their annual revenue and 19% of unsuccessful applicants reported that the TCN had positively impacted their annual revenue.' There is some evidence of an increase in the value of exports of construction products and services following the introduction of the TCN, although this is not the case for all areas of construction. While the ONS Pink Book data shows that construction service exports grew at a compound annual growth rate (CAGR) of 14% from 2018 to 2020, compared with CAGR rate of 9% from 2012 to 2018, this does not apply to exports of pre-manufactured buildings, where an increase has been seen since 2018. The Challenge-level evaluation identified that 'there are activities within the TCN that have driven new policy in other countries to adopt TCN concepts in order to create new markets for UK firms.' While the influence of TCN on improving productivity is not fully evidenced, findings from the Challenge-level evaluation show a positive impact. For example, '51% of survey respondents already using at least one TCN concept reported a large positive impact on their organisation's productivity and 71% reported a positive impact in speed of delivery. In addition, 47% of respondents actively considering using at least one TCN concept expect the use of TCN concepts to have a large positive impact on their organisation's productivity, and 35% expect a small positive impact.'

		The TCN is committed to increasing productivity and has surpassed its target of influencing a total of £10bn of projects to achieve productivity improvements of around 13.5%. As of 2021, internal TCN data shows that 'the funding target has been surpassed, with a cumulative committed project value of £ 29.3 billion.' It is expected that changes to productivity from incorporating TCN concepts will be realised in the next 5-10 years. **GVA and new products/services:** There is some evidence that the TCN has had a positive impact on productivity. 'From 2018 onwards, construction-related activities have tended to have a higher annual growth rate compared with UK-wide productivity (ONS Labour Productivity). Annual gross value added (GVA) per worker across sub sectors of construction has been relatively constant and in line with the UK non-financial business economy average, with the exception of construction of buildings where we see a light increase relative to the benchmark groups. (ONS ABS data). A slightly accelerating trend in the CAGR of mean GVA per employee after 2018 (CAGR of 2.6% from 2012–2017 and 2.9% from 2017–2020) has been reported. (Glenigan data on annual self-reported median value added per full-time equivalent employed). In addition, from 2017–2019, GVA per worker has increased for firms with over 250 employees (the Association for Consultancy and Engineering). GVA per worker of large UK engineering consulting firms has increased following TCN's start. From 2017–2019, net revenue per fee earner increased by 5.8% and 12.7% for "large" and "largest" firms, respectively. From 2017–2019, net revenue as a proportion of staff costs increased by 0.4% and 1.8% for "large" and "largest" firms.' The Challenge-level evaluation found that CIH funding was used to set up and run the programme, and two construction companies were already in the first cohort. **Productivity and geographic distribution:** 'The TCN is operating in an environment of modestly increasing productivity in the sector.' There is evidence of higher annual growth rates in construction-related activities compared with UK-wide productivity, with all construction-related activities growing faster than the entire economy over 2018–2021, and the best performance being seen for civil engineering and manufacture of RPNM.
Transforming Food Production	Yes	**Economic impact:** N/A. **GVA and new products/services:** There is some evidence that the Transforming Food Production Challenge has supported new products in reaching the market at various scales. 'One product is being sold in the UK to a small number of farmers, while another product has reached the European market, landing its first commercial sale with a European client and receiving around 20 expressions of interest from other potential clients following a "soft launch" in the UK.' **Productivity and geographic distribution:** Increasing productivity in the sector precedes establishment of the Transforming Food Production Challenge, in 2017, with a rise in productivity of approximately 9% between 2012 and 2021. There is no evidence to suggest that the TFP Challenge has increased productivity beyond the upward trend the sector has experienced.
Smart Sustainable Plastic Packaging	Yes	**Economic impact:** There is some evidence to indicate that the Challenge has led to increased revenues, with additional revenue generated for more than half (9/14) of completed projects, a part of which is from exports of new products and services. While projects had long-term plans for overseas products, processes or services, and while initial plans are taking shape, there is currently no evidence of achieved impact related to exports. Plans included two overseas spin-outs, three overseas licensing agreements, and contracting overseas manufacturers.

