May 2025

# Evaluation of Transforming Foundation Industries Industrial Strategy Challenge Fund

## Final Report: Annexes

SQW

# Contents



**Contact:**
Sarah Brown
Tel: 0161 475 2102
email: sbrown@sqw.co.uk

**Approved by:**
Osman Anwar
Director
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# Introduction

1.1 This report contains the annexes for the Evaluation of Transforming Foundation Industries Industrial Strategy Challenge Fund Final Report.

# Annex A: SIC codes for the Foundation Industries

**A.1** As there is no agreed definition of foundation industries, the TFI Challenge team provided a working definition based on 2007 SIC codes, shown below. It was noted that this definition is relatively narrow, focusing predominantly on the primary producers.

**Table A-1: SIC codes for Foundation Industries**

| SIC Code | Description |
|---|---|
| **Paper and pulp** | |
| 17110 | Manufacture of pulp |
| 17120 | Manufacture of paper and paperboard |
| 17211 | Manufacture of corrugated paper and paperboard, sacks and bags |
| 17219 | Manufacture of other paper and paperboard containers |
| 17220 | Manufacture of household and sanitary goods and of toilet requisites |
| 17230 | Manufacture of paper stationery |
| 17240 | Manufacture of wallpaper |
| 17290 | Manufacture of other articles of paper and paperboard n.e.c. |
| **Chemicals** | |
| 20110 | Manufacture of industrial gases |
| 20130 | Manufacture of other inorganic basic chemicals |
| 20140 | Manufacture of other organic basic chemicals |
| 20150 | Manufacture of fertilizers and nitrogen compounds |
| 20160 | Primary plastics |
| 20590 | Manufacture of other chemical products n.e.c. |
| **Glass** | |
| 23110 | Manufacture of flat glass |
| 23120 | Shaping and processing of flat glass |
| 23130 | Manufacture of hollow glass |
| 23140 | Manufacture of glass fibres |
| **Ceramics** | |

| SIC Code | Description |
|---|---|
| 23310 | Manufacture of ceramic tiles and flags |
| 23320 | Manufacture of bricks, tiles and construction products, in baked clay |
| 23410 | Manufacture of ceramic household and ornamental articles |
| 23420 | Manufacture of ceramic sanitary fixtures |
| 23430 | Manufacture of ceramic insulators and insulating fittings |
| 23440 | Manufacture of other technical ceramic products |
| 23490 | Manufacture of other ceramic products n.e.c. |
| **Cement** | |
| 23510 | Manufacture of cement |
| 23520 | Manufacture of lime and plaster |
| 23630 | Manufacture of ready-mixed concrete |
| 23640 | Manufacture of mortars |
| 23650 | Manufacture of fibre cement |
| **Metals** | |
| 24100 | Manufacture of basic iron and steel and of ferro-alloys |
| 24410 | Precious metals production |
| 24420 | Aluminium production |
| 24430 | Lead, zinc and tin production |
| 24440 | Copper production |
| 24450 | Other non-ferrous metal production |

*Source: Transforming Foundation Industries Challenge Team*

# Annex B: List of consultees

**Table B-1: List of consultees**

| Role | Organisation |
|---|---|
| **CRD (W2) business beneficiaries and partners** | |
| Project Collaborator | Becker Industrial Coatings Limited |
| Project Collaborator | Biopower Technologies Limited |
| Project Lead | Cloud Cycle Ltd. |
| Project Lead | Fabricnano Limited |
| Project Lead | First Graphene (Uk) Limited |
| Project Lead | Futraheat Limited |
| Project Lead | Hybird Ltd |
| Project Lead | James Cropper Public Limited Company |
| Project Lead | Kenoteq Ltd |
| Project Lead | Nationwide Engineering Group Ltd |
| Project Lead | Parkinson - Spencer Refractories Limited |
| Project Lead | PTML (Pilkington Technology Management Ltd) |
| Project Lead | Pyroptik Instruments Limited |
| Project Lead | Recycl8 Limited |
| Collaborator | Twi Limited |
| Project Lead | European Metal Recycling Limited |
| Project Lead | Material. Evolution Ltd. |
| Project Collaborator | Celsa Manufacturing (Uk) Limited |
| Project Collaborator | Glass Technology Services Ltd |
| Project Collaborator | Abbey Forged Products Limited |
| Project Collaborator | Britest Limited |
| Project Collaborator | Carbon Upcycling Technologies Uk Ltd |
| Project Lead | Almath Crucibles Limited |

| Role | Organisation |
|---|---|
| Project Lead | Saica Paper Uk Limited |
| Project Collaborator | Tata Steel Uk Limited |
| Project Collaborator | Authentise Ltd |
| Project Lead | Lunts Castings Limited |
| Project Collaborator | Solomon & Wu Ltd |
| Project Lead | I3D Robotics Ltd |
| **UKRI Delivery Team** | |
| Challenge Director | UKRI |
| Deputy Challenge Director | UKRI |
| Innovation Lead (leaving in July 2023) | UKRI |
| Knowledge Transfer Manager | Innovate UK Business Connect (formally known as Knowledge Transfer Network) |
| Knowledge Transfer Manager | Innovate UK Business Connect (formally known as Knowledge Transfer Network) |
| Innovation Lead | UKRI |
| Programme Manager | UKRI |
| Project Manager | UKRI |
| **IVP (W5) Businesses** | |
| Project Lead | Tepeo Ltd |
| Project Lead | Carbon Re Ltd |
| Project Lead | Holiferm Limited |
| Project Lead | Hydregen Limited |
| Project Lead | Adaptavate Limited |
| Project Lead | Puraffinity Ltd |
| **IVP (W5) Investors** | |
| Investment Director | Clean Growth Fund |
| Managing Director | Turqoise |
| Investment Director | Future Planet Capital (MidVen) |

| Role | Organisation |
|---|---|
| Director | HG Ventures |
| Investment Manager (& UKRI lead) | Speedinvest |
| **Wider Stakeholders** | |
| Senior Research Officer | ESPRC |
| Trade Association rep | Paper |
| Challenge Director | Industrial Decarbonisation ISCF and BEIS Industrial Clusters Mission Lead |
| Stakeholder Steering Group | John Bolton Consulting |
| Head of Market Intelligence | BEIS IETF and other relevant funds |
| Lead Policy Advisor– Steel Communications, Markets and R&D | Department for Business and Trade |
| Manager (Infrastructure & Materials) | DBT |
| Hydrogen Innovation Programme Manager | DESNZ |
| Innovation Lead | Mineral Products Association |
| CTO | HVM Catapult |
| Managing Director of Enric previously (Advisory Group Member) | Encirc |
| Tata Steel Professor of thermo-mechanical processing (Advisory Group Member) | University of Warwick |
| Co-Chair, Future Leaders Group (Advisory Group Member) | Glass Futures |
| Co-Chair, Future Leaders Group (Advisory Group Member) | MPI |
| Director General (Advisory Group Member - Chair) | UK Steel |
| National Technical Manager (Advisory Group Member) | Hanson Cement |
| Chief Executive (Advisory Group Member); (send calendar invites out to Tony AND Julie, his PA) | Lucideon |
| CEO | Cast Metals Federation |
| CEO | Henry Royce Institute |
| Wider HVMC colleagues (focus groups) | HVMC |
| Glass Futures Steering Group Chair | ITM Consulting |

| Role | Organisation |
|---|---|
| **Glass Facility (W1) team members** | |
| CEO | Glass Futures Ltd |
| Innovation and Partnerships Manager | Glass Futures Ltd |
| General Manager | Glass Futures Ltd |
| QHSE Manager | Glass Futures Ltd |
| Finance Manager | Glass Futures Ltd |
| **Glass Facility (W1) users** | |
| Director of Sustainability; Deputy Director of Operations | Encirc Ltd |
| Chief Executive | F.I.C UK |
| **Academics (W3 and W4)** | |
| Network+ Director | University of Sheffield |
| Network+ Deputy Director | University of Leeds |
| Network+ Manager | University of Sheffield |
| Network+ Co-Investigator | University of Manchester |
| Principle Investigator / Director, TransFIRe | Cranfield University |
| TransFIRe Manager | Cranfield University |
| Co-investigator, TransFIRE & Network+ | University of Cambridge |
| ED&I Lead, Network+ | University of Durham |
| Co-investigator, TransFIRe | University of York |
| Co-investigator, TransFIREe | University of Bangor |
| Co-investigator, TransFIRe | NERC British Geological Survey |
| Technical Programme Manager, TransFIRe | University of Leeds |
| **Non-beneficiaries** | |
| Unsuccessful applicant to Fast Start | Meta Additive Limited |
| Unsuccessful applicant to Large CRD | Intellegens Limited |
| Unsuccessful applicant to Large CRD | Ferroday Limited |
| Unsuccessful applicant to Small Strand 2 | Intellisense.Io Limited |

| Role | Organisation |
|---|---|
| Unsuccessful applicant to Small Strand 2 | Metlase Limited |
| Unsuccessful applicant to Resilient Recovery | Advanced Sampling Process Instruments Limited |
| Unsuccessful applicant to Resilient Recovery | Zicon Limited |
| Unsuccessful business applicant to IVP | Low Sulph Co |
| Unsuccessful applicant to Network+ | Warwick University |

*Source: SQW*

# Annex C: Further detail on methodology

## Theory-based framework

C.1 The evaluation design was based on an theory-based framework. It investigated net outcomes and impacts by exploring the causal chains thought to bring about change by an intervention. This approach is explicitly concerned with both the extent of the change and why the change occurs. In addition, it often considers the context in which the intervention is being implemented (Magenta Book, 2020).[1]

C.2 The logic model and theory of change explicitly articulate the context and rationale for a policy or programme, and describe the relationship between the inputs, activities, outputs, outcomes and impacts. They are a tool that help to structure an evaluation and inform the collection of evidence needed to test whether the underlying logic and theory has happened in practice. Using the tool helps evaluators to test the extent to which, and how, the outputs, outcomes and impacts have been achieved and the causal links between these and the activities (i.e. the theory of change). In short, the approach provides the basis for developing a coherent evaluation framework in two ways:

- informing the identification of indicators for monitoring and assessing performance
- outlining the main features of an intervention

C.3 In doing so, the approach frames the key research questions for the evaluation.

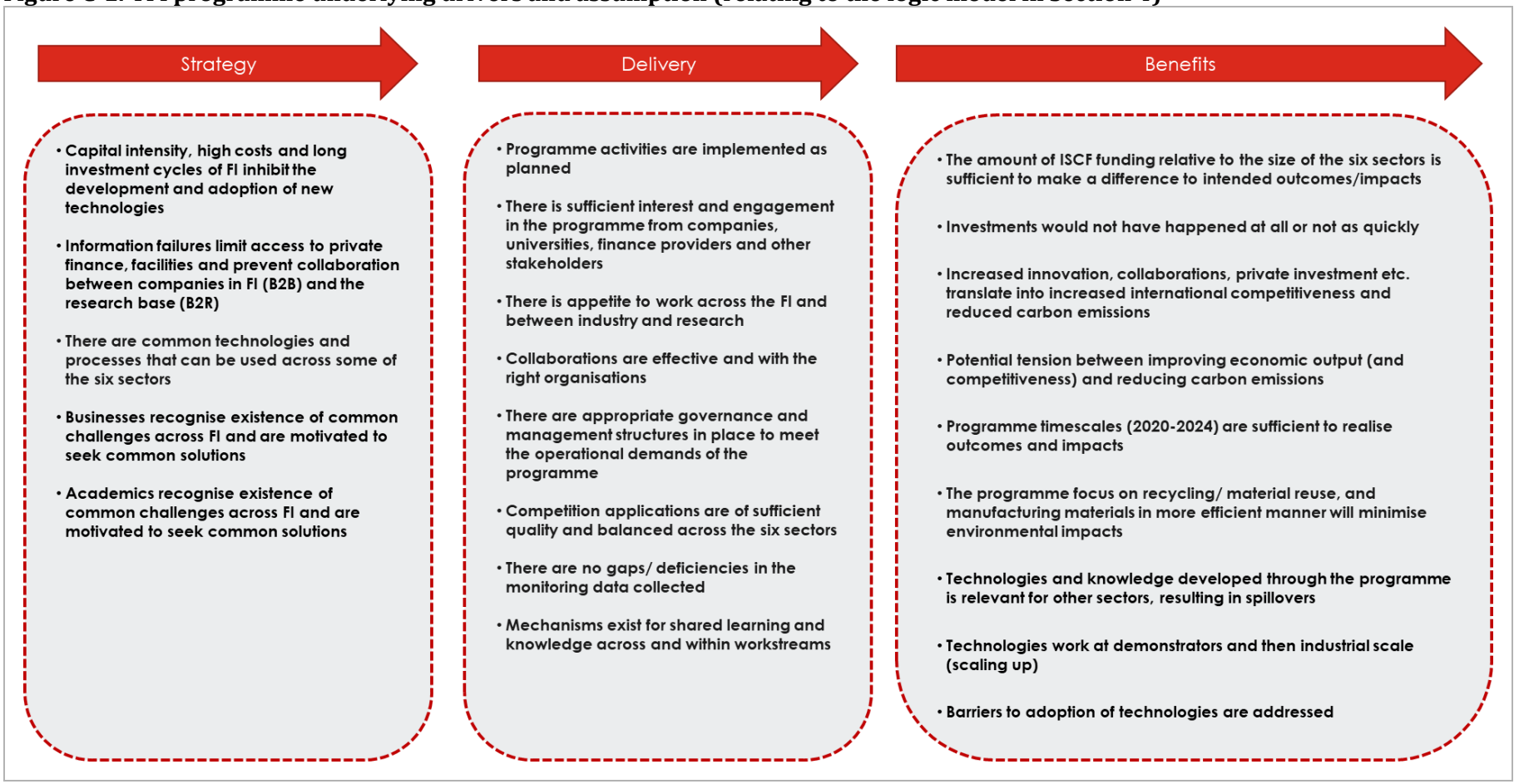
C.4 Taking account of the above, a refined logic model and theory of change for the TFI programme is presented in Section 4 of the Final Report, with the underpinning drivers and assumptions set out in Figure C-1.

### Developing the 'contribution story'…

C.5 A specific theory-based approach – Contribution Analysis (CA) – was used to test the evidence on outcomes and impacts, whilst considering other factors which may have contributed to these benefits. The box at the end of Annex C provides detail on the aims and applications of CA.

[1] HM Treasury (2020) Magenta Book - Central Government guidance on evaluation.

**Figure C-1: TFI programme underlying drivers and assumption (relating to the logic model in Section 4)**




*Source: SQW*

## Contribution Analysis

CA is a theory-based evaluation approach that "aims to define the links between each element of a logic model, and test and refine these theoretical links between the programme and the expected impacts. It provides a framework for analysing not just whether the programme has had an impact, but how that impact materialised and whether any particular element of the programme or contextual factors were crucial to the impact".[2]

CA can increase confidence in evaluation: instead of developing a picture of what would have happened in the absence of the intervention (which is often difficult to determine for complex interventions), CA focuses on whether there is strong evidence that the intervention rather than something else was critical in causing the benefits observed.[3] It, therefore, puts the onus on the intervention. CA draws on the development of logic models and underlying theory of change as to how intended outcomes and impacts came to materialise. The supporting evidence collected is used to prove the intervention made the difference by constructing a 'contribution story' on the extent to which the intervention was important in generating these observed outcomes and impacts relative to other factors.

These other factors could be internal or external the intervention. Wider government policy influencing innovation and sustainability (e.g. incentives to reduce energy use), other innovation programmes accessed by TFI ISCF programme beneficiaries, sector-specific market conditions (e.g. market structure, regulations, and industry-specific shocks), and internal business factors (e.g. firm characteristics).

[2] Innovate UK (2018) Evaluation Framework. How we assess our impact on business and the economy.
[3] Befani, B., and Mayne, J., (2014) Process Tracing and Contribution Analysis: A Combined Approach to Generative Causal inference for Impact Evaluation, IDS Bulletin, Vol. 45 No. 6.

# Annex D: Scenario analysis

## Purpose & Process: How the scenarios were built and why

**D.1** Imagining the future is an essential tool for all businesses to make flexible long term planning. For sectors like foundational industries, where investment decisions operate over long cycles and will have far-reaching consequences for the potential viability of further innovations, it can be crucial. In scenario analysis, instead of trying to predict the future, the aim is to study probable and preferable multiple futures as systematically possible. Scenarios are imagined futures – they are not forecasts – that can help decision-makers understand what kind of futures are possible, how one can prepare for them, what kind of ends are sought, and how to move towards the most desired ones.

**D.2** Scenarios are always internally consistent visions of the future with a plausible connection to the past. They are especially useful for planning purposes during periods of disruption or instability.

**D.3** Typically, scenarios are multiple 'extreme' visions that are then used to develop plans and roadmaps. If a plan or strategy can work well under each of the multiple scenarios, then that strategy is considered to be more robust than others. The same is true for other decisions, such as investments, or in this case, the design of a robust evaluation framework for a sector that has very long investment cycles.

**D.4** Scenarios can be seen as tools for decision-makers to better understand the range of possible long term changes and future options. They create a frame for discussions, strategies and direct operations. High quality scenario analysis requires deskwork but also stakeholder engagement to build plausible scenarios.

**D.5** In this project, scenarios will give us the confidence needed to build robust (sometimes called 'no-regret') evaluation strategies together with stakeholders. We followed a recognised process, starting with reading what others have already written about the possible futures and current challenges of the sectors, plus some views on the possible changes to context (such as how policy might change as we move to a digital world). We reviewed 47 reports; 10 were for general background, 11 cross sectoral and 26 on specific sectors. Also, we conducted ten interviews across the sectors. We ran five workshops where we initially built seven scenarios. After discussions and evaluation with stakeholders, we rebuilt the scenarios and reduced the numbers of scenarios to 4. We placed the new scenarios in a matrix where reactive - low stress is one end and proactive - high stress another end. The matrix is intended to encourage discussions about similarities and differences between scenarios and frame the evaluation design and any related strategy building.

# The Scenarios

## Scenario 1: Constant flux

**D.6** In this world there are no periods of stability because of constant external changes effecting the FI. Short periods of high demand, high throughput are rare and don't last. Downturns are often surprises (not cyclical). Downturns are long and short, sharp and soft and come from multiple directions (geopolitics, economic downturns, weather, competitors). It becomes increasingly difficult to confidently predict future demand and to match traditional investment cycles.

**D.7** In this scenario we expect material flow disruptions as well as extreme demand disruption, dumping from international competitors, innovations flowing to China, and extreme challenges to investment cycles.

## Scenario 2: Constrained technology flow

**D.8** In this world the flow of technology is not determined by innovation capacity but by external events. The availability of money and customers waxes and wanes. Demand growth in Asia pulls money, factories and therefore investment Eastward. National governments either leave the FI to the market or set policies around a goal of material security.

**D.9** In this scenario we expect Foundation Industry R&D to shift to China, customers to leave the UK, and government policy to shift to material security.

## Scenario 3: Internally driven flourishing

**D.10** In this world UK government research and industry have solved the problems of material circularity. The FI moves to a service model retaining ownership of molecules and bringing them back for reuse at end of life. Raw material imports continually decrease and new subsectors emerge.

**D.11** In this scenario we expect the supply of local recycled materials to eventually under-cut imported virgin materials, and the FI become the system that provides (re-cycles and renews) fundamental core molecules in service of the Nation.

## Scenario 4: Externally fed flourishing

**D.12** In this world UK government research and industry have solved the problems of CCU & S, and Hydrogen production and distribution. Renewable electricity is cheaper than natural gas. The UK leads the world in low cost, low carbon foundation materials and easily finds export markets.

**D.13** In this scenario we expect a vigorous FI enthusiastically adopting technologies driven by other sectors and/or government policy (such as CCU&S, hydrogen distribution), and FI becomes the system that takes low carbon energy and imported molecules to deliver materials in service of the Nation.

### 'Business as usual or business as hoped for' scenario

**D.14** There is a further scenario that warrants attention – this is the future that many industry insiders predict as the most likely. Based on interviews with those from the sector, we could call this the **'business as usual or business as hoped for' scenario**. It has NOT been included as a scenario because it is not plausible, and the cognitive gap between what the industry hopes will happen and what is likely to happen is a major concern drawn out from the interviews and reports. In this scenario demand continues to grow, there are few technology breakthroughs, policies get tougher targets but no new directions. Overall this future is a linear extrapolation of the current situation.

## Key Insights from the scenario development

**D.15** During our data gathering and analysis, we identified many important insights that are not captured into a specific scenario (because they are ubiquitous, or because they are too narrow, or because they are too big!). We triaged these into critical/notable/other insights.

**D.16** There is only **one critical insight**, with many observers pointing out that there is a failure of many leaders in the FI to understand influences that will stop 'business as usual' continuing through the 2020's. This is also visible in the 'business as usual scenario' mentioned above.

**D.17** We identified **10 notable insights**, ranging from the view that Ceramics / Glass / Paper / Steel may be 2 speed industries with a smaller high tech sector and a traditional lower tech / commoditized sector, with the expectation that changes and improvements will trickle down, to the worry over a lack of Foundation Industry Catapult to the observation that the FI cannot afford to be innovative AND cannot afford NOT to be innovative (not enough scale or local ownership to invest, but without investment a decline is inevitable).

**D.18** There are **29 other insights**, with some of the leading observers pointing to the lack of debate around Bio-chemical manufacturing, Electro-chemical manufacturing, or Distributed manufacturing as forces that will shape the future of FI. A similar concern was voiced over the limited vision for the future of digital in the Foundation Industries. There is an interesting frustration felt about the FI inability to create demand for low carbon/sustainable products even when technology and capability is ready e.g. low/no carbon cement. Some observers pointed to the lack of companies acting as systems integrators to enable the benefits from synergies to be realized, based on the view that cross-sub-sector integration is one key future shift together with an envied look at other sectors that do have 'system integrators' (such as construction/aero/auto). The interactions between pace of change, very complex investment conditions and the culture that "*real men spend capital*", point to systemic challenges.

# Annex E: Performance on output metrics

**Table E-1: Challenge performance on output metrics**

| Logic model metric name | Achievement | Target |
|---|---|---|
| Glass pilot scale facility delivered in terms of progress against milestones (W1)* | | |
| Furnace ready for light on | 02/04/25 | 27/02/23 |
| Pilot line ready for projects | 25/04/25 | 03/07/23 |
| Manufacturer sign off | 30/06/25 | 04/08/23 |
| Engage with national glass supply chain organisations | 133 | 103 |
| Engage with international glass supply chain organisations | 97 | 50 |
| Glass Pilot Facility academic & RTO partner engagements | 18 | 50 |
| Training courses delivered / knowledge exchange | 311 | 200 |
| Cross-sector training courses / knowledge exchange / opportunities identified | 1,687 | 15 |
| Marketing – virtual & physical events | 149 | 68 |
| Marketing – dissemination activities | 1,151 | 300 |

| Logic model metric name | Achievement | Target |
|---|---|---|
| Academic & RTO partners investing in Glass Pilot Facility | 12 | 16 |
| Industry investment in Facility (total cumulative in-kind investment) | £5.8m | £5m |
| Total industry co-leverage into Pilot line | £14.1m | n/a |
| Public sector investment in Glass Pilot Facility (total cumulative investment) | £11.2m | £10m |
| Cumulative of investments made into Facility that are directly related to pilot line | £8.3m | n/a |
| Glass Pilot facility membership scheme | £1.3m<br>48 members (28 UK, 20 international) | £1.7m<br>65 members |
| Programme of R&D projects in line with a sustainable business plan | 30 (17 cross-sector) | 50 |
| Number of CRD competitions (W2) | 6 (with 2 additional competitions being brought into TFI Challenge when projects awarded were from FI) | 6 |
| Number of CRD competition applications (W2) | 114 (22 Fast Start, 43 Resilient Recovery, 11 Large CRD, 17 Small Strand 1, 7 Small Strand 2, 14 Demonstrator)[4] | n/a |
| Number of CRD competition awards (W2) | 74 projects awarded of which eight projects were later withdrawn, terminated early or put on hold. | n/a |

[4] This does not include the additional five REforMM projects and the three Fast Start (Covid-19) projects that were added to TFI's portfolio.

| Logic model metric name | Achievement | Target |
|---|---|---|
| Value of CRD grants awards (£) | £31.5m awarded across projects successfully completed or still live (see Chapter 5 in full report for competition breakdown). | £31.5m |
| Number of partnerships developed, including cross-sectoral (W2) | 182 unique partners supported:<br>• 151 unique businesses (with 12 taking part in more than one project)<br>• 20 unique academic research organisations (with 4 taking part in more than one project)<br>• 7 unique RTOs (with 5 taking part in more than one project)<br>• 4 unique partners classed as 'other' including charities and industry organisations<br>49 of the 66 projects were collaborative[5] and included 165 organisations | 40 |
| Number of projects progressed / completed (W2) | 66 projects completed or live as of October 2024[6]:<br>• 12 Fast Start<br>• 18 Resilient Recovery<br>• 7 Large CRD<br>• 12 Small Strand 1<br>• 3 Small Strand 2<br>• 6 Demonstrators<br>• 5 REforMM<br>• 3 Fast Start (Covid-19) | n/a |

[5] 5 Resilient Recovery, 7 Small Strand 1, 2 ReforMM and the 3 Fast Start (Covid -19) projects were not collaborative.
[6] Not including Demonstrator EOI projects which were all <£15k and intended to support applicants develop fuller proposals for full stage projects rather than deliver R&D activity.

| Logic model metric name | Achievement | Target |
|---|---|---|
| Number of industry-research collaborations established (W3) | 130 collaborations and partnerships established (involving 12 research organisations and over 130 companies, NGOs and government organisations).[7] | 150 |
| Number of industry-research projects progressed/completed (W3) | No data reported separately from the 130 collaborations and partnerships referenced above | n/a |
| Number and types of reports produced (e.g. sector strategy, skills) | 15 reports published by TransFIRe<br>20 reports published in Workstream 4 (*14 in Network+, 6 in Sector Strategy*). | 30 (TransFIRe), 20 (Workstream 4) |
| Number of industry and academic engagement activities delivered (W4) | 44 (Network+: 29 in-person engagement and networking events, 13 webinars, 2 forums delivered in partnership with the TransFIRe). | 20 (Network+) |
| Number of research projects progressed/ completed (W4) | 34 projects across 16 UK universities:<br>• 5 projects in Call 1 - Energy efficiency in the FI<br>• 6 projects in Call 2 - Resource Efficiency and Circular Economy in the FI<br>• 10 projects in Call 3 - Next generation and Intelligent processes for the FI<br>• 8 projects in Call 4 - Early Career Researchers: Transformative impact on the FI<br>• 5 projects in Call 5 - Enablers of Transformation in the FI | 20 (Network+) |
| Skills and training courses progressed/completed (W4) | Network+: 42 events and workshops aimed at bringing people across the FI together (c. 4,000+ participants).<br>Sector Strategy: wide range of skills and training initiatives:<br>Skills e.g. hackathons, one day STEM educational experiences delivered in schools and Skills Road mapping exercise (conducted by UKRI). | n/a |

[7] TransFIRe reported 130 collaborations. The UKRI benefits tracker, which includes activity from TransFIRe, Glass Futures and Network+, shows 142 industry / academic collaborations were established (B9e).

| Logic model metric name | Achievement | Target |
|---|---|---|
| | Equality, Diversity & Inclusion e.g. Women in Leadership Programme (40 funded places) and WINFI, a mentorship initiative to support women in the FI (x20). | |
| Number and type of firms funded (W5) | Six firms funded (nine awarded funding but three withdrew/closed the project) across the FI:<br>Number of projects engaging with each sector is Chemicals (4 projects), Metal (3), Glass (2), Paper (2), Cement (1), Ceramic (1) | n/a |
| Value of Government funding for firms with resource/energy efficiency technologies (£) (W5) | £4.68m spent | £4.8m allocated |
| Value of private funding for firms with resource/energy efficiency technologies (£) (W5) | £99.4m private investment realised. | £2.9m |
| Privately funded projects progressed against milestones (W5) | Six projects completed (nine launched, two withdrawn at the set-up, one withdrew later). UKRI data show:<br>• All projects focused on the development of new sustainable technologies for FI<br>• Four projects involved collaboration with other partners (mostly RTOs or universities, with one project completing demonstrator work with another industry partner)<br>• Four projects contributed to product/process testing, demonstration and validation activities, with some final follow-up activities / investment required before commercialisation<br>• Two projects led to direct commercialisation of the technology.<br>• All projects are expected to be relevant for international markets. | n/a |

*Source: SQW from information provided by TFI Challenge programme team*

# Annex F: Performance on outcome and impact metrics

**Table F-1: Challenge performance on technology outcome and impact metrics**

| Logic model metric name | Achievement | Target |
|---|---|---|
| Operationally sustainable glass facility | Facility not open. Latest programme Board paper (Dec 24) states:<br>• *"Installation continuing well but time to complete functional safety assessments means that start-up has moved back to April 2025."*<br>• *"All plant and equipment installations needed for start-up are now due to be complete by the end of January 2025."*<br>• Key risks associated with issues with water flow rates, electricity supply and time consuming processes required to confirm electrical system is safe before opening. | Operationally sustainable glass facility |
| Level of usage by member organisation of glass facility (days) | Not yet monitored as facility not open. | n/a |
| Technologies accelerated to market | 12 technologies adopted at scale (across W2&5, UKRI's benefits tracker, Benefit B1e, W2&5) | 30 |
| Number of new technologies developed | 30 technologies with proven scalability (across W2&5, UKRI's benefits tracker, Benefit B1b, W2&5) | 15 |
| Number of papers published relating to research on FI | 64 papers published:<br>• 48 scientific papers were published (TransFIRe)<br>• 26 academic papers were published (For Network+) | n/a |

| Logic model metric name | Achievement | Target |
|---|---|---|
| Number of patents generated on innovation related to FI | 29 (across W2&5, UKRI's benefits tracker, Benefit B10b, W2&5) | 10 |
| Patent applications | Not collected.<br>Data on number of patents by FI sector, 2020, as follows (data presented at a more aggregated SIC level of granularity than UKRI Foundation Industry sector definitions due to data limitations; correspondence based on a mapping between IPC v8 classification and NACE classification, see https://ec.europa.eu/eurostat/ramon/documents/IPC_NACE2_Version2_0_20150630.pdf. Source: OECD (Patents by technology):<br>• Paper and pulp - 12<br>• Chemicals - 808<br>• Glass, ceramics and cement - 52<br>• Metals - 13 | n/a |

*Source: SQW analysis of TFI monitoring data and CE analysis of secondary data*

**Table F-2: Challenge performance on attitude outcome and impact metrics**

| Logic model metric name | Achievement | Target |
|---|---|---|
| Establishment of a shared FI identity (perceptions of internal FI and external stakeholders) | • 64% beneficiary survey respondents recognise term 'Foundation Industries' (15% respondents from wider sector)<br>• 44% beneficiary survey respondents feel part of FI (50% respondents from wider sector)<br>• 44% beneficiary survey respondents have an increased sense of shared identity (8% respondents from wider sector) | 40% |

| Logic model metric name | Achievement | Target |
|---|---|---|
| Willingness among FI companies to innovate | 68% beneficiary survey respondents have an increased willingness to innovate ('a lot' or 'a little') (34% respondents from wider sector) | n/a |
| Willingness among FI companies to collaborate | 78% beneficiary survey respondents have an increased willingness to collaborate ('a lot' or 'a little') (26% respondents from wider sector) | n/a |
| Willingness among FI companies and academics to collaborate | 70% beneficiary survey respondents have an increased willingness to invest ('a lot' or 'a little') (38% respondents from wider sector) | n/a |

*Source: SQW analysis of TFI monitoring data*

**Table F-3: Challenge performance on business outcome and impact metrics**

| Logic model metric name | Achievement | Target |
|---|---|---|
| Number of new collaborations between companies across FI and with the academic base | 130 'new partnerships' formed across different FI sectors (across W2&5, UKRI's benefits tracker, Benefit B2c) | 40 |
| Value of private R&D investment on activity supported by the Challenge (£) | £186m additional private R&D spend committed (UKRI co-investment survey shows: £99.4m investment from IVP investors, £61.6m of private investment for CRD projects, £20m for the glass facility, £3.8m for TransFIRe, £0.7m for Network+ (in-kind funding)) | £30m |
| Value of private R&D investment at firm-level (£) (evidence for programme and context) | UKRI benefits tracker data (B2d - Increase in Technology Related Investment) shows increase in tech-related investment has been achieved in 16% of projects, against target of 5%. | n/a |
| Value of private R&D investment at wider sector level (£) (for context) | Investment (gross fixed capital formation) in the foundation industries as a whole increased by 3.6% pa over 2019-24 | n/a |
| Value of private R&D investment/GVA (for context) | Total foundation industries GVA increased by 0.8% pa over 2019-24 | n/a |

| Logic model metric name | Achievement | Target |
|---|---|---|
| Value of foreign direct investment (FDI) secured by the Challenge (£) | UKRI's benefits tracker shows there has been £77.4 million attracted in FDI (B5a) | £50m |
| Value of FDI secured at firm level (£) (for context) | Not provided – data fluctuate year to year and do not provide helpful context | n/a |
| Value of FDI secured at wider sector level (£)(for context) | As above | n/a |
| Value of FDI/GVA (£)(for context) | As above | n/a |
| Technologies developed and adopted across the FI | 12 (UKRI's benefits tracker, across CR&D, IVP and Network+ projects) | 30 |
| Amount of material used by industry | Two beneficiary survey respondents reported achievement of reduced materials, seven reported expected within 1-3 years | |
| Energy consumption by industry | Data not collected | n/a |
| Emissions intensity (GHG emissions per real unit of GVA) | Emissions intensity in the Foundation Industries increased over 2019-24 by 6.8%, driven by a significant increase in metals. | n/a |
| Number of skills shortages (vacancies) at firm level | Data not collected. Thirty-six of the forty beneficiary survey respondents reported staff having gained skills through participation in the Challenge: across these respondents, 143 people had been upskilled. | n/a |
| Incidence of skills shortages (vacancies) at sector level | Data not collected | n/a |
| Senior management have a plan/ taking action on innovation and net-zero | Over half of beneficiary survey respondents (25/40) confirmed their company business plan includes actions intended to improve both energy and resource efficiency in their company. Another 20% (8/40) confirmed their company business plan includes actions intended to improve either energy or resource efficiency in their company | n/a |

| Logic model metric name | Achievement | Target |
|---|---|---|
| Senior management have the skills to deliver innovation and net-zero successfully | Nearly three quarters (29/40) beneficiary survey respondents reported that they either strongly agreed or tended to agree that senior management in their business have the necessary skills to deliver innovation related to net zero | n/a |
| Employment by sector | Gross figures provided by UKRI: 2,941 new jobs created in FI; 2,440 jobs retained; 60 apprenticeships<br>Total employment in the Foundation Industries sector declined by 0.4% pa over 2019-24, resulting in a loss of 3,000 jobs | 5,000<br>400<br>150 |
| Value of turnover (£) | Total Foundation Industries GVA increased by 0.8% per annum (pa) over 2019-24 | n/a |
| Gross operating profit (£) | Data not collected | n/a |
| Gross operating surplus (GVA minus employment costs) (£) | Gross Operating Surplus (GOS) increased at by 6% pa over 2019-24 across the Foundation Industries as a whole | n/a |
| Share of exports in total turnover (%) | Exports increased modestly in the FI by 1.9% pa over 2019 24 | n/a |
| Export market share (UK as a share of global exports) | Data not collected | n/a |

*SQW analysis of TFI monitoring data*

# Annex G: Secondary data analysis

**G.1** This section contains analysis of secondary data relating the Foundation Industries (FI). The aim of the analysis is to provide context for the evaluation of the Transforming Foundation Industries Industrial Strategy Challenge Fund (TFI ISCF). The metrics were agreed with the TFI Challenge team as part of the development of the evaluation framework. The full list of outcome and impact metrics is given in Annex F. The analysis was undertaken by Cambridge Econometrics (CE).

**G.2** This analysis provides sector-level evidence about the circumstances in which the TFI programme operates, both in terms of the position since the Challenge was announced, and to contextualise performance during the evaluation. It is worth bearing in mind that:

- Data are provided up to end of 2024, and, therefore, indicate **the state of the Foundation Industries since the launch of the TFI Challenge**. They do not characterise the performance of the TFI ISCF to date.
- The data provide **context** for understanding findings from other sources of evidence, including the business survey, and cannot explain any direct causal links in changes of performance.
- The data describe the FI as a whole industry and at the sector level. As such, the analysis cannot provide a detailed look at the different types of businesses within the sectors, nor of businesses within the supply chains and wider economy that also interact with the FI. Other aspects of the evaluation will be able to explore these nuances.