		Initial evidence suggests that there has been additional revenue generated for 6/14 completed projects as a result of exports, although a further assessment of export sales from projects funded by the Challenge should be made at a later stage. **GVA and new products/services:** There is currently insufficient evidence to determine the impact of the Challenge in terms of new products and services to date. However, the expected impacts of the Challenge are considerable, including increasing the UK's capacity to process plastic packaging, reducing environmental impacts of plastic packaging, and encouraging clean growth. Demonstrator projects alone are set to increase the UK's recycling capacity for plastic packaging by at least 144,000 tonnes per annum and should be realised within the lifetime of the UK Plastics Pact. This is of course dependent on the development of commercially affordable technologies that can be scaled up and rolled out. The technologies themselves could lead to further products and services, generating higher-value recyclable materials that can be included in plastics design and manufacturing. **Productivity and geographic distribution:** N/A.
Driving the Electric Revolution	Yes	**Economic impact:** The direct impact of the Challenge on turnover cannot be assessed with available evidence at the Challenge-level evaluation. However, a consortium representative stated that they had seen 25% revenue growth in 2021 and were expecting a further 50% increase in 2022, which was attributed to a favourable ecosystem, including the Challenge. While there is the expectation that the Challenge will have a positive impact on sectoral growth (81% of survey respondents), with 93% of survey respondents expecting the sector to grow, there is currently no evidence of achieved impact. There is early evidence that the Challenge supports expansion into new markets. For example, technologies used traditionally in aerospace are being considered for use in the automotive industry. In addition, combination products, such as compound semiconductors, can provide a single, enhanced solution to two different markets, increasing their market share in both. **GVA and new products/services:** N/A. **Productivity and geographic distribution:** There is currently insufficient evidence to support claims on productivity from the Challenge, as the projects have not yet had sufficient time to impact productivity. While there is the expectation that the Challenge projects will lead to productivity and skills benefits in the future, this cannot be confirmed at this stage. However, one project (Midlands DER-IC site) has enhanced the UK's manufacturing productivity by providing equipment to test products and purposes at a low risk and cost.

Farraday Battery	Yes	**Economic impact:** There is some evidence to suggest that FBC has led to increased sales revenues and financial gains across projects, of £120 annually. However, the source, quality and strength of that evidence cannot be determined from the Challenge-level evaluation report. The FBC is likely to improve the UK ecosystem for battery production in the long term, increasing financial support for battery development and investment in R&D in battery technologies. However, the speed at which this is being achieved is considered slow, with capacity issues remaining. **GVA and new products/services:** N/A. **Productivity and geographic distribution:** There is some evidence to suggest that the FBC has had a systematic effect on the conduct of R&D, which is likely to result in productivity-enhancing spillovers. However, the source, quality and strength of that evidence cannot be determined from the Challenge-level evaluation report.
Future Flight	Yes	N/A.

E.5. Wider societal impact

Table 19. Summary of health impact at the Challenge level

Challenge	Impact in scope?	Summary of health impact at Challenge level
Audience of the Future	No	N/A.
Medicines Manufacturing	Yes	Only one code to evidence in relation to health and wellbeing, related to the Medicines Manufacturing Challenge's impact in advancing the UK's strengths in ATMP development. The evaluation either does not have the intention to impact health and wellbeing, or no evidence is yet available in the interim impact report.
Data to Early Diagnosis	No	Improvements have been made to new and existing infrastructure, for example, the National Training Centre has been completed and new high-tech equipment has been installed at the Royal National Orthopaedic Hospital and NPIC Centre in Leeds. Additionally, 'the launch of the AI Deployment Engine (AIDE) at the NHS site in Kings College Hospital is being used in patient care'. The Challenge has also shown significant progress in building the Federated Learning Platform (known as FLIP), which helps link data from multiple NHS Trusts to enable AI at scale. The Challenge impacted the bringing together of large networks of NHS Trusts and provided the infrastructure to accelerate the digitise pathology labs and maximise the potential of AI in medical imaging.
Commercialising Quantum Technologies	No	N/A.
Digital Security by Design	No	N/A.
Next Generation Services	No	N/A.
Manufacturing Smarter Innovation	No	N/A.
Robotics for a Safer World	No	N/A.

Transforming Foundation Industries	No	N/A.
Prospering from the Energy Revolution	No	N/A.
Industrial Decarbonisation	No	N/A.
Transforming Construction	No	N/A.
Transforming Food Production	No	N/A.
Smart Sustainable Plastic Packaging	No	N/A.
Driving the Electric Revolution	No	N/A.
Farraday Battery	No	N/A.
Future Flight	No	N/A.

Table 20. Summary of environmental impact at the Challenge level

Challenge	Impact in scope?	Summary of environmental impact at Challenge level
Audience of the Future	No	N/A.
Medicines Manufacturing	No	N/A.
Data to Early Diagnosis	No	N/A.
Commercialising Quantum Technologies	No	N/A.