## Methodology

**G.3** The historical baseline for the FI examined trends in the five years leading up to the launch of the TFI programme (2014 to 2019). The evaluation report considers the period since the launch of the TFI programme (2019 to 2024). This analysis comprises secondary data gathered from a range of publicly available data sources and estimates, using the most up-to-date data available for each indicator. In some cases, the latest year of data available is 2022. In such cases, the historical data have been extended to 2024 using CE's in-house economic model for the UK, MDM-E3. MDM-E3 is developed and maintained by CE as a framework for generating detailed economic forecasts and analysing changes in economic structure.

**G.4** The analysis compares trends across the six Foundation Industries sectors listed above,[8] the FI in aggregate, the entire manufacturing sector (the FI and the rest of the manufacturing sector, as defined by SIC Section C) and the wider (non-financial) economy (i.e. the overall economy,

[8] These sectors are based on UKRI's working definition of the Foundation Industries, using 2007 SIC codes, as per the Evaluation Framework (March 2021). The definition is provided in Annex A.

excluding financial and insurance activities as defined by SIC Section K[9]). While there are clearly important differences between the FI and the wider manufacturing sector, comparison provides a useful point of reference. Divergences can be explored to understand reasons for improving or declining performance by the FI and its component sectors.

**G.5** The analysis covers the following baseline indicators:

- output (turnover)
- Gross Value Added (GVA) (output having accounted for inputs)
- gross operating profit (as a measure of profitability)
- employment
- labour productivity
- exports and imports
- investment
- R&D spending
- Foreign Direct Investment (FDI)
- Greenhouse Gas (GHG) emissions intensity (emissions per output).[10]

**G.6** For R&D spending, FDI and energy intensity, the granularity of available data means that the indicators are presented for slightly wider industry definitions than those given above. More detail is provided alongside the relevant indicators. The use of slightly wider industry definitions for these metrics may affect the indicators, but it is hard to determine how and to what extent. As the industry definitions are only slightly wider, it is probable that the indicators are reasonably reflective of the performance of the FI sectors. At the very least, the indicators are likely to provide a good indication of the overarching trend for these metrics.

### International comparisons

**G.7** The analysis provides a comparison between the UK's FI with those in Germany, France and Belgium in 2022 (the most recent year for which comparable data are available) for key indicators. The comparator countries were chosen based on the following criteria.

[9] SIC Section K is not covered by the Annual Business Survey (ABS) and so has been excluded from comparison for indicators drawn from the ABS.
[10] While the challenges relating to the use of the terms energy intensity and emissions intensity are recognised, we have retained the use of 'intensity' to be consistent with the terminology used by ONS and other data sources.

- UK domestic market penetration – a key objective of the TFI programme outlined in the business case is the displacement of imports into the UK domestic market.

- Importance of the UK market to the foreign exporter – countries that export a high proportion of their total exports to the UK are more likely to produce goods that are customised to the UK market (as opposed to countries exporting lower value-added goods across the world). These are the types of goods that UK producers are likely competing to sell on the domestic market.[11]

- Data availability – to facilitate meaningful comparison between countries, data should be comparable and consistent in terms of sector definitions and indicator definitions, and the methodology for collecting and collating the data.

### Economic and emissions projections

**G.8** Projections are provided for the six Foundation Industry sectors out to 2040 for GVA, employment, labour productivity and emissions. These projections are derived from CE's forecasting model, MDM-E3 and incorporate historical trends for sectors.

**G.9** MDM-E3 provides a one-model approach in which the detailed industry analysis is consistent with the macroeconomic analysis. In addition to the mechanisms within MDM-E3, the model also methodically adjusts based on internal assumptions about the likely future. This is done by routinely assembling a team of economists to revise the forecast's short-run outlook. It allows the model to account for major events that are not captured by the analysis of long-run historical trends.

**G.10** The projections in this paper are based on the latest edition of MDM-E3 from April 2024. This version of MDM-E3 incorporates factors such as the longer-term impacts of Brexit, the price and supply shocks following the war in Ukraine, updated population and migration projections, recovery from COVID-19 lockdowns, and other relevant developments in the economy. Further detail on the model assumptions is given below.

**G.11** Considering the EU-UK Trade and Cooperation Agreement (signed 30th December 2020) has now been in effect for a number of years, data capturing the impact of Brexit are available. The economists who contributed to the MDM-E3 forecast considered the impacts that Brexit would have on trade, investment, and migration. In the case of trade and investment, the impact of Brexit has been observed over recent years of historical data. As these data are incorporated into the model equations, no additional assumptions about the impact of Brexit on trade or investment were made. Trends in migration since 2021 have diverged from expectations at the time of the Brexit deal agreement: the UK has experienced relatively high levels of net migration over 2021-23. The migration assumptions in the April 2024 version of MDM-E3, therefore, incorporated

[11] Note that the goods being measured are those being exported by FI sectors so they will be products sold rather than raw materials processed by FI. Depending on the sector/product, it could be a mix of intermediate (semi-processed) goods and finished goods.

higher future net migration levels, and so higher population projections, than the principal population projections published by the ONS at the time.

**G.12** To develop the projections for GVA and employment, the latest MDM-E3 sector forecasts (SIC 2-digit) for GVA and employment have been applied to the latest year of historical baseline data for each of the Foundation Industry sectors. The labour productivity projection (measured as GVA per job) is then calculated from the GVA and employment projections.

**G.13** The emissions projections are calculated based on estimating GHG emission intensity factors (an average amount of emissions per unit of GVA) and multiplying them with the GVA projections. Emissions intensity factors are projected forward based on the time trend in the historical data back to 1990. In the case of GHG emissions in the metals FI sector, trends in emissions factors have changed over time. In this case, the projection of future emissions intensity is based on trends in the historical data back to 2008.

## Historical performance of the FI, 2019-24

**G.14** It is worth noting that over the relatively short time period of five years, there is some volatility evident among some sectors on some metrics. Average rates may be influenced by a particularly high or low performance on a specific metric for the starting year, 2019, and/or the final year, 2024. Where possible, we have explored reasons for volatility. However, the findings should still be treated with caution.

### The wider economic context

**G.15** Both the wider economic landscape and trends in the manufacturing sector in the UK need to be taken into account when considering the performance of the UK Foundation Industries in recent years.

**G.16** Whilst remaining an important part of the UK economy, output and particularly employment in the manufacturing sector as a whole has declined, driven by lower-cost competition from overseas and the fragmentation of global supply chains. In 1990, manufacturing accounted for around 13% of GVA in the whole economy and 17% of all employment. By 2023 this had fallen to 11% of GVA in the whole economy and 7% of total employment.

### Diversity within UK Foundation Industries

**G.17** Before presenting performance of the FI on key metrics, it is worth noting that economic activity within most of the Foundation Industry sectors is dominated by one or two large subsectors (as shown in Table G-1). In Ceramics, Cement and Metals, the largest subsector represented more than 60% of the sector's GVA in 2022, while in Paper and pulp, the largest subsector represented 44% of the sector's GVA. In the Glass sector, two subsectors (out of four) represented 75% of the sector's GVA. Chemicals is the most diversified sector, with the manufacture of other chemical products accounting for 32% of the sector's GVA in 2022, and the rest of the sector's GVA being shared relatively evenly among five other subsectors. Therefore, the GVA figures shown in the

following tables are largely driven by the performance of the most significant subsectors within each Foundation Industry, with turnover and Gross Operating Surplus[12] (GOS) (a proxy for profitability) broadly following a similar pattern.

**Table G-1: Share of most significant subsectors in terms of GVA, 2022**

| FI Sector | Most significant subsector (SIC class) | Share of sector GVA |
|---|---|---|
| Paper and pulp | 17.21 Manufacture of corrugated paper and paperboard and containers of paper and paperboard | 44% |
| Chemicals | 20.59 Manufacture of other chemical products n.e.c. | 32% |
| Glass | 23.12 Shaping and processing of flat glass | 37% |
| | 23.13 Manufacture of hollow glass | 38% |
| Ceramics | 23.32 Manufacture of bricks, tiles and construction products, in baked clay | 67% |
| Cement | 23.63 Manufacture of ready-mixed concrete | 65% |
| Metals | 24.1 Manufacture of basic iron and steel and of ferro-alloys | 71% |

*Source: ONS (Annual Business Survey)*

# Key performance metrics

## Output and profitability

### Turnover, GVA and gross operating surplus

**G.18** The recent performance of the Foundation Industries in the UK can be assessed using the data presented in Table G-2. The table presents data on recent trends in output (as measured by real turnover and real GVA) and a broad measure of profitability (real gross operating surplus) in the UK Foundation Industries, manufacturing sector and wider non-financial economy for the period 2019-24.

**G.19** Total Foundation Industries GVA increased[13] by 0.8% per annum (pa) over 2019-24, markedly slower than the wider non-financial economy (2.2% pa over the same period), while GVA in manufacturing as a whole increased by 2.1% pa over the same period. The sluggish growth of the FI can be explained by the variation between sectors. Metals had the strongest growth over 2019-

[12] Gross Value Added minus employment costs.
[13] Growth here is measured by average growth rate per annum from 2019-24. It is important to note that the growth within a period reflects the differences between the starting and the end point of a series, and therefore it is not, in isolation, indicative of a trend, i.e. the series might have peaked or might oscillate substantially between the two points.

24, with growth of 6.7% pa, followed by Paper and pulp (5.6% pa), while Cement showed a decrease of 7.1% pa.

**G.20** GVA in Chemicals, the largest of the Foundation Industry sectors by GVA, decreased by 1.5% pa over 2019-24, while GVA in Ceramics and Glass decreased by 3.9% pa and 0.3% pa, respectively. GVA in metals increased over the 2019-24 period, though it decreased over 2021-22 (amid steel plant closures and production cuts due to the pressure of international competition and rising production costs[14]) before picking up again in 2023.

**G.21** While turnover remained unchanged in Manufacturing as a whole over 2019-24, it decreased by 2.1% pa in the Foundation Industries, in contrast to the wider non-financial economy, which grew by 1.8% pa over the same period. Turnover declined in all the Foundation Industry sectors over 2019-24, other than Paper and pulp, in which there was no change in turnover. Turnover in Glass decreased the most, 5.5% pa over 2019-24, and turnover in Metals decreased by 4.5% pa, despite GVA in the sector increasing over the period.

**G.22** Gross Operating Surplus (GOS), an indicator of profitability, increased by 6% pa over 2019-24 across the Foundation Industries as a whole, suggesting falling employment costs along with rising GVA. The average annual growth of GOS in the Foundation Industries was nearly three times larger than that of the wider non-financial economy (2.1% pa over 2019-24). GOS grew particularly sharply in metals (15.2% pa over 2020-24) and Paper and pulp sector (12.8% pa over 2019-24), while it decreased in Cement and Ceramics over 2019-24 (-10.6% pa and -8.7% pa, respectively).

[14] https://commonslibrary.parliament.uk/research-briefings/cbp-7317/

**Table G-2: Recent trends in output and profitability in the Foundation Industries, manufacturing sector, and wider (non-financial) economy, 2019-24**

| | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | Average growth |
|---|---|---|---|---|---|---|---|---|
| **GVA (£ 2019 millions)** | Paper and pulp | 3,598 | 3,300 | 4,474 | 4,773 | 4,617 | 4,726 | 5.6% |
| | Chemicals | 5,784 | 6,589 | 6,550 | 5,769 | 5,297 | 5,354 | -1.5% |
| | Glass | 1,200 | 1,395 | 1,381 | 1,238 | 1,171 | 1,185 | -0.3% |
| | Ceramics | 1,061 | 812 | 1,009 | 907 | 857 | 867 | -3.9% |
| | Cement | 1,155 | 1,012 | 945 | 833 | 788 | 797 | -7.1% |
| | Metals | 1,142 | 1,749 | 2,298 | 1,506 | 1,574 | 1,581 | 6.7% |
| | Foundation Industries | 13,939 | 14,858 | 16,658 | 15,028 | 14,304 | 14,510 | 0.8% |
| | Manufacturing | 170,442 | 165,453 | 184,294 | 186,230 | 188,105 | 188,786 | 2.1% |
| | Non-financial economy | 1,312,859 | 1,118,050 | 1,310,951 | 1,446,205 | 1,454,267 | 1,460,457 | 2.2% |
| **Turnover (£ 2019 millions)** | Paper and pulp | 12,113 | 11,669 | 12,232 | 12,246 | 11,845 | 12,125 | 0.0% |
| | Chemicals | 17,899 | 18,565 | 20,132 | 17,923 | 16,456 | 16,633 | -1.5% |
| | Glass | 3,712 | 2,750 | 3,149 | 2,921 | 2,762 | 2,795 | -5.5% |
| | Ceramics | 2,041 | 1,867 | 1,862 | 1,806 | 1,707 | 1,728 | -3.3% |
| | Cement | 4,393 | 3,969 | 4,400 | 3,930 | 3,715 | 3,760 | -3.1% |
| | Metals | 9,931 | 8,224 | 8,903 | 7,535 | 7,875 | 7,906 | -4.5% |

| | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | Average growth |
|---|---|---|---|---|---|---|---|---|
| | Foundation Industries | 50,089 | 47,044 | 50,677 | 46,361 | 44,359 | 44,946 | -2.1% |
| | Manufacturing | 565,274 | 500,761 | 538,991 | 557,711 | 564,688 | 565,072 | 0.0% |
| | Non-financial economy | 4,096,509 | 3,398,453 | 3,948,249 | 4,441,881 | 4,454,467 | 4,472,858 | 1.8% |
| **Gross operating surplus (£ 2019 millions)** | Paper and pulp | 1,612 | 1,285 | 2,374 | 2,965 | 2,889 | 2,949 | 12.8% |
| | Chemicals | 3,476 | 4,277 | 4,395 | 3,930 | 3,659 | 3,732 | 1.4% |
| | Glass | 462 | 729 | 634 | 621 | 554 | 579 | 4.6% |
| | Ceramics | 561 | 346 | 488 | 386 | 337 | 356 | -8.7% |
| | Cement | 643 | 563 | 476 | 395 | 350 | 367 | -10.6% |
| | Metals | -177 | 459 | 1,162 | 556 | 753 | 808 | 15.2%[15] |
| | Foundation Industries | 6,577 | 7,658 | 9,529 | 8,852 | 8,541 | 8,792 | 6.0% |
| | Manufacturing | 76,586 | 74,835 | 92,787 | 98,011 | 101,058 | 103,364 | 6.2% |
| | Non-financial economy | 618,406 | 464,523 | 587,613 | 688,703 | 684,531 | 687,406 | 2.1% |

*Note: Data for 2023 and 2024 are estimated using MDM-E3. Totals may differ due to rounding.*

*Source: ONS (Annual Business Survey) and Cambridge Econometrics (MDM-E3).*

[15] The growth rate for gross operating surplus in Metals was calculated over 2020-24, as the value in 2019 was negative.

## Employment

**G.23** Table G-3 shows employment in the Foundation Industries, the Manufacturing sector and the wider non-financial economy for the period 2019-24. Total employment in the Foundation Industries sector declined by 0.4% pa over 2019-24, resulting in a loss of 3,000 jobs, compared to a decrease in employment in manufacturing as a whole of 0.8% pa over the same period. In contrast, employment in the wider non-financial economy increased by 0.8% pa over 2019-24.

**G.24** The largest increase in employment was in Chemicals, which increased by 5,000 jobs over 2019-24. Employment growth in cement and metals remained flat, while it decreased in paper and pulp and glass by around 2.0% pa over 2019-24. Annual changes in employment in glass fluctuated, with employment in the sector decreasing by 3,000-5,000 jobs in some years and increasing by 6,000 jobs in another year. Note that **trends in employment for the individual sectors do not necessarily match their individual trends in GVA and turnover**. For example, turnover and GVA in cement decreased, but employment in the sector remained unchanged.

**Table G-3: Employment (000s), 2019-24**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | Average growth |
|---|---|---|---|---|---|---|---|
| Paper and pulp | 55 | 52 | 52 | 57 | 48 | 50 | -2.0% |
| Chemicals | 40 | 36 | 41 | 37 | 45 | 45 | 2.3% |
| Glass | 21 | 22 | 18 | 24 | 20 | 19 | -1.9% |
| Ceramics | 13 | 14 | 13 | 17 | 13 | 13 | -0.9% |
| Cement | 9 | 10 | 9 | 11 | 9 | 9 | 0.1% |
| Metals | 34 | 32 | 36 | 33 | 35 | 33 | -0.2% |
| Foundation Industries | 172 | 166 | 171 | 178 | 171 | 169 | -0.4% |
| Manufacturing | 2,509 | 2,432 | 2,404 | 2,456 | 2,460 | 2,414 | -0.8% |
| Non-financial economy | 30,676 | 30,174 | 30,884 | 31,480 | 31,830 | 31,967 | 0.8% |

*Note: Data for 2024 are estimated using MDM-E3. Totals may differ due to rounding.*

*Source: ONS (Business Register and Employment Survey; Annual Business Survey) and Cambridge Econometrics (MDM-E3).*

## Labour productivity

**G.25** Table G-4 shows labour productivity measured as real GVA per worker.[16] Labour productivity in the Foundation Industries increased at a slower rate than Manufacturing as a whole (1.2% pa compared to 2.9% pa over 2019-24), but it was in line with labour productivity growth in the

[16] Labour productivity is a common and well established measure of productive efficiency and competitiveness. Labour productivity comparisons are useful to compare the amount of value added per worker between, for example, sectors, countries, and across time.

wider non-financial economy (1.3% pa over 2019-24). There was substantial variation in productivity across the FI sectors in 2024, with Chemicals having the highest productivity of any of the other sectors by a large margin (£120,000 GVA per worker in 2024).

**G.26** Within the Foundation Industries, labour productivity increased in Paper and pulp (7.8% pa over 2019-24), Metals (6.9% pa over 2019-24), and Glass (1.7% pa over 2019-24), while it decreased in Cement (-7.2% pa over 2019-24), Chemicals (-3.8% pa over 2019-24), and Ceramics (-3.1% pa over 2019-24). Some of these changes are likely to have been influenced by factors other than just worker behaviour and efficiency, for example, changes in prices of raw materials.