Digital Security by Design	No	There is one example of reduction in power consumption and CO_2 emissions, showing improvement in process optimisation and delivery of energy efficiency.
Next Generation Services	No	N/A.
Manufacturing Smarter Innovation	Yes	N/A.
Robotics for a Safer World	No	Evidence shows the benefit of this Challenge to the offshore wind sector in making positive contributions to the reduction of carbon emissions. Within the RAI logic model, longer-term societal impacts include making a contribution to cleaner energy (this is yet to be fully realised, but the contribution to offshore wind is a positive step).
Transforming Foundation Industries	Yes	N/A.
Prospering from the Energy Revolution	Yes	N/A.
Industrial Decarbonisation	Yes	N/A.
Transforming Construction	Yes	Internal TCN data and the TCN evaluation suggest that 'there is a clear optimism about the role of TCN concepts improving the environmental performance of built assets. TCN has surpassed its target of £3bn towards projects that reduce greenhouse gas emissions – as of 2021 the committed project value was £22.8 billion'. 'Activities within TCN have the potential to improve environmental performance of built assets through the integration of TCN concepts. 'For example, the Active Office programme sought to build a prototype building using cutting-edge off-site manufacturing techniques and incorporating innovative technologies that generate, store and release solar energy. The Optimised Retrofit Programme has successfully measured the impact of retrofitting on the environmental performance of affordable housing. In the TCN evaluation, more than 70% of survey respondents reported a positive impact from adopting TCN concepts on CO_2 emissions, energy consumption and waste produced on site.' However, the evidence does not suggest that the TCN is currently having a significant impact on the environmental performance of built assets across the sector.
Transforming Food Production	Yes	N/A.

Smart Sustainable Plastic Packaging	Yes	'The SSPP Challenge and Challenge funding has sent a strong signal to the market that the sustainability of plastic packaging for consumer products is an important societal issue to be addressed. The Challenge aligns and supports a number of existing priorities and commitments: • The SSPP Challenge team took a conscious and deliberate decision to align the Challenge objectives to Plastics Pact targets – these were developed collaboratively with businesses, UK government and non-governmental organisations. • Alignment with UK Plastics Pact ensures similar alignment with Pacts in Europe and India. • SSPP and funded projects recognise importance of re-use, recycling, removal of problematic plastics and development of new bio-polymers and plastics replacement.'
Driving the Electric Revolution	Yes	'Environmental impacts are not a leading indicator. Therefore, it is unsurprising that case studies for the interim impact evaluation could not yet find evidence for the Challenge's impact on environmental policy and sustainability. The lack of this evidence should therefore not be seen as an early warning sign.' There is a lack of evidence for impacts towards environmental policy at the interim stage of the Challenge. Further analysis of this impact (or lack of impact), conducted through a thematic case study, highlights several reasons for this: • 'There is a view that government policies for semiconductor tech are few and fragmented. • Coordination across government is poor between departments. • There is no clear framework or strategy from the UK government – increases uncertainty of UK investors. • There are other examples of the report highlighting the reasons for a lack of policy impact: • Challenge needs to focus on the PEMD supply chain so those outside the sector take note. • The Challenge focuses on influencing policy in too many departments in the UK government – spread across too many areas with a modest investment – barely scratches the surface of issues and cant [sic] impact environmental policy and standards more broadly.'
Farraday Battery	Yes	Increasing interest in eV sector as part of 'green' recovery strategy. The Challenge has strengthened the battery technology policy landscape through research and outreach activities. 'This is reflected in progress across all four clusters of metrics identified for this evaluation theme: (1) cross-government policy frameworks for attracting Gigafactories; (2) the policy community's understanding of value chains; (3) investor interest; and (4) public understanding and acceptance of battery technology and value chains.'
Future Flight	Yes	Future flight has driven the move towards delivering economic and social benefits.