**Table G-4: Labour productivity (£ 2019 thousands of GVA per worker), 2019-2024**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | Average % growth |
|---|---|---|---|---|---|---|---|
| Paper and pulp | 65 | 63 | 86 | 84 | 96 | 95 | 7.8% |
| Chemicals | 145 | 182 | 158 | 157 | 117 | 120 | -3.8% |
| Glass | 56 | 64 | 75 | 51 | 59 | 61 | 1.7% |
| Ceramics | 80 | 58 | 79 | 54 | 67 | 69 | -3.1% |
| Cement | 125 | 106 | 101 | 77 | 83 | 86 | -7.2% |
| Metals | 34 | 54 | 63 | 46 | 44 | 47 | 6.9% |
| Foundation Industries | 81 | 90 | 98 | 85 | 84 | 86 | 1.2% |
| Manufacturing | 68 | 68 | 77 | 76 | 76 | 78 | 2.9% |
| Non-financial economy | 43 | 37 | 42 | 46 | 46 | 46 | 1.3% |

*Note: Data for 2023 and 2024 are estimated using MDM-E3. Totals may differ due to rounding.*

*Source: ONS (Business Register and Employment Survey; Annual Business Survey) and Cambridge Econometrics (MDM-E3).*

**G.27** R&D

**G.28** Table G-5 shows Foundation Industries' R&D spending[17] in monetary terms (£m) and as a percentage of the sector's GVA.

**Table G-5: R&D expenditure, 2022**

| | | 2022 |
|---|---|---|
| **R&D expenditure (£millions)** | Paper and pulp | 242 |
| | Chemicals | 861 |
| | Glass, Ceramics and Cement | 167 |

[17] R&D expenditure includes funding from a variety of public and private sources. See Annex E for more detail.

| | | 2022 |
|---|---|---|
| | Metals | 367 |
| **R&D expenditure / GVA (%)** | Paper and pulp | 5.1 |
| | Chemicals | 6.6 |
| | Glass, Ceramics and Cement | 2.3 |
| | Metals | 7.5 |

*Note: Data presented at a more aggregated SIC level of granularity than UKRI Foundation Industry sector definitions due to data limitations. SIC correspondence: Paper and pulp - SIC 17; Chemicals - SIC 20; Glass ceramic and cement - SIC23, Metals – SIC 24. Source: ONS (Research and Development in UK Businesses, 2022; Annual Business Survey).*

**G.29** R&D expenditure in 2022 varied across sectors, both in absolute terms and as a percentage of GVA. Chemicals spent the most on R&D (£861 million or 6.6% of the sector's GVA), followed by Metals, which spent £367 million (7.5% of the sector's GVA), and Paper and pulp (£242 million, or 5.1% of the sector's GVA). Glass, ceramics, and cement had the lowest expenditure (£167 million or 2.3% of the sectors' GVA), indicating a relatively limited focus on R&D compared to the other sectors.

### Investment

**G.30** Table G-6 shows real investment (gross fixed capital formation) in the Foundation Industries, manufacturing and the wider non-financial economy during the period 2019-24.[18] Investment in Foundation Industries as a whole increased by 3.6% pa over 2019-24, though investment decreased by 13% in 2020 during the COVID-19 pandemic, before picking back up and increasing by 19% in 2021 and 12% in 2022. Investment in the wider non-financial economy followed a similar trend, though growth was slower (1.4% pa over 2019-24). Investment in Manufacturing as a whole, however, decreased by 1.0% pa over 2019-24, driven by a sharp decrease in 2020 during the COVID-19 pandemic, after which investment has not recovered to pre-pandemic levels.

**G.31** The sector that saw the strongest growth in investment over the whole period was Paper and pulp (9.8% pa over 2019-24), followed by Cement (5.1% pa over 2019-24, supported by a strong recovery from the COVID-19 pandemic in 2021) and Chemicals (3.1% pa over 2019-24). Investment in Ceramics and Glass, however, decreased by 6.9% pa and 0.6% pa, respectively. Despite a strong increase in investment in Metals in 2022, there has not been much growth in investment in the sector since, resulting in investment in metals only increasing by 0.3% pa over 2019-24.

**G.32** Investment tends to fluctuate greatly from year to year, so longer time series tend to show a clearer picture of long-term trends in investment. For example, investment in the Foundation Industries decreased by 2.2% over 2008-19 (the period from the Global Financial Crisis to the start of the COVID-19 pandemic), which was in contrast to the recent 3.6% pa growth in

[18] The investment figures will capture large single investments, but the data are not sufficiently granular to identify specific cases where increases in investment have been driven by a single large investment.

investment over 2019-24. The fall in investment over 2008-19 was driven by a decrease in investment in Cement (−16.9% pa), Glass (−3.1% pa), and Metals (−0.8% pa). While there was a 5.1% pa increase in investment in cement over 2019-24, it is worth noting that there has been a long term trend of decline in investment in the sector. The increase in investment over 2019-24 in Paper and pulp and Chemicals reflects the long term trend of increasing investment in the sectors. Investment in Paper and pulp and Chemicals increased by 3.5% and 0.4% pa respectively over 2008-19, albeit at a slower rate than over 2019-24. Investment in Ceramics grew by 6.7% pa over 2008-19, in sharp contrast to the decline in investment in this sector over 2019-24 (−6.9% pa).

**Table G-6: Investment (£ 2019 millions), 2019-24**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | Average % growth |
|---|---|---|---|---|---|---|---|
| Paper and pulp | 414 | 518 | 534 | 614 | 643 | 660 | 9.8% |
| Chemicals | 1,153 | 883 | 1,170 | 1,313 | 1,341 | 1,341 | 3.1% |
| Glass | 153 | 135 | 159 | 148 | 149 | 148 | -0.6% |
| Ceramics | 97 | 71 | 70 | 67 | 68 | 68 | -6.9% |
| Cement | 117 | 94 | 156 | 149 | 151 | 150 | 5.1% |
| Metals | 346 | 278 | 271 | 352 | 354 | 351 | 0.3% |
| Foundation Industries | 2,280 | 1,978 | 2,359 | 2,642 | 2,706 | 2,718 | 3.6% |
| Manufacturing | 19,718 | 17,010 | 16,865 | 18,536 | 18,793 | 18,733 | -1.0% |
| Non-financial economy | 167,473 | 152,151 | 163,305 | 171,936 | 178,496 | 179,458 | 1.4% |

*Note: Data for 2023 and 2024 are estimated using MDM-E3. Totals may differ due to rounding.*

*Source: ONS (Annual Business Survey) and Cambridge Econometrics (MDM-E3).*

## Foreign Direct Investment

**1.2** Table G-7 shows (inward) Foreign Direct Investment (FDI) in the Foundation Industries.[19] The available data are not granular enough to identify FDI for each individual sector. FDI in Textiles and wood activities (which includes paper and pulp) decreased substantially between 2019 and 2021, falling from £179 million to £13 million. FDI in Petroleum, chemicals, pharmaceuticals,

[19] Table G-7 presents inward FDI. Inward FDI measures investments made in the UK by foreign investors. There can be both inflows (purchases of UK assets) and outflows (disposals of UK assets or reverse investments) of inward FDI. Inward FDI is usually presented on net bases, so the data are calculated by subtracting net outflows from net inflows. Inflows of inward FDI are investments in the UK by foreign investors. Outflows are disinvestments (disposal of assets to a third parts) or reverse investments (where the UK entity acquires assets of the foreign entity or provides a loan to the foreign entity). Outward FDI is not included in this table. Outward FDI measures investment by UK investors into foreign markets.

rubber and plastic products (which includes chemicals) was negative in 2019 and 2022 (reflecting stronger outflows than inflows), despite growth in FDI in 2020 and 2021. FDI in Metal and machinery products (which includes metals) fluctuated, but remained positive, with particularly strong growth in 2022, increasing from £273 million in 2021 to £6,971 million in 2022. FDI contributed considerably to output in metal and machinery products in 2022, accounting for 18% of GVA produced in those sectors in 2022.

**Table G-7: Foreign Direct Investment**

| | | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|
| £ million | Textiles & wood activities | 179 | - | 13 | - |
| | Petroleum, chemicals, pharmaceutical, rubber, plastic products | -1,069 | 762 | 1,933 | -4,204 |
| | Metal and machinery products | 696 | 1,954 | 273 | 6,971 |
| % of GDP | Textiles & wood activities | 1% | - | 0% | - |
| | Petroleum, chemicals, pharmaceuticals, rubber, plastic products | -4% | 2% | 6% | -11% |
| | Metal and machinery products | 2% | 7% | 1% | 18% |

*Note: Data presented at a more aggregated SIC level of granularity than UKRI Foundation Industry sector definitions due to data limitations. SIC correspondence: Textile & wood activities SIC 13, 14, 16, 17, 18; Petroleum, chemicals, pharmaceuticals, rubber, plastic products SIC 19, 20, 21, 22; Metal and machinery products SIC 24, 25, 28. Negative values represent a net disinvestment in the UK.*

*Source: ONS Foreign direct investment (FDI) involving UK companies.*

## Exports and imports

**G.33** Table G-8 shows the evolution of real exports in the Foundation Industries during the period 2019-24. Despite strong growth in exports in the Foundation Industries in 2022, exports increased modestly by 1.9% pa over 2019-24. This was driven by exports in Metals, which accounted for the largest share of the Foundation Industries' exports in each year (around 50-75%), and increased by 4.8% pa over 2019-24, while exports in all other sectors decreased over the same period.[20] Exports in Ceramics decreased by 16.2% pa over 2019-24, while it also declined in Paper and pulp (-7.3% pa over 2019-24) and Glass (-6.6% pa over 2019-24).

**Table G-8: Exports (£ 2019 millions), 2019-24**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | Average % growth |
|---|---|---|---|---|---|---|---|
| Paper and pulp | 2,601 | 2,208 | 1,972 | 2,413 | 1,780 | 1,781 | -7.3% |
| Chemicals | 20,112 | 21,554 | 20,946 | 21,725 | 17,978 | 19,081 | -1.0% |

[20] Trade figures for the Metals sector do not include the precious metals production sub-sector, because trade statistics for this sub-sector are distorted by gold trading (due to London's role as a gold trading hub, UK trade statistics are regularly distorted by gold trading).

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | Average % growth |
|---|---|---|---|---|---|---|---|
| Glass | 1,005 | 788 | 832 | 884 | 712 | 715 | -6.6% |
| Ceramics | 48 | 31 | 13 | 29 | 20 | 20 | -16.2% |
| Cement | 275 | 193 | 258 | 282 | 269 | 270 | -0.3% |
| Metals | 27,288 | 28,485 | 22,879 | 80,563 | 34,576 | 34,564 | 4.8% |
| Foundation Industries | 51,329 | 53,258 | 46,900 | 105,897 | 55,335 | 56,431 | 1.9% |

*Note: Data for 2024 have been estimated using MDM-E3. Data presented at a more aggregated SIC level than UKRI Foundation Industry sector definitions due to data limitations. Paper and pulp SIC 17; Chemicals SIC 20.11, 20.13, 20.14, 20.15, 20.16, and 20.5; Glass SIC 23.1; Ceramics SIC 23.3; Cement 23.5 and 23.6; and Metals 24.1 and 24.4. Totals may differ due to rounding.*

*Source: ONS (MQ10) and Cambridge Econometrics (MDM-E3).*

**G.34** Table G-9 shows the evolution of real imports in the Foundation Industries during the period 2019-24. Import in Foundation Industries decreased by 5.2% pa over 2019-24, with growth fluctuating year on year. There was strong growth in imports in 2021 following a decrease in 2020 during the COVID-19 pandemic, followed by another fall in 2023. The increase in 2021 was driven by imports in Chemicals, Cement and Ceramics, with Chemicals accounting for the biggest share of Foundation Industries' imports. As is the case with exports, Chemicals and Metals accounted for the largest share of imports, although Paper and pulp also accounted for 9-14% of imports over 2019-24, despite the sector accounting for 5% or less of imports each year. Growth in imports of Cement was the strongest, increasing by 15.7% pa over 2019-24, followed by Ceramics and Chemicals, which increased by 11.7% pa and 7.4% pa, respectively.

**Table G-9: Imports (£ 2019 millions), 2019-24**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | Average % growth |
|---|---|---|---|---|---|---|---|
| Paper and pulp | 7,279 | 6,167 | 6,414 | 9,948 | 6,519 | 6,480 | -2.3% |
| Chemicals | 21,780 | 19,649 | 35,200 | 37,345 | 30,554 | 31,125 | 7.4% |
| Glass | 1,852 | 1,443 | 2,163 | 2,319 | 2,114 | 2,094 | 2.5% |
| Ceramics | 560 | 435 | 793 | 1,862 | 982 | 973 | 11.7% |
| Cement | 889 | 683 | 1,441 | 2,208 | 1,857 | 1,840 | 15.7% |
| Metals | 33,042 | 19,373 | 27,824 | 18,289 | 7,673 | 7,614 | -25.4% |
| Foundation Industries | 65,402 | 47,749 | 73,835 | 71,970 | 49,699 | 50,126 | -5.2% |

*Note: Data for 2024 have been estimated using MDM-E3. Data presented at a more aggregated SIC level than UKRI Foundation Industry sector definitions due to data limitations. Paper and pulp SIC 17; Chemicals SIC 20.11, 20.13, 20.14, 20.15, 20.16, and 20.5; Glass SIC 23.1; Ceramics SIC 23.3; Cement 23.5 and 23.6; and Metals 24.1 and 24.4. Totals may differ due to rounding. Source: ONS (MQ10) and Cambridge Econometrics (MDM-E3).*

**G.35** Table G-10 shows the evolution of UK Foundation Industries' share of total world exports over 2019-23. Of the UK Foundation Industry sectors, Metals had the strongest presence in terms of exports in the global market, accounting for 9-10% of world metals exports in 2022 and 2023. UK Chemicals, and Paper and pulp exports were the second and third largest as proportions of total world exports and remained broadly stable over 2019-2023. The other sectors' shares of total world exports were also relatively stable, accounting for less than 1% of world exports in their respective sectors in most years.

**Table G-10: UK shares of total world exports, 2019-23**

| | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|
| Paper and pulp | 2.2% | 2.1% | 2.7% | 2.5% | 2.4% |
| Chemicals | 2.4% | 2.6% | 2.1% | 2.2% | 2.8% |
| Glass | 0.6% | 0.6% | 0.6% | 0.5% | 0.7% |
| Ceramics | 1.1% | 0.9% | 0.8% | 0.7% | 0.8% |
| Cement | 0.8% | 0.6% | 0.7% | 0.7% | 0.7% |
| Metals | 5.4% | 5.4% | 6.8% | 9.8% | 8.8% |

*Source: UN Comtrade*

## Emissions intensity[21]

**G.36** Table G-11 shows emissions intensity[22] for the Foundation Industries, Manufacturing and the wider non-financial economy. Emissions intensity in the Foundation Industries increased slightly over 2019-24, while emissions intensity in Manufacturing and the wider non-financial economy remained broadly unchanged. Within the Foundation Industries, there was a slight decrease in emissions intensity in Paper and pulp, Chemicals and Cement, while emissions intensity in Metals increased sharply. Despite decreases in emissions intensities in some of the sectors, all Foundation Industries still have higher emission intensities compared to Manufacturing as a whole and the wider non-financial economy.

**Table G-11: Emission intensity (thousand tonne of CO2 per £m of real GVA)**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | Average % growth |
|---|---|---|---|---|---|---|---|
| Paper and pulp | 0.6 | 0.7 | 0.5 | 0.6 | 0.5 | 0.5 | -3.4% |

[21] This section uses the standard definition of emissions intensity, which is typically either measured by dividing emissions by GVA or by GDP. While there are challenges to the use of this measure, emissions intensity for the overall economy is often calculated by dividing emissions by GDP. When presenting emissions intensity by sector, it is good practice to use GVA because GVA measures the value-added by the sector to the overall economy (GDP is equal to the sum of GVA across all sectors plus product subsidies and minus product axes). The ONS provides an overview of emissions intensity here.
[22] Emissions of greenhouse gases under the Kyoto protocol per unit of GVA.

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | Average % growth |
|---|---|---|---|---|---|---|---|
| Chemicals | 1.5 | 1.1 | 1.5 | 1.5 | 1.4 | 1.3 | -1.8% |
| Glass | 1.3 | 1.1 | 1.3 | 1.5 | 1.4 | 1.4 | 1.6% |
| Ceramics | 1.3 | 1.1 | 1.3 | 1.5 | 1.4 | 1.4 | 1.6% |
| Cement | 2.0 | 1.7 | 2.0 | 2.0 | 2.0 | 1.9 | -1.3% |
| Metals | 2.3 | 2.4 | 7.4 | 8.4 | 8.3 | 8.2 | 28.5% |
| Foundation Industries | 1.3 | 1.2 | 2.1 | 1.9 | 1.9 | 1.9 | 6.8% |
| Manufacturing | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | -2.8% |
| Non-financial economy | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | -3.8% |

*Note: Data for 2023 and 2024 are estimated using MDM-E3. Average growth may differ to the emission intensities presented due to rounding.*

*Source: ONS (Annual Business Survey, GHG emission in the UK) and Cambridge Econometrics (MDM-E3)*

## Reflections

**G.37** Examination of the individual sectors reveals their heterogeneity, with contrasting trends in key metrics. For instance Chemicals, and Paper and pulp are the two largest sectors within the Foundation Industries in terms of GVA, turnover, and GOS, but while GVA and GOS has increased in Paper and pulp, it has decreased in Chemicals. Metals is characterised by an increase in GVA, GOS, and labour productivity, and is the sector which accounts for the highest share of exports among the Foundation Industries, despite turnover in the sector having decreased over 2019-24. Among the smaller Foundation Industries, there was a strong decrease in GVA, turnover, GOS and labour productivity in Cement, driven by an increase in material costs.

**G.38** The emissions intensity of the Foundation Industries also increased by 6.8% pa, driven by an increase in emissions intensity in metals, despite emissions intensity decreasing in manufacturing as a whole by 2.8% pa over 2019-24. As a result, the Foundation Industries had much higher levels of emissions intensity in 2024 than manufacturing as a whole and the non-financial economy.

**G.39** Applying some caution based on the relatively short time period covered in this section, we can conclude that Foundation Industries follow dynamics that tend to diverge from the Manufacturing sector as a whole. On some measures (GVA, turnover, GOS, and labour productivity), manufacturing performed better than the Foundation Industries as a whole, while on others (investment), Manufacturing lagged behind the Foundation Industries.

# International comparison

**G.40** This section compares performance of the UK Foundation Industries with those in Belgium, France and Germany. The evidence on international comparison provides additional contextual evidence to inform the evaluation of TFI. It will not infer direct causal links between the Challenge and differences in performance between the UK Foundation Industries and the comparators.

## Comparison of key performance metrics

**G.41** The following tables present performance on the following key indicators by each Foundation Industry sector in Belgium, France, Germany and the UK in 2022:

- Employment
- Employment cost
- GVA
- Investment
- Labour productivity[23]
- Turnover

**G.42** Data were collected from the Eurostat Structural Business Statistics and ONS Annual Business Survey for the UK data with 2022 as the latest available year.[24] As the data are only a snapshot of performance in one year, some caution must be applied in interpreting results. Data from a different year may have indicated different respective performance between countries.

### Paper

**G.43** Table G-12 shows the performance of the paper and pulp sector among the selected countries. The UK sector accounted for a similar share of its manufacturing sector in terms of employment, employment costs, GVA and turnover in 2022 as the other countries, accounting for approximately 2%. It accounted for a slightly larger share of investment in manufacturing in the UK (3.3%) than in Belgium (1.3%) and Germany (2.3%), but in line with France (3.2%). However,

[23] For this report, the international comparisons use data from Eurostat and ONS Annual Business Survey for the UK data, which is collected by each country's national statistics office in accordance with a common set of guidelines and is further processed by Eurostat to make sure the data are harmonised. This improves the consistency and validity of comparing labour productivity across countries. Labour productivity comparisons between countries can be skewed by variation in purchasing power between countries. The comparators used in this report have very similar purchasing power to the UK so this is unlikely to affect the comparison.

[24] The data are provided to Eurostat by each country's National Statistics Office. In most countries a combination of survey and administrative data is used rather than company returns. The data are available for 4-digit level NACE codes.

the UK sector was one of the least productive of the four countries (£84,000 of GVA per worker), with Belgium's sector having the highest labour productivity (£91,000 of GVA per worker).

**Table G-12: Paper and pulp, international comparison, 2022**

| | Belgium | France | Germany | UK |
|---|---|---|---|---|
| Employment (% of Manufacturing) | 2.2% | 2.0% | 1.8% | 2.3% |
| Employment cost (% of Manufacturing) | 2.2% | 2.0% | 1.7% | 2.2% |
| GVA (% of Manufacturing) | 1.7% | 2.2% | 2.0% | 2.4% |
| Investment (% of Manufacturing) | 1.3% | 3.2% | 2.3% | 3.3% |
| Labour productivity (£k of GVA per worker, 2022 prices) | 91 | 82 | 88 | 84 |
| Turnover (% of Manufacturing) | 1.7% | 2.0% | 2.0% | 2.3% |

*Note: Manufacturing is defined as NACE Section C in Belgium, France, and Germany and SIC Section C in the UK.*

*Source: Eurostat (Structural Business Statistics; Currency exchange rates); ONS (Annual Business Statistics).*

## Chemicals

**G.44** In 2022, the UK chemicals sector represented a smaller share of the manufacturing sector compared to the other countries in terms of employment, employment cost, GVA, and turnover, as shown in Table G-13. Labour productivity in the sector (£202k of GVA per worker), however, was higher than Germany and France (£140k and £108k), but lower than in Belgium (£221k). Investment in the sector accounted for 7.1% of manufacturing investment, similar to Germany (8.1%), but much lower than Belgium (17.6%)

**Table G-13: Chemicals, international comparison, 2022**

| | Belgium | France | Germany | UK |
|---|---|---|---|---|
| Employment (% of Manufacturing) | 6.4% | 2.7% | 3.4% | 1.5% |
| Real employment cost (% of Manufacturing) | 10.4% | 3.6% | 5.4% | 2.4% |
| Real GVA (% of Manufacturing) | 11.6% | 4.0% | 5.9% | 3.8% |
| Real investment (% of Manufacturing) | 17.6% | 5.3% | 8.1% | 7.1% |

| | Belgium | France | Germany | UK |
|---|---|---|---|---|
| Labour productivity (£k of GVA per worker, 2022 prices) | 221 | 108 | 140 | 202 |
| Real turnover (% of Manufacturing) | 12.9% | 4.5% | 7.2% | 3.8% |

*Note(s); Manufacturing is defined as NACE Section C in Belgium, France, and Germany and SIC Section C in the UK.*

*Source(s): Eurostat (Structural Business Statistics; Currency exchange rates); ONS (Annual Business Statistics).*

## Glass

**G.45** The UK glass sector was comparable with the sector in Germany, accounting for 0.6-1.0% of manufacturing in terms of employment, employment costs, GVA, investment and turnover, whilst the sector accounted for a bigger share of manufacturing in Belgium and France across all indicators. The UK glass sector was the least productive with £63k of GVA per worker,[25] notably behind Belgium (£83k).

**Table G-14: Glass, international comparison, 2022**

| | Belgium | France | Germany | UK |
|---|---|---|---|---|
| Employment (% of Manufacturing) | 1.4% | 1.4% | 0.7% | 1.0% |
| Real employment cost (% of Manufacturing) | 1.6% | 1.6% | 0.6% | 0.8% |
| Real GVA (% of Manufacturing) | 1.0% | 1.5% | 0.6% | 0.8% |
| Real investment (% of Manufacturing) | 2.4% | 1.1% | 1.1% | 0.8% |
| Labour productivity (£k of GVA per worker, 2022 prices) | 83 | 75 | 74 | 63 |
| Real turnover (% of Manufacturing) | 1.2% | 1.1% | 0.5% | 0.6% |

*Note(s): Manufacturing is defined as NACE Section C in Belgium, France, and Germany and SIC Section C in the UK.*

*Source: Eurostat (Structural Business Statistics; Currency exchange rates); ONS (Annual Business Statistics).*

[25] Note differences in productivity between countries could be due to differences in product mix but the data are not sufficiently detailed to show this. To mitigate the risk that the comparator country TFI sectors produce different products, we chose countries that export a high proportion of their total exports to the UK, on the basis that these countries are more likely to produce goods that UK producers are directly competing to sell on the domestic market.

## Ceramics

**G.46** The ceramics sector accounted for around 0.7% of manufacturing employment, 0.6% of manufacturing employment cost and GVA and 0.4% of manufacturing investment and turnover, similar to all comparator countries.

**G.47** Table Productivity in the sector (£67k of GVA per worker) was lower than in Belgium (£107k) and Germany (£76k).

**Table G-15: Ceramics, international comparison, 2022**

| | Belgium | France | Germany | UK |
|---|---|---|---|---|
| Employment (% of Manufacturing) | 0.6% | 0.4% | 0.5% | 0.7% |
| Real employment cost (% of Manufacturing) | 0.6% | 0.3% | 0.4% | 0.6% |
| Real GVA (% of Manufacturing) | 0.5% | 0.3% | 0.5% | 0.6% |
| Real investment (% of Manufacturing) | 0.8% | 0.4% | 0.4% | 0.4% |
| Labour productivity (£k of GVA per worker, 2022 prices) | 107 | 56 | 76 | 67 |
| Real turnover (% of Manufacturing) | 0.3% | 0.2% | 0.3% | 0.4% |

*Note(s): Manufacturing is defined as NACE Section C in Belgium, France, and Germany and SIC Section C in the UK.*

*Source(s): Eurostat (Structural Business Statistics; Currency exchange rates); ONS (Annual Business Statistics)*

## Cement

**G.48** Table G-16 shows the international comparison for the cement sector among the selected countries. The cement sector in the UK accounted for 0.4% of manufacturing in terms of employment, 0.5% of manufacturing employment costs and GVA, and 0.8% of manufacturing investment and turnover, which is comparable to France and Germany, but not as prominent a sector as in Belgium. Productivity in the UK cement sector was £96k of GVA per worker, which was lower than Belgium (£117k) and Germany (£97k), but higher than France (£57k).

**Table G-16: Cement, international comparison, 2022**

| | Belgium | France | Germany | UK |
|---|---|---|---|---|
| Employment (% of Manufacturing) | 1.2% | 0.8% | 0.4% | 0.4% |
| Real employment cost (% of Manufacturing) | 1.4% | 0.7% | 0.4% | 0.5% |
| Real GVA (% of Manufacturing) | 1.2% | 0.7% | 0.5% | 0.5% |
| Real investment (% of Manufacturing) | 1.3% | 0.8% | 0.7% | 0.8% |
| Labour productivity (£k of GVA per worker, 2022 prices) | 117 | 57 | 97 | 96 |
| Real turnover (% of Manufacturing) | 0.9% | 0.7% | 0.4% | 0.8% |

*Note(s): Manufacturing is defined as NACE Section C in Belgium, France, and Germany and SIC Section C in the UK.*

*Source(s): Eurostat (Structural Business Statistics; Currency exchange rates); ONS (Annual Business Statistics).*

## Metals

**G.49** Table G-17 shows the performance of the metals sector within the selected countries. The metals sector in the UK accounted for 1.1-1.3% of total manufacturing employment and GVA, 1.5% of manufacturing employment cost, and 1.8-1.9% of investment and turnover, representing the smallest shares among the countries considered. As with the glass sector, it had the lowest labour productivity (£64,000 of GVA per worker), much lower than productivity in the other countries, which was between £99,000-£190,000 GVA per worker.

**Table G-17: Metals, international comparison, 2022**

| | Belgium | France | Germany | UK |
|---|---|---|---|---|
| Employment (% of Manufacturing) | 3.0% | 1.3% | 1.8% | 1.3% |
| Real employment cost (% of Manufacturing) | 4.1% | 1.6% | 2.2% | 1.5% |
| Real GVA (% of Manufacturing) | 4.8% | 1.7% | 2.5% | 1.1% |
| Real investment (% of Manufacturing) | 3.3% | 2.2% | 3.1% | 1.9% |

| | Belgium | France | Germany | UK |
|---|---|---|---|---|
| Labour productivity (£k of GVA per worker, 2022 prices) | 190 | 99 | 113 | 64 |
| Real turnover (% of Manufacturing) | 4.7% | 2.7% | 4.3% | 1.8% |

*Note(s): Manufacturing is defined as NACE Section C in Belgium, France, and Germany and SIC Section C in the UK.*

*Source(s): Eurostat (Structural Business Statistics; Currency exchange rates); ONS (Annual Business Statistics).*

### Patents

**G.50** Table G-18 shows the number of patents by Foundation Industry sector in the different countries.[26] In each sector, Germany issued the most patents, followed by France, and then usually UK and then Belgium. This indicates that the UK lags on this measure of innovative activity within the FIs compared to Germany and France. This result can be partially linked to the smaller weight in the overall UK economy (e.g. in terms of employment and GVA) of sectors such as chemicals and metals, while in sectors whose dimension is similar across all four countries, such as glass, ceramics and cement, the fewer number of patents issued in the UK reflects weaker innovation. There may also be national business or cultural factors influencing these measures, which can be explored through other aspects of the evaluation, such as the qualitative research.

**Table G-18: Number of patents by FI sector, 2020**

| | Belgium | France | Germany | UK |
|---|---|---|---|---|
| Paper and pulp | 2 | 16 | 18 | 12 |
| Chemicals | 300 | 1,036 | 1,843 | 808 |
| Glass, ceramics and cement | 34 | 156 | 294 | 52 |
| Metals | 14 | 59 | 130 | 13 |

*Note: Data presented at a more aggregated SIC level of granularity than UKRI Foundation Industry sector definitions due to data limitations. The correspondence is based on a mapping between the IPC v8 classification and the NACE classification, see https://ec.europa.eu/eurostat/ramon/documents/IPC_NACE2_Version2_0_20150630.pdf.*

*Source: OECD (Patents by technology)*

## Conclusions

**G.51** The table below summarise the UK's rankings among the four countries in terms of three of the indicators reported on above: labour productivity, innovation (as measured by patents) and GVA as a share of manufacturing. The rankings should be considered with caution due to the issues

[26] Note, there is a case for scaling patents to the relevant national economy for a fairer comparison.

that can affect country performance on the same metrics, but may be indicative of relative performance.

**Table G-19: UK ranking in performance of FI sectors, relative to Belgium, France and Germany, 2022**

| | Labour productivity | Number of patents | GVA as share of Manufacturing |
|---|---|---|---|
| Paper and pulp | 3 | 3 | 1 |
| Chemicals | 2 | 3 | 4 |
| Glass | 4 | 3 | 3 |
| Ceramics | 3 | 3 | 1 |
| Cement | 3 | 3 | 3 |
| Metals | 4 | 4 | 4 |

*Source: Cambridge Econometrics' calculations.*

**G.52** The data show that two of the UK's six Foundation Industries sectors (glass and metals) were the least productive among the countries considered. The UK ranked second among the four countries in the chemicals sector and third in the paper and pulp, ceramics and cement sectors.

**G.53** In terms of the number of patents issued, the UK ranked third in five out of the six sectors, with its lowest position being fourth in the metals sector, reflecting that the UK sector lagged in terms of innovation, as measured by patents.

**G.54** The UK ranked highest in terms of GVA as a share of manufacturing in both the paper and pulp and ceramics sectors, reflecting these sectors represent a bigger proportion of the manufacturing economy in the UK than in the other countries. The UK ranked lowest, however, in chemicals and metals on this measure.

**G.55** Overall, the international comparison indicates that, despite some strengths (the paper and pulp and ceramics sectors), there is scope for UK Foundation Industries to catch up with their peers in competitor countries. This points to particular need for support for the glass, chemicals and metals sectors, although with the caveat that the data represent a snapshot of performance in 2022.

## Updated projections

**G.56** This section presents projections for the Foundation Industries up to 2040 on economic and energy metrics (GVA, employment, labour productivity and emissions). The projections are based on historical data to 2022/2023 (depending on the variable), which includes the TFI programme period. The modelling provides a baseline business-as-usual trajectory of the FI, and does not attempt to estimate potential future major disruptions.

## GVA

**G.57** Real GVA in the Foundation Industries is expected to increase by 0.8% pa over 2024-30, before slowing down to 0.6% pa over 2030-40. Over this period, GVA is expected to grow at a faster pace in manufacturing as a whole (0.9-1.0% pa over 2024-40) and the wider non-financial economy (1.2% pa over 2024-40).

**G.58** Chemicals, glass, ceramics and cement are the Foundation Industry sectors for which GVA is expected to grow the fastest in the medium term (1.0% pa over 2024-30), following a period of decline over 2019-24. Growth in glass, ceramics and cement, however, are expected to slow down to 0.1% pa over 2030-40. After strong GVA growth in paper and pulp and metals over 2019-24, GVA growth in these sectors is expected to slow down to 0.5-0.8% pa over 2024-40.

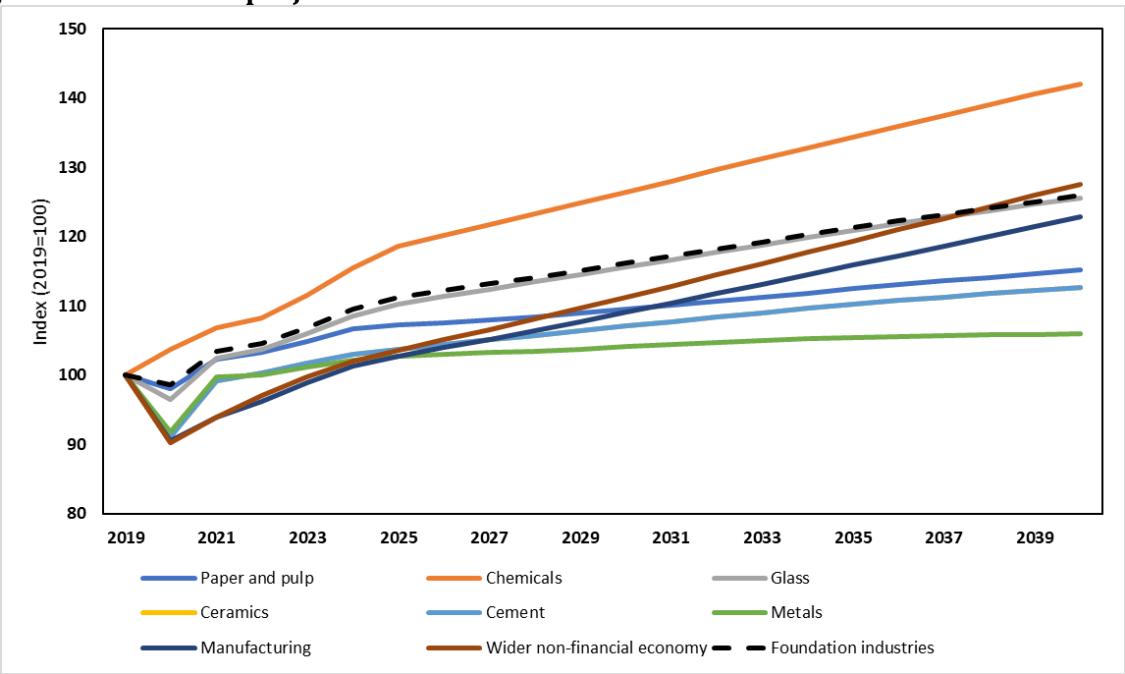
**G.59** The levels projections for 2024, 2030 and 2040 are provided in Table G-20, with the projection over time (indexed to 2019) shown in Figure G-1.

**Table G-20: Real GVA projections to 2040**

| | Levels (£ 2019 millions) | | | Growth (% pa) | | |
|---|---|---|---|---|---|---|
| | **2024** | **2030** | **2040** | **2019-24** | **2024-30** | **2030-40** |
| Paper and pulp | 4,726 | 4,900 | 5,331 | 5.6% | 0.6% | 0.8% |
| Chemicals | 5,354 | 5,668 | 6,112 | -1.5% | 1.0% | 0.8% |
| Glass | 1,185 | 1,255 | 1,266 | -0.3% | 1.0% | 0.1% |
| Ceramics | 867 | 919 | 927 | -3.9% | 1.0% | 0.1% |
| Cement | 797 | 845 | 852 | -7.1% | 1.0% | 0.1% |
| Metals | 1,581 | 1,642 | 1,730 | 6.7% | 0.6% | 0.5% |
| Foundation industries | 14,510 | 15,229 | 16,217 | 0.8% | 0.8% | 0.6% |
| Manufacturing | 188,786 | 199,842 | 218,740 | 2.1% | 1.0% | 0.9% |
| Wider non-financial economy | 1,460,457 | 1,569,083 | 1,765,607 | 2.2% | 1.2% | 1.2% |

*Source(s): ONS (Annual Business Survey) and Cambridge Econometrics (MDM-E3)*

**Figure G-1: Real GVA projections to 2040**




*Source: ONS (Annual Business Survey) and Cambridge Econometrics (MDM-E3)*

## Employment

**G.60** The Foundation Industries are expected to lose 32,000 jobs over 2024-40 (1.3% pa), following a trajectory similar to that of the manufacturing sector, in which employment is expected to decrease by 1.1% pa over 2024-40. In contrast, employment is expected to increase by 0.4% pa in the wider non-financial economy.