Table 21. Summary of infrastructure and services impact at the Challenge level

Challenge	Impact in scope?	Summary of infrastructure and services impact at Challenge level
Audience of the Future	Yes	Improvements made to VR headsets to improve the ergonomics, e.g. Quest 2. According to the AOTF evaluation, out of the 48 participants surveyed, 71% reported the development of new working processes, while 50% reported the improvement of existing working processes in relation to creative immersive content. Additionally, the respondents indicated that their AOTF project had resulted in the development of new methods for 60% of them and improved methods for 52% of them. Some UK companies and products have received international awards and have been supported through the AOTF programme, including CUTECIRCUIT's SoundShirt, which received AOTF funding through the Design Foundations competition.
Medicines Manufacturing	Yes	The Challenge showcases examples of increasing knowledge sharing among businesses, supply chains, academia and the NHS – opening up more opportunities to create a more varied service. There are also examples of collaborations with large pharma firms, CDMOs, therapy developers and the NHS. These collaborations have enabled network creations. The programme has facilitated collaborations among large pharmaceutical firms, CDMOs, therapy developers, and the NHS, resulting in increased knowledge sharing across these sectors. The creation of the ATTC network and the efforts of the challenge director and the programme team have enabled collaborations with national strategic significance. All of these collaborations and knowledge-sharing examples have improved infrastructure and services within MM (e.g. enabling 'rapid coordination of supply chains for early trials of the Oxford and Imperial COVID-19 vaccines' and has providing testing grounds for the development of standards and products in the ATMP supply chain). The programme has had particularly strong effects in advancing the UK's strengths in ATMP development through skills-based development.
Data to Early Diagnosis	No	Improvements have been made to new and existing infrastructure – for example, the National Training Centre has been completed and new high-tech equipment has been installed at the Royal National Orthopaedic Hospital and NPIC Centre in Leeds. Additionally, the launch of the AIDE at the NHS site in Kings College Hospital is being used in patient care. The Challenge has also shown significant progress in building the FLIP, which helps link data from multiple NHS Trusts to enable AI at scale. The Challenge impacted the bringing together of large networks of NHS Trusts and provided the infrastructure to accelerate the digitise pathology labs and maximise the potential of AI in medical imaging.
Commercialising Quantum Technologies	No	N/A.

Digital Security by Design	Yes	Increased awareness and changing attitudes to DSBD have facilitated the development of new skills and tools in R&D to increase capacity and capability for using DSBD technology when it becomes commercially available. Evidence in the report impacts show a small improvement in researcher skills base due to the engagement of career researchers, funding two PhDs and leading training sessions. There is some evidence of knowledge transfer to enable DSBD success. Examples of improved security for e-commerce, Edge computing and telecoms sectors.
Next Generation Services	Yes	N/A.
Manufacturing Smarter Innovation	No	N/A.
Robotics for a Safer World	Yes	RAI logic model: Long-term societal impacts: Reduced human exposure to hazardous environments and Safer Nuclear decommissioning and maintenance. The main societal impact so far of RAI work is focused on limiting human involvement in the cutting and sorting of nuclear waste, to improve the safety conditions around decommissioning.
Transforming Foundation Industries	No	N/A.
Prospering from the Energy Revolution	Yes	N/A.
Industrial Decarbonisation	No	N/A.
Transforming Construction	No	N/A.
Transforming Food Production	No	N/A.
Smart Sustainable Plastic Packaging	No	Infrastructure and services around SSP are improving as a result of the Challenge stimulating further investment in R&I to improve the sustainability of plastic packaging. Projects under the Challenge have patents and IP in place for further technology development. New standards and methods for measuring the environmental impacts of the full life cycle of plastic packaging have been developed under the Challenge.

Driving the Electric Revolution	No	'Environmental impacts are not a leading indicator. Therefore, it is unsurprising that case studies for the interim impact evaluation could not yet find evidence for the Challenge's impact on environmental policy and sustainability. The lack of this evidence should therefore not be seen as an early warning sign. (DER Evaluation – Phase 3 – Final Report, p. 110) There is a lack of evidence for impacts towards environmental policy at the interim stage of the Challenge. Further analysis of this impact (or lack of), through a thematic case study highlights several reasons for this: • There is a view that government policies for semiconductor tech are few and fragmented. • Coordination across government is poor between departments. • There is no clear framework or strategy from the UK government – increases uncertainty of UK investors.' There are other examples of the report highlighting the reasons for a lack of policy impact: • 'Challenge needs to focus on the PEMD supply chain so those outside the sector take note. • The Challenge focuses on influencing policy in too many departments in the UK government – spread across too many areas with a modest investment – barely scratches the surface of issues and cannot impact environmental policy and standards more broadly.'
Farraday Battery	No	Increasing interest in eV sector as part of 'green' recovery strategy. The Challenge has strengthened the battery technology policy landscape through research and outreach activities. 'This is reflected in progress across all four clusters of metrics identified for this evaluation theme: (1) cross-government policy frameworks for attracting Gigafactories; (2) the policy community's understanding of value chains; (3) investor interest; and (4) public understanding and acceptance of battery technology and value chains.'
Future Flight	Yes	Future flight focuses on improving existing infrastructure for social good. Examples of this include disability and accessibility, marginalised groups' access and experiences, digital exclusion from future flight transport and socio-economic exclusion and inclusion.

Table 22. Summary of wider societal benefit at the Challenge level

Challenge	Impact in scope?	Summary of wider societal benefit at Challenge level
Audience of the Future	Yes	Change in attitude: 92% of programme participants said their SFA involvement 'made them convinced or enthusiastic about the future of immersive storytelling'. 'Academics who participated in the Train the Trainer workstream also reported changing attitudes towards and greater recognition for immersive within their institutions because of their participation in the programme.'

Medicines Manufacturing	No	N/A.
Data to Early Diagnosis	No	N/A.
Commercialising Quantum Technologies	Yes	This Challenge has helped to bolster the UK's QT workforce by employing more than 1300 people, which could be knock-on effects on public perception.
Digital Security by Design	Yes	Other impacts that are still related to societal impacts can be seen through changes to the perception of cyber threats and DSBD. Examples of increasing UK business investment in DSBD and improved R&D capability and capacity and technology adoption are through: - creating cross-sector collaborations - 'increased industrial sectors' awareness of cyber and digital security issues and market failures'. - 'prioritising the research agenda' - 'making progress towards new regulatory standards and legislation' 'Benefits to other sectors: e.g. manufacturing, CAVs, utilities, military; CNI.' There has been some impact on the UK's reputation in cybersecurity as the programme has matured. 'The delivery team have investigated international markets through government-led missions to key countries: The US have a long-standing relationship with the Cambridge University team that developed CHERI (which has had support from DARPA since 2010) and the US is a significant target market. Missions have also been to India, Japan, and Australia. The relationship with Australia is significant because of the Five Eyes global security partnership and AUKUS trilateral security pact; some Morello boards have been delivered to Australia and have the potential to be used in the supply chain for Five Eyes security initiatives.'
Next Generation Services	No	Evidence highlights cultural and attitudinal changes towards AI to improve capacity and understanding of the potential for AI and individual skills needs, which in turn have the potential to influence the strategic direction of companies. Attitude change has also created a scenario of increased adoption into other industry domains, such as insurance firms, mid-market accounting firms, law firms/legal services and the digital currency landscape (cryptocurrency accounting). Participants in the CR&D projects reported an increased understanding of sector challenges and opportunities, challenges and opportunities relating to AI and data, and the potential for applying AI solutions in their sectors of activity. The programme has led to a positive change in attitudes towards AI and data, with participants reporting increased awareness and understanding of their potential and challenges. '89% Increased understanding of sector challenges and opportunities. 97% Increased understanding of challenges and opportunities relating to AI & Data. 94% A better understanding of the potential for applying AI solutions in their sectors of activity'.

Manufacturing Smarter Innovation	No	N/A.
Robotics for a Safer World	Yes	Early impacts show signs of positive impacts in terms of policy influence to provide national and international methods and tools, for developing, implementing, using and assessing robotics and autonomous systems.
Transforming Foundation Industries	No	N/A.
Prospering from the Energy Revolution	Yes	N/A.
Industrial Decarbonisation	No	N/A.
Transforming Construction	No	TCN has changed the way some policymakers, public procurement bodies and consumers recognise the importance of change in order to facilitate early adoption and stakeholder buy-in. 'This recognises the importance of demand in spurring innovation and technology adoption.' Other examples of cultural change have been highlighted in the TCN evaluation from key stakeholders in BEIS, which also includes material changes in major private infrastructure projects. 'Overall, we are seeing a big cultural change which is guided towards outcomes rather than inputs we are expecting a very positive impact from it' (BEIS stakeholder). Since TCN is an important element in the issue of climate change, additional cultural shifts are happening due to TCN's assistance in bringing industry and government together to tackle climate change. TCN has improved awareness of TCN concepts in the organisations it has engaged with to date.
Transforming Food Production	Yes	N/A.
Smart Sustainable Plastic Packaging	Yes	N/A.
Driving the Electric Revolution	Yes	There is evidence to show impacts towards levelling-up – monitoring data on the distribution of winning companies for the Challenge are widespread in terms of regionality.
Farraday Battery	No	The perception of the UK as an investment location for batteries, alongside Gigafactory announcements, has established a rise in prospects of positive economic outcomes in the UK's medium-term future.
Future Flight	No	N/A.