**G.61** Employment is expected to decline in all of the Foundation Industry sectors. In particular, it is expected to decrease fastest in glass, ceramics and cement (-2.0% pa over 2024-30 and -2.8% pa over 2030-40). The largest decrease in employment over 2024-40 in terms of the number of jobs is expected in chemicals (8,000 jobs) and metals (7,000 jobs).

**G.62** The levels projections for 2024, 2030 and 2040 are provided in Table G-21, with the projection over time (indexed to 2019) shown in Figure G-2.

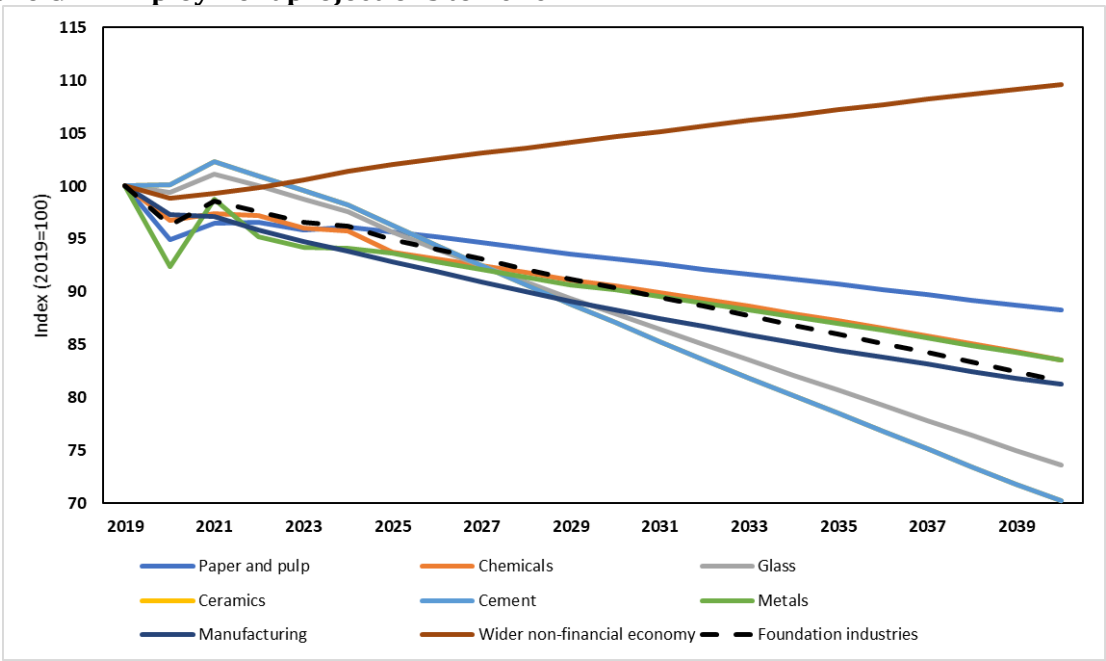
**Table G-21: Employment projections to 2040**

| | Levels (000s) | | | Growth (% pa) | | |
|---|---|---|---|---|---|---|
| | 2019 | 2030 | 2040 | 2019-24 | 2024-30 | 2030-40 |
| Paper and pulp | 50 | 48 | 46 | -2.0% | -0.5% | -0.6% |
| Chemicals | 45 | 42 | 37 | 2.3% | -1.1% | -1.3% |
| Glass | 19 | 17 | 13 | -1.9% | -2.0% | -2.8% |
| Ceramics | 13 | 11 | 8 | -0.9% | -2.0% | -2.8% |

| | Levels (000s) | | | Growth (% pa) | | |
|---|---|---|---|---|---|---|
| Cement | 9 | 8 | 6 | 0.1% | -2.0% | -2.8% |
| Metals | 33 | 31 | 27 | -0.2% | -1.3% | -1.4% |
| Foundation industries | 169 | 158 | 137 | -0.4% | -1.1% | -1.4% |
| Manufacturing | 2,414 | 2,247 | 2,024 | -0.8% | -1.2% | -1.0% |
| Wider non-financial economy | 31,967 | 32,812 | 34,268 | 0.8% | 0.4% | 0.4% |

*Source: ONS (Business Register and Employment Survey; Annual Business Survey); Cambridge Econometrics (MDM-E3).*

**Figure G-2: Employment projections to 2040**




*Source: ONS (Annual Business Survey) and Cambridge Econometrics (MDM-E3)*

## Labour productivity

**G.63** Real labour productivity is expected to grow in all of the Foundation Industries sectors by 2.0-2.1% pa over 2024-40, in line with the manufacturing sector as a whole, but more than double the rate of growth expected in the wider non-financial economy (0.7-0.8% pa over 2024-40).

**G.64** Labour productivity is expected to increase in all Foundation Industry sectors. In particular, labour productivity in glass, ceramic and cement are expected to increase the fastest (3.0% pa over 2024-40), followed by chemicals and metals (1.9-2.0% pa over 2024-40). Chemicals is expected to remain the most productive sector by a great margin, while metals is projected to remain the least productive.

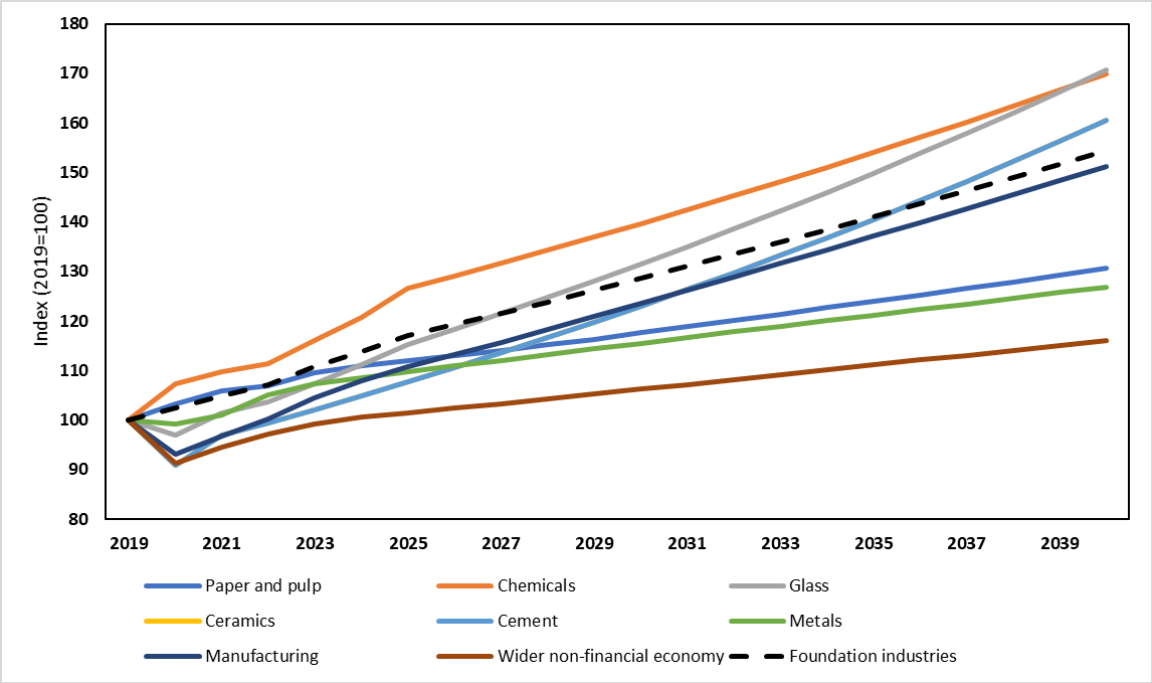
**G.65** The levels projections for 2024, 2030 and 2040 are provided in Table G-22, with the projection over time (indexed to 2019) shown in Figure G-3.

**Table G-22: Labour productivity projections to 2040**

| | Levels (£ 2019 thousands GVA per worker) | | | Growth (% pa) | | |
|---|---|---|---|---|---|---|
| | 2024 | 2030 | 2040 | 2019-2024 | 2024-30 | 2030-40 |
| Paper and pulp | 95 | 101 | 117 | 7.8% | 1.1% | 1.4% |
| Chemicals | 120 | 135 | 166 | -3.8% | 2.0% | 2.0% |
| Glass | 61 | 73 | 98 | 1.7% | 3.0% | 3.0% |
| Ceramics | 69 | 82 | 111 | -3.1% | 3.0% | 3.0% |
| Cement | 86 | 102 | 138 | -7.2% | 3.0% | 3.0% |
| Metals | 47 | 53 | 65 | 6.9% | 1.9% | 1.9% |
| Foundation industries | 86 | 97 | 119 | 1.2% | 2.0% | 2.1% |
| Manufacturing | 78 | 89 | 108 | 2.9% | 2.2% | 2.0% |
| Wider non-financial economy | 46 | 48 | 52 | 1.3% | 0.8% | 0.7% |

*Source: ONS (Business Register and Employment Survey; Annual Business Survey); Cambridge Econometrics (MDM-E3).*

**Figure G-3: Labour productivity projections to 2040**




*Source: ONS (Annual Business Survey) and Cambridge Econometrics (MDM-E3)*

## Emissions

**G.66** Emissions by the Foundation Industries are expected to decline by 1.8-2.0% pa over 2024-40, slightly slower than the rate the wider non-financial economy and manufacturing as a whole is expected to reduce emissions over the same period (-2.5% pa and -3.2% pa, respectively).

**G.67** All Foundation Industries are expected to reduce their levels of emissions. The fastest rate of emissions decline is expected in chemicals (-4.5% pa over 2024-40), followed by paper and pulp (-3.5% pa over 2024-40). The biggest decrease in emissions in terms of thousand tonnes of CO2 equivalent is expected in Chemicals, with a decrease of 3,725 thousand tonnes of CO2 equivalent over 2024-40.

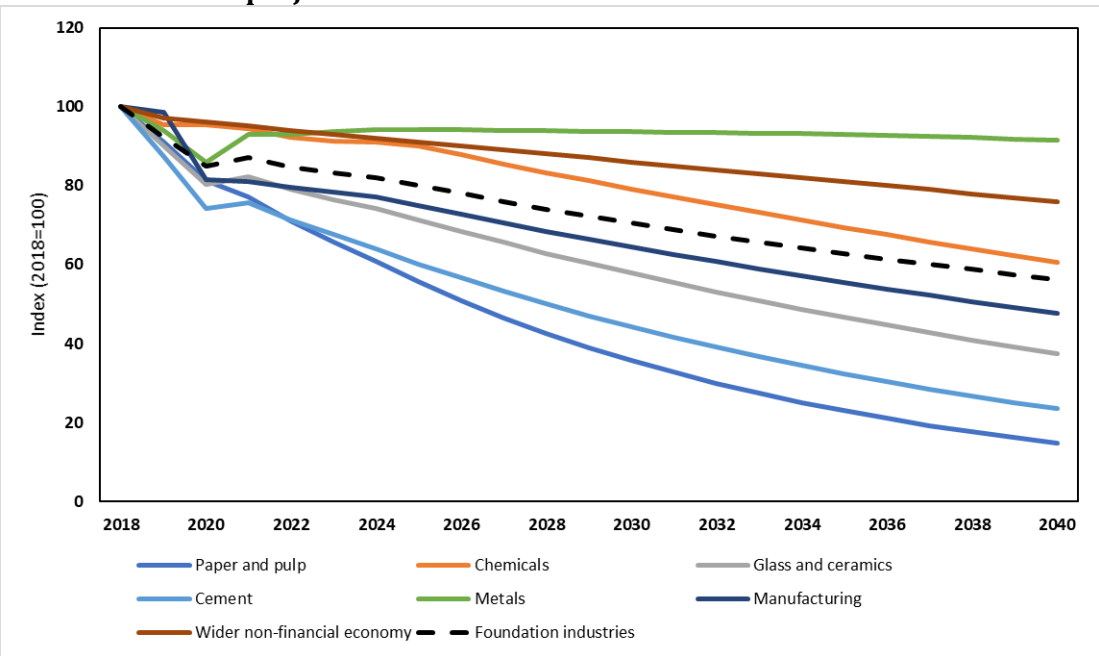
**G.68** The levels projections for 2024, 2030 and 2040 are provided in Table G-23, with the projection over time (indexed to 2019) shown in Figure G-4.

**Table G-23: Emissions projections to 2040**

| | Levels (Thousand tonnes of CO2 equivalent) | | | Growth (% pa) | | |
|---|---|---|---|---|---|---|
| | 2024 | 2030 | 2040 | 2019-24 | 2024-30 | 2030-40 |
| Paper and pulp | 2,384 | 1,906 | 1,344 | 2.0% | -3.7% | -3.4% |
| Chemicals | 7,155 | 5,247 | 3,430 | -3.4% | -5.0% | -4.2% |
| Glass | 1,693 | 1,683 | 1,527 | 1.3% | -0.1% | -1.0% |
| Ceramics | 1,240 | 1,233 | 1,118 | -2.4% | -0.1% | -1.0% |
| Cement | 1,516 | 1,360 | 1,038 | -8.3% | -1.8% | -2.7% |
| Metals | 12,937 | 12,366 | 11,342 | 37.2% | -0.7% | -0.9% |
| Foundation industries | 26,925 | 23,794 | 19,800 | 7.6% | -2.0% | -1.8% |
| Manufacturing | 67,019 | 55,343 | 40,046 | -0.8% | -3.1% | -3.2% |
| Wider non-financial economy | 253,212 | 217,262 | 168,062 | -1.7% | -2.5% | -2.5% |

*Source: ONS (Annual Business Survey; GHG emissions in the UK); Cambridge Econometrics (MDM-E3).*

**Figure G-4: Emissions projections to 2040**




*Source: ONS (Annual Business Survey) and Cambridge Econometrics (MDM-E3)*

## Conclusions

**G.69** The modelled projections provide one way of understanding the potential trajectory of the Foundation Industries over the next couple of decades to 2040. The model is based on past trends and is informed by expert views on likely macroeconomic and market trends. The projections provide a baseline 'business as usual' trajectory of the Foundation Industries, and does not attempt to estimate potential future major disruptions. The advantage of the projections is that they provide a quantified description of the potential future performance of the Foundation Industries.

**G.70** In summary, the projections suggest that GVA growth in the Foundation Industries over 2024-40 is expected to be slower than in manufacturing as a whole and the wider non-financial economy. Both employment and emissions in the Foundation Industries are expected to decrease, in line with manufacturing as a whole (for employment) and the wider non-financial economy (for employment and GHG emissions). Labour productivity in the Foundation Industries and manufacturing as a whole, therefore, is projected to increase, despite it decreasing in the wider non-financial economy. Labour productivity in the Foundation Industries is expected to increase at a faster pace than over 2019-24, catching up with expected labour productivity growth in manufacturing as a whole, and outpacing expected labour productivity growth in the wider non-financial economy. The increase in labour productivity is expected to be supported by employment in the Foundation Industries and manufacturing as a whole decreasing at a faster pace than over 2019-24.

**G.71** Chemicals and paper and pulp stand out as the sectors with the greatest relative increase in GVA over the projection period, driving most of the GVA increase in the Foundation Industries as a whole. Employment in glass, ceramics and cement is expected to decrease at the fastest rate

within the Foundation Industries sectors, with labour productivity in those sectors also increasing at the fastest rate, and faster than manufacturing as a whole and the wider non-financial economy. GVA, employment and labour productivity growth in metals is projected to be in line with the Foundation Industries as a whole. All Foundation Industries are expected to reduce their levels of emissions, with chemicals projected to be the sector expected to decrease its emissions the most.

## Comparison of baseline projections to outturns

**G.72** The TFI baseline report, published in May 2021, included projections for each of the FI sectors, the Foundation Industries as a whole, manufacturing, and the wide non-financial economy to 2040. An analysis was undertaken to compare the projections from the baseline report against outturns over the period 2019-24.[27] Broadly, this analysis shows how the Foundation Industries have performed since the start of the programme, relative to expectations in the baseline report.

**G.73** Table G-24 shows both the projections (from the baseline report) and outturns for GVA, employment, labour productivity, and GHG emissions in the Foundation Industries over 2019-24. In this period, the growth in GVA and labour productivity was lower than expected. At the time of the baseline report, GVA in the Foundation Industries was expected to grow by 1.8% pa, while the growth in outturns was 0.8% pa. Similarly, growth in labour productivity was expected to be 2.6% pa, while the growth in outturns was 1.2% pa. Employment in the Foundation Industries was expected to fall by 0.8% pa over 2019-24, while the decrease in outturns was smaller, at 0.4% pa. The baseline report projected GHG emissions to fall by 2.3% pa in the Foundation Industries, but emissions outturns increased over 2019-24 by 7.6% pa.

**Table G-24: Annual growth of Foundation Industries over 2019-24**

| Variable | Previous projections (baseline report), % pa growth | Outturns, % pa growth |
|---|---|---|
| GVA | 1.8% | 0.8% |
| Employment | -0.8% | -0.4% |
| Labour productivity | 2.6% | 1.2% |
| GHG emissions | -2.3% | 7.6% |

*Notes: Outturns for 2024 estimated for employment; outturns for 2023 and 2024 are estimated for GVA, labour productivity, and GHG emissions. Estimations are made using MDM-E.*

*Sources: ONS (Annual Business Survey; Business Register and Employment Survey; GHG emissions in the UK); Cambridge Econometrics (MDM-E3).*

**G.74** Figure G-5 shows the comparison between the baseline report projections and outturns in the Foundation Industries over 2019-24 in four individual charts for GVA, employment, labour productivity, and GHG emissions. Both GVA and labour productivity growth outperformed the

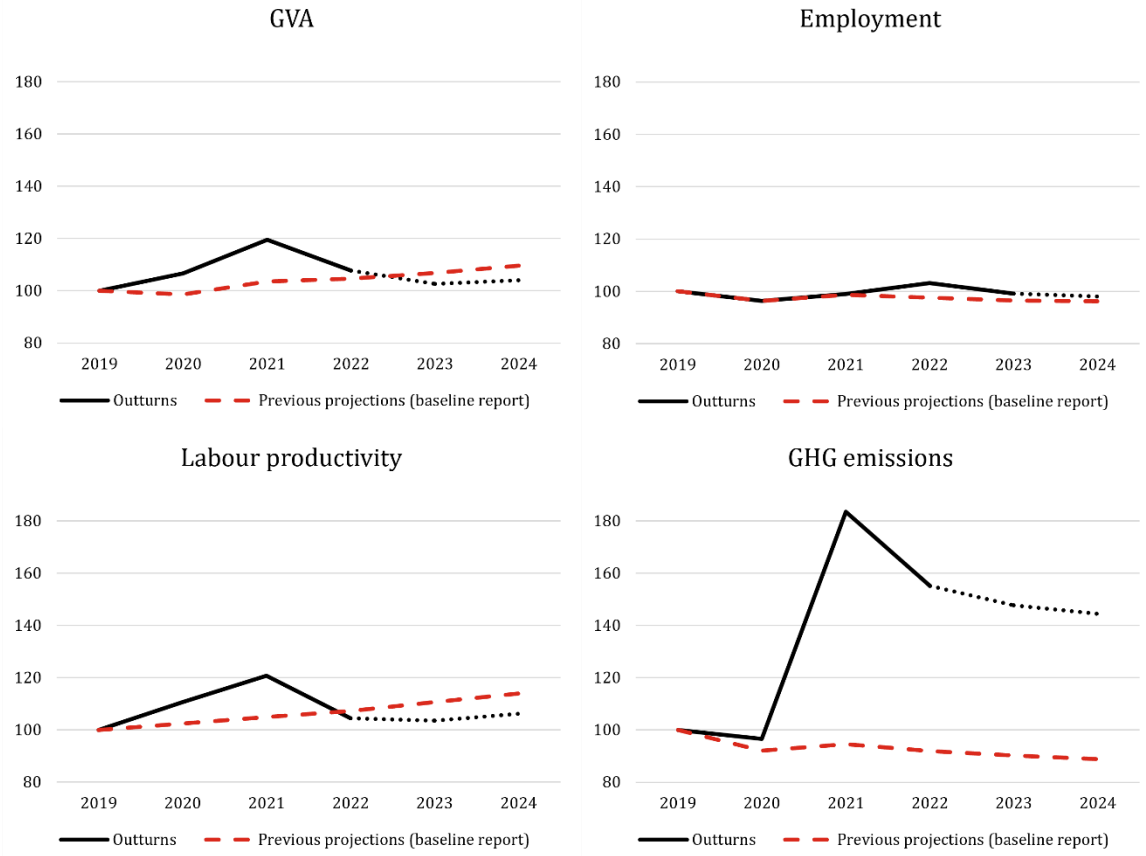
[27] Outturns refers to observed data from 2019 to 2022 or 2023, as well as estimated values for 2023 and/or 2024, depending on the variable. Estimates were made using forecasts from MDM-E3.

original projections up until 2022, though the more recent forecasts track below those original projections through to 2024. GVA growth in metals, glass and chemicals, in particular, was faster than expected over 2019-21, while growth in ceramics and cement was slower than expected over the whole period (2019-24). Labour productivity growth in cement, chemicals, and ceramics over 2019-24 was slower than projected in the baseline, while it was generally faster than expected in paper and pulp and metals.

**G.75** While employment growth in the Foundation Industries as a whole was roughly in line with the baseline projections, growth in the individual sectors differed from expectations. In particular, employment growth in metals and cement was faster than expected in the baseline projections.

**G.76** Outturns in GHG emissions are the most different from projections of any of the variables. There was a large observed increase in GHG emissions growth in 2021, which was primarily driven by metals, more specifically, iron and steel production. Though growth in GHG emissions decreased from 2022 to 2024, growth was still faster over 2019-24 than expected. Growth in GHG emissions in metals, paper and pulp and glass was faster than expected, while growth in GHG emissions in cement was slower than expected.

**Figure G-5: Growth in the Foundation Industries over 2019-24 (2019=100)**




*Notes: 2023 and/or 2024 data, as indicated by the dotted line in the Outturns series, are estimated based on historical data and forecasts from MDM-E3.*

*Sources: ONS (Annual Business Survey); Cambridge Econometrics (MDM-E3).*

### Conclusions

**G.77** Performance in the Foundation Industries compared to the baseline projections has varied, depending on the indicator in question. GVA and labour productivity growth over 2019-24 have both been slower than expected, while growth in GHG emissions over the same period has been considerably faster than expected, against the expectation in the baseline report that GHG emissions would decrease over 2019-24. Only employment growth was slightly better than expected, with a slower decrease in employment than projected in the baseline report. Part of GVA and labour productivity outturns might be attributable to the economic shock of the COVID-19 pandemic; however, real GVA in five of the six FI sectors (chemicals, glass, ceramics, cement, and metals) decreased over 2021-24, the period when other sectors were recovering from the COVID-19 shock.

**G.78** Of the FI sectors, there has been GVA growth in only metals and paper and pulp over 2019-24, accompanied by an increase in labour productivity in these two sectors over that period. There was, however, also a strong increase in GHG emissions in metals over 2019-24, a concerning trend for the UK's decarbonisation efforts.

## Sub-sector indicators

### Paper and pulp

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| GVA (£2019 millions) | 3,598 | 3,300 | 4,474 | 4,773 | 4,617 | 4,726 |
| Turnover (£2019 millions) | 12,113 | 11,669 | 12,232 | 12,246 | 11,845 | 12,125 |
| Gross operating surplus (£2019 millions) | 1,612 | 1,285 | 2,374 | 2,965 | 2,889 | 2,949 |
| Employment (000s) | 55 | 52 | 52 | 57 | 48 | 50 |
| Labour productivity (£2019 thousands of GVA per worker) | 65 | 63 | 86 | 84 | 96 | 95 |
| Investment (£2019 millions) | 414 | 518 | 534 | 614 | 643 | 660 |
| Emissions intensity (Thousand tonnes of carbon dioxide equivalent per £1m of GVA) | 0.6 | 0.7 | 0.5 | 0.6 | 0.5 | 0.5 |
| Exports (£2019m) | 2,601 | 2,208 | 1,972 | 2,413 | 1,780 | 1,781 |
| Imports (£2019m) | 7,279 | 6,167 | 6,414 | 9,948 | 6,519 | 6,480 |

*Note: data for 2019 is estimated using MDM.*

*Source: ONS (Annual Business Survey, GHG emission in the UK), Comext and Cambridge Econometrics (MDM-E3)*

## Chemicals

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| GVA (£2019 millions) | 5,784 | 6,589 | 6,550 | 5,769 | 5,297 | 5,354 |
| Turnover (£2019 millions) | 17,899 | 18,565 | 20,132 | 17,923 | 16,456 | 16,633 |
| Gross operating surplus (£2019 millions) | 3,476 | 4,277 | 4,395 | 3,930 | 3,659 | 3,732 |
| Employment (000s) | 40 | 36 | 41 | 37 | 45 | 45 |
| Labour productivity (£2019 thousands of GVA per worker) | 145 | 182 | 158 | 157 | 117 | 120 |
| Investment (£2019 millions) | 1,153 | 883 | 1,170 | 1,313 | 1,341 | 1,341 |
| Emissions intensity (Thousand tonnes of carbon dioxide equivalent per £1m of GVA) | 1.5 | 1.1 | 1.5 | 1.5 | 1.4 | 1.3 |
| Exports (£2019m) | 20,112 | 21,554 | 20,946 | 21,725 | 17,978 | 19,081 |
| Imports (£2019m) | 21,780 | 19,649 | 35,200 | 37,345 | 30,554 | 31,125 |

*Note: data for 2019 is estimated using MDM.*

*Source: ONS (Annual Business Survey, GHG emission in the UK), Comext and Cambridge Econometrics (MDM-E3)*

## Glass

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| GVA (£2019 millions) | 1,200 | 1,395 | 1,381 | 1,238 | 1,171 | 1,185 |

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Turnover (£2019 millions) | 3,712 | 2,750 | 3,149 | 2,921 | 2,762 | 3,712 |
| Gross operating surplus (£2019 millions) | 462 | 729 | 634 | 621 | 554 | 579 |
| Employment (000s) | 21 | 22 | 18 | 24 | 20 | 19 |
| Labour productivity (£2019 thousands of GVA per worker) | 56 | 64 | 75 | 51 | 59 | 61 |
| Investment (£2019 millions) | 153 | 135 | 159 | 148 | 149 | 148 |
| Emissions intensity (Thousand tonnes of carbon dioxide equivalent per £1m of GVA) | 1.3 | 1.1 | 1.3 | 1.5 | 1.4 | 1.4 |
| Exports (£2019m) | 1,005 | 788 | 832 | 884 | 712 | 715 |
| Imports (£2019m) | 1,852 | 1,443 | 2,163 | 2,319 | 2,114 | 2,094 |

*Note: data for 2019 is estimated using MDM.*

*Source: ONS (Annual Business Survey, GHG emission in the UK), Comext and Cambridge Econometrics (MDM-E3)*

## Ceramics

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| GVA (£2019 millions) | 1,061 | 812 | 1,009 | 907 | 857 | 867 |
| Turnover (£2019 millions) | 2,041 | 1,867 | 1,862 | 1,806 | 1,707 | 2,041 |
| Gross operating surplus (£2019 millions) | 561 | 346 | 488 | 386 | 337 | 356 |

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Employment (000s) | 13 | 14 | 13 | 17 | 13 | 13 |
| Labour productivity (£2019 thousands of GVA per worker) | 80 | 58 | 79 | 54 | 67 | 69 |
| Investment (£2019 millions) | 97 | 71 | 70 | 67 | 68 | 68 |
| Emissions intensity (Thousand tonnes of carbon dioxide equivalent per £1m of GVA) | 1.3 | 1.1 | 1.3 | 1.5 | 1.4 | 1.4 |
| Exports (£2019m) | 48 | 31 | 13 | 29 | 20 | 20 |
| Imports (£2019m) | 560 | 435 | 793 | 1,862 | 982 | 973 |

*Note: data for 2019 is estimated using MDM.*

*Source: ONS (Annual Business Survey, GHG emission in the UK), Comext and Cambridge Econometrics (MDM-E3)*

## Cement

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| GVA (£2019 millions) | 1,155 | 1,012 | 945 | 833 | 788 | 797 |
| Turnover (£2019 millions) | 4,393 | 3,969 | 4,400 | 3,930 | 3,715 | 3,760 |
| Gross operating surplus (£2019 millions) | 643 | 563 | 476 | 395 | 350 | 367 |
| Employment (000s) | 9 | 10 | 9 | 11 | 9 | 9 |
| Labour productivity (£2019 thousands of GVA per worker) | 125 | 106 | 101 | 77 | 83 | 86 |

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Investment (£2019 millions) | 117 | 94 | 156 | 149 | 151 | 150 |
| Emissions intensity (Thousand tonnes of carbon dioxide equivalent per £1m of GVA) | 2.0 | 1.7 | 2.0 | 2.0 | 2.0 | 1.9 |
| Exports (£2019m) | 275 | 193 | 258 | 282 | 269 | 270 |
| Imports (£2019m) | 889 | 683 | 1,441 | 2,208 | 1,857 | 1,840 |

*Note: data for 2019 is estimated using MDM.*

*Source: ONS (Annual Business Survey, GHG emission in the UK), Comext and Cambridge Econometrics (MDM-E3)*

## Metals

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| GVA (£2019 millions) | 1,142 | 1,749 | 2,298 | 1,506 | 1,574 | 1,581 |
| Turnover (£2019 millions) | 9,931 | 8,224 | 8,903 | 7,535 | 7,875 | 7,906 |
| Gross operating surplus (£2019 millions) | -177 | 459 | 1,162 | 556 | 753 | 808 |
| Employment (000s) | 34 | 32 | 36 | 33 | 35 | 33 |
| Labour productivity (£2019 thousands of GVA per worker) | 34 | 54 | 63 | 46 | 44 | 47 |
| Investment (£2019 millions) | 346 | 278 | 271 | 352 | 354 | 351 |
| Emissions intensity | 2.3 | 2.4 | 7.4 | 8.4 | 8.3 | 8.2 |

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| (Thousand tonnes of carbon dioxide equivalent per £1m of GVA) | | | | | | |
| Exports (£2019m) | 27,288 | 28,485 | 22,879 | 80,563 | 34,576 | 34,564 |
| Imports (£2019m) | 33,042 | 19,373 | 27,824 | 18,289 | 7,673 | 7,614 |

*Note: data for 2019 is estimated using MDM.*

*Source: ONS (Annual Business Survey, GHG emission in the UK), Comext and Cambridge Econometrics (MDM-E3)*

# Annex H: Definitions and sources for data and UK forecast assumptions

**Table H-1: Definitions and sources**

| Indicator | Definition | Source |
|---|---|---|
| Turnover | Turnover is defined as the total value of sales. This is calculated by adding together the values of:<br>sales of goods produced<br>goods purchased and resold without further processing<br>work done and industrial services rendered<br>non-industrial services rendered | ONS Annual Business Survey |
| Gross Value Added | Turnover generated by the business, industry or sector less their intermediate consumption of goods and services used up in order to produce their output, labour costs (for example, wages and salaries) and an operating surplus (or loss). | ONS Annual Business Survey |
| Gross Operating Surplus | Gross Value Added minus employment costs. | ONS Annual Business Survey and CE calculations |
| Employment | Average employment over the year. | ONS Annual Business Survey |
| Labour productivity | Units of GVA per worker. | Annual Business Survey and CE calculations |
| R&D expenditure | R&D expenditure in £ millions, funded by either the UK government, overseas entities (e.g. European Commission), other UK businesses, own funds, non-profit organisations, higher education establishment, international organisations. | ONS Research and Development in UK Businesses, 2022; ONS Annual Business Survey |
| Investment | Sum of new building work, acquisitions less disposals of land and existing buildings, vehicles and plant and machinery. | ONS Annual Business Survey |
| Foreign Direct Investment | Foreign direct investment (FDI) is cross-border investment made with the objective of establishing a lasting interest in the host economy. FDI is also defined by control relationships, where the direct investor (parent company) controls at least 10% of the voting power (ordinary shares) of the direct investment enterprise. | ONS Foreign direct investment (FDI) involving UK companies, 2022 |
| Energy use | UK energy use by industry, source and fuel. | ONS Energy use by industry, source and fuel, 1990 to 2022 |

| Indicator | Definition | Source |
|---|---|---|
| Emissions intensity | Emissions of greenhouse gases under the Kyoto protocol per unit of GVA. | ONS Annual Business Survey, ONS Environmental Accounts (Greenhouse gas emission in the United Kingdom 1990 to 2022). |
| Exports | Value of goods exported. | ONS MQ10 |
| Imports | Value of good imported. | ONS MQ10 |
| Employment costs | Sum of wages, salaries and social security costs borne by the employer. | Eurostat Structural Business Statistics; ONS Annual Business Statistics |

**H.1** This annex provides further detail on the assumptions used in the April 2024 update of Cambridge Econometrics' macro-econometric UK forecasting model, MDM-E3.

# Macroeconomic assumptions

**H.2** The medium-term macroeconomic assumptions consider issues such as: global economic development; disruptions to supply chains; the Russia-Ukraine war; the Israel-Gaza war, the energy crisis; the cost-of-living crisis; and high interest rates. Assumptions for potential longer-term issues, such as Brexit and COVID-19 are discussed separately below.

## Summary

**H.3** There is expected to be low growth in household consumption in 2024, because of an increase in both the tax burden and the cost of borrowing, with a modest recovery expected in 2025 and 2026. This is expected to decrease imports, and businesses are expected to continue to postpone investment plans in the face of economic uncertainty. Recovery in exports, as supply-chain disruptions ease worldwide, is expected to be limited by a global economic slowdown. Due to the continued efforts towards a green transition, GVA in Oil and Gas, and Mining and Quarrying are expected to fall in 2024 and beyond.

## The War in Ukraine

**H.4** The main economic shock to the UK economy resulting from the War in Ukraine, which began in February 2022, is an increase in commodity prices in 2022 and 2023. Commodity price projections in the UK forecast are adjusted based on data from the International Monetary Fund and the World Bank.[28,29] While no assumptions are made about the length of the war, we assume

[28] https://www.imf.org/en/Research/commodity-prices
[29] https://openknowledge.worldbank.org/entities/publication/e5eccc2f-f1ab-5e65-901a-a430ba85f8a0

commodity prices will stabilise by 2025. Thus, the short-term macroeconomic forecast accounts for depressed consumer spending, due to higher commodity prices until 2025.

### Cost-of-living crisis and inflation

**H.5** As of January 2024, CPI inflation in the UK was 4.2%, with pressures on food and energy costs easing as supply chain disruptions subside.[30] However, core inflation (excluding food and fuel prices) remains above headline inflation, driven by rapidly rising prices in services and housing. Further easing of inflation is expected following the 12% reduction in the energy price cap in April.[31] We expect inflation to reach the government's 2% target by the summer of 2024, before rising again due to labour market tightness, causing an upward pressure on wages, in line with forecasts from the Bank of England.[32]

**H.6** According to the Quarterly Economic Survey in 2024Q1 by the British Chamber of Commerce (BCC), expectations of business inflation remain high, with 58% of firms reporting inflation to be their biggest concern.[33] However, while there is a risk of inflation continuing to increase due to a wage-price spiral, that risk is low due to depressed consumer spending. The current economic slowdown and high interest rates are expected to reduce domestic demand and lower inflationary pressure in the manufacturing and distribution sectors. Instead, inflationary pressure is expected to be driven by the service sectors.

### High interest rates

**H.7** Interest rates have peaked at the end of 2023 at 5.25%, with the first cut in the interest rate expected in the summer of 2024. However, further cuts in the interest rate are expected to be delayed in anticipation of an overly expansionary market reaction. This is in line with the February 2024 Bank of England forecasts, which project that the interest rate will fall to around 3.9% in 2025 Q1.[34] High interest rates are expected to reduce borrowing for both households and firms, continue to depress consumption (amidst a squeeze in real wages) and business investment.

### Disruption to supply chains

**H.8** Sustained disruption to global supply chains have put upward pressures on tradable goods prices since the COVID-19 pandemic. Disruptions to supply chains have, however, eased in 2023, which reduced the upward pressure on UK import prices. Bottlenecks in global distribution have eased, in part due to the slowdown in global demand, and global shipping cost indices falling sharply.

[30] Consumer price inflation, UK - Office for National Statistics
[31] Welcome fall in the price cap but high debt levels remain | Ofgem
[32] In February 2024, the Bank of England (BoE) forecasted inflation will reach 3.7% in 2024Q1, falling to 3.0% in 2025Q1, and 2.3% in 2026Q1.
See Table 1.A in: Monetary Policy Report - February 2024 | Bank of England
[33] Quarterly Economic Survey - British Chambers of Commerce
[34] Monetary Policy Report - February 2024 | Bank of England

We assume these disruptions will continue to ease, leading to a downward pressure on inflation after 2025.

**H.9** Geopolitical developments like the Israel-Gaza war risk causing potential disruption to oil production or transportation routes. Similarly, the Red Sea crisis risks causing potential disruption to shipping through the Red Sea maritime trade routes. Furthermore, trade wars can lead to trade disputes, tariffs, and other protectionist measures, further disrupting supply chains. Given the uncertainty around these developments, we do not impose additional assumptions in our forecast about the future implications of these events.

### Government investment and spending assumptions

**H.10** The short-term public finances has improved because of higher income tax revenue as a result of nominal wage growth, despite slower economic growth and higher interest payables on central government debt. Following the Office for Budget Responsibility's (OBR) published budget, government spending in 2024 is expected to increase, before slowing down in 2025.[35]

## Brexit assumptions

**H.11** The forecast focussed primarily on the macroeconomic effects of Brexit on exports and imports, migration and investment.

### Exports and imports

**H.12** UK trade with the EU is expected to decline in the long term, with the largest impacts expected in trade in services. A large proportion of the decrease in total long-run exports of goods is expected to have happened in 2021 (immediately following the end of the transition period on 31 December 2020). The new customs formalities and customs checks are expected to have initially reduced exports in goods after the transition period, but the impacts on goods exports is expected to stabilise in the medium-term. Trade in services, however, is expected to continue to decline in the longer-term. Our historical data, which the forecasts are based on, includes the ONS UK historical trade data published in 2023, which already accounts for these effects. Thus, we do not impose further short-term assumptions on UK exports.

**H.13** In addition, we have included assumptions on the potential effect of the future trade deals with non-EU countries, such as the US, Australia, Canada and New Zealand. We take a moderate view that is aligned with the potential impact of the UK-US free trade agreement modelled by the Department for International Trade (no agreements as of December 2022).[36,37] We assume that UK exports to the US, Australia, Canada and New Zealand will increase in the long-run (relative to a counterfactual in which the UK had remained in the EU). The implicit assumption is that the

[35] Economic and fiscal outlook – November 2023 - Office for Budget Responsibility (obr.uk)
[36] https://www.gov.uk/government/publications/the-uks-approach-to-trade-negotiations-with-the-us
[37] https://commonslibrary.parliament.uk/research-briefings/cbp-9314/

UK will form trade arrangements with non-EU countries similar to those it achieved through EU membership.

**H.14** The net effect of these assumptions is a slowdown in the growth of total UK exports in the long-run. Effects on imports are forecasted implicitly within the model framework and we do not impose further assumptions on imports.

### Migration

**H.15** Net migration with the EU fell sharply in the period between the Brexit referendum in June 2016 and the start of the COVID-19 pandemic in early 2020, while non-EU net migration increased.[38] After Brexit, many EU citizens previously residing in the UK relocated to the EU.

**H.16** UK net migration was around 345,000 in 2016 and dropped to under 235,000 in 2017, the first year after the Brexit referendum. The average annual net migration between 2018 and 2021 was just above 250,000. However, ONS reported that total net migration was just over 672,000 in the year ending June 2023, a much higher level than expected. The large increase in net migration over this period can in part be attributed to higher in-migration from those arriving via humanitarian routes (including Ukrainian and British National Overseas schemes), as well as an increase in non-EU students and workers.[39]

**H.17** The ONS 2021-based interim population projections (international migration variant) published in January 2023 projected long-term annual net migration would be 245,000. This was revised up to annual net migration reaching 315,000 in the updated ONS projections published in January 2024.[40] Given that the recent net migration figures have been volatile, we assume UK annual net migration will be 280,000 from 2026 onwards (the midpoint between the two ONS projections). The increase in population from net migration is distributed across the regions of the UK based on regional population shares in the projection years.

### Investment

**H.18** Post-referendum uncertainty about the future of the UK-EU relationship depressed investment. While the new agreement clarifies the current relationship, our expectation is that reductions in UK-EU trade will outweigh any gains made through other trade agreements (as above). Combined with continued uncertainty about the speed of any future regulatory divergence, UK investment post-Brexit is likely to be lower than it might otherwise have been (viewed in isolation of the impact of COVID-19).

**H.19** The latest national accounts include data on private sector investment in the post-Brexit period, which are used as input variables in the forecast. We therefore no longer make explicit assumptions about the effect of Brexit on private investment.

[38] https://www.ons.gov.uk/peoplepopulationandcommunity/
[39] Long-term international migration, provisional - Office for National Statistics (ons.gov.uk)
[40] National population projections - Office for National Statistics

# COVID-19 assumptions

**H.20** The long-term impacts of COVID-19 on productivity and education have been considered.

## Labour force and Productivity

**H.21** As of March 2023, ONS estimated 1.9 million people are living with long COVID conditions.[41] This condition is most prevalent in people aged 35 to 69 years and is expected to have negative impacts on the labour force. Research by the Institute for Fiscal Studies (IFS) shows current levels of long COVID could be causing 110,000 workers to be missing from the labour market, costing the country £1.5 billion per year.[42] Given that there is limited evidence on how severe and permanent the health scarring could be, however, we do not make any explicit assumptions on the impact of long COVID on the labour force in this forecast.

## Education and remote learning

**H.22** School closures and remote education during the COVID-19 pandemic could have led to long-term impacts on human capital and productivity.[43] Based on a study by McKinsey, the change in education provision during the pandemic for the current student cohort could lower their lifetime earnings by approximately 3%.[44] Similarly, findings from an OCED report forecast that current students will suffer a 2.5%-4% loss in income across their entire career, due to the learning time lost from school closures for a third of a school year.[45] However, due to the lack of conclusive evidence on the long-term impact, we do not impose additional assumptions on employee earnings.

[41] Prevalence of ongoing symptoms following coronavirus (COVID-19) infection in the UK - Office for National Statistics (ons.gov.uk)
[42] https://ifs.org.uk/publications/long-covid-and-labour-market
[43] https://blogs.lse.ac.uk/covid19/2022/05/16/what-do-we-know-so-far-about-the-effect-of-school-closures-on-educational-inequality/
[44] https://www.mckinsey.com/industries/education/our-insights/covid-19-and-education-the-lingering-effects-of-unfinished-learning
[45] https://www.oecd.org/education/The-economic-impacts-of-coronavirus-covid-19-learning-losses.pdf

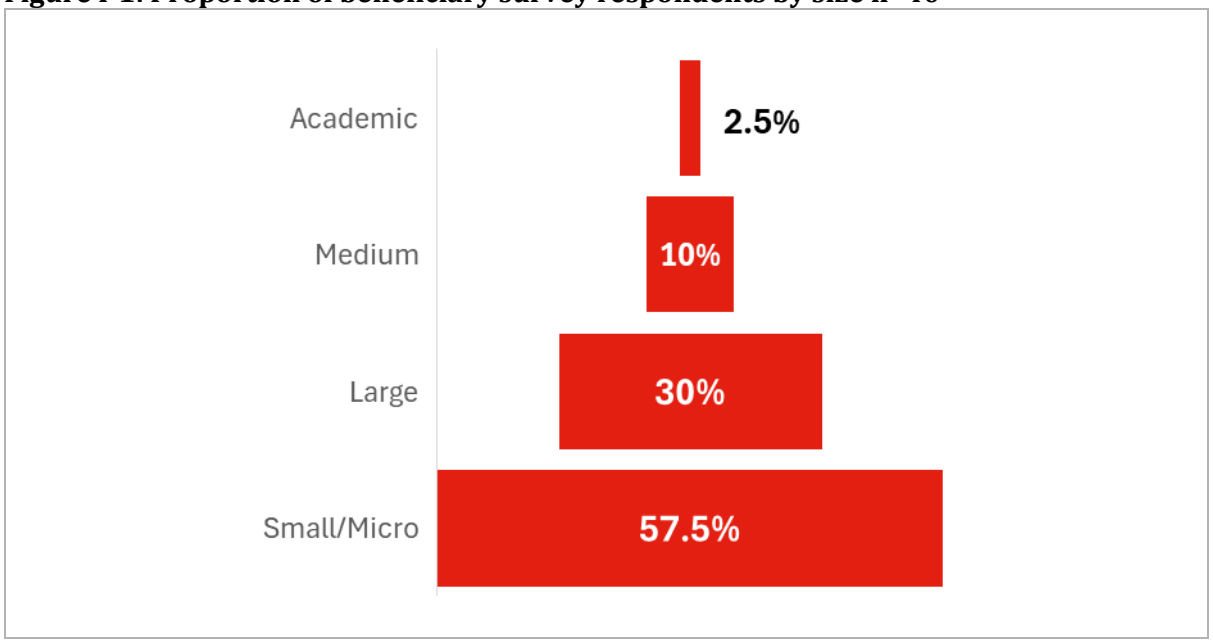
# Annex I: Beneficiary survey results

## Beneficiary characteristics

### Size

I.1 More than half of the beneficiaries who responded to the survey (23) were small or micro businesses. One respondent is a university. Two of the businesses self-identify as large are RTOs.

**Figure I-1: Proportion of beneficiary survey respondents by size n=40**

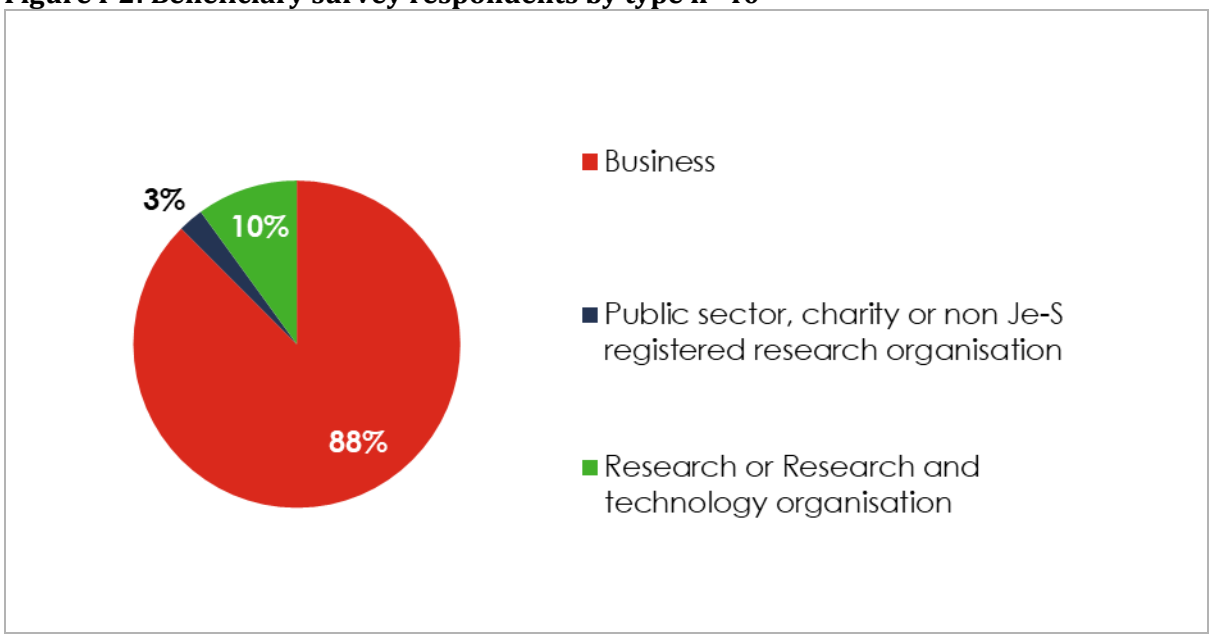



*Source: SQW analysis of beneficiary survey*

### Type

I.2 The vast majority (35, 88%, n=40) of respondents are businesses, of these, 25 are part of the FI industries. Amongst the 5 non-business organisations, one respondent self-identified as a public sector charity or non-Je-S registered research organisation. Four respondents (10%, n=40) self-identified as research or research and technology organisations.

**Figure I-2: Beneficiary survey respondents by type n=40**



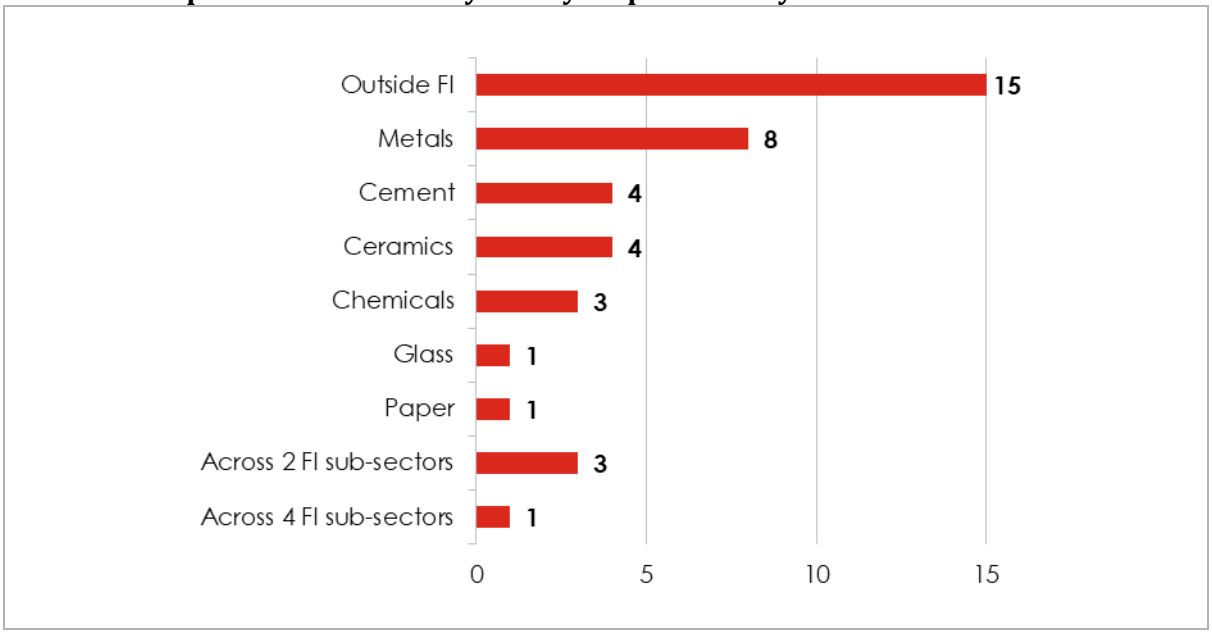

*Source: SQW analysis of beneficiary survey*

## Foundation Industries Sub-Sectors

**I.3** Slightly over a third of respondents (15 of the 40) are from outside the Foundation Industries sector. The majority were from adjacent sectors, for example they were manufacturers of equipment/products (e.g.: compressors, precision instruments) that use foundation materials but who do not develop these materials themselves, energy and net zero consultancies, aerospace, technology and software development. Three of the 15 are RTOs, and within these RTOs one of them focuses on glass more specifically. There is one university, and one trade association, the latter focused on the paper industry

**I.4** Metals had double the number of respondents (eight) than that of the next sub sectors (ceramics and cement with four respondents each). Three business worked across two Foundation Industries' subsectors (Cement + Metals, Metals + Chemicals, Paper + Chemical). One business worked across four sectors (Cement + Paper + Metals + Chemicals).

**Table I-1: Proportion of beneficiary survey respondents by sector n=40**




*Source: SQW analysis of beneficiary survey*

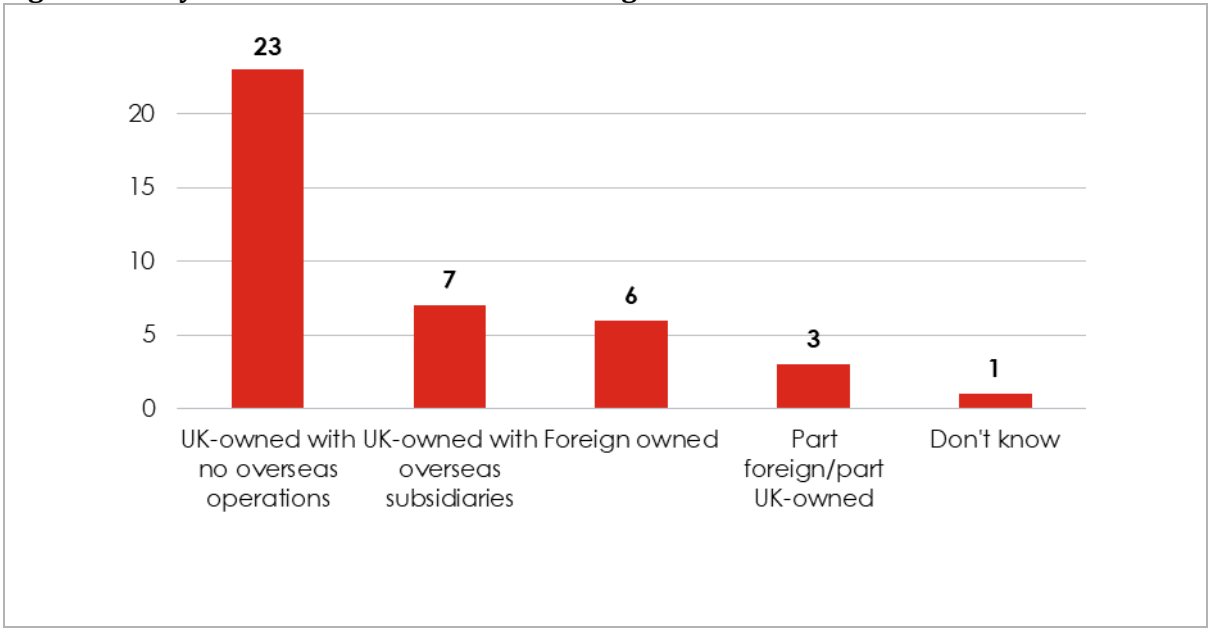
## Regional Distribution

I.5 The regional distribution of the beneficiary survey respondents shows a varied spread across the United Kingdom. The Southeast and East of England both have the highest representation, each with 6 respondents. Other regions with relatively higher counts include the Northwest, East Midlands, and Yorkshire and the Humber, each contributing five respondents. The West Midlands follows closely with four respondents. Regions like Wales, London (Central), and London (North) have a more modest representation, with three, two, and one respondent respectively. Scotland, Northeast, and London (West) each have a single respondent.

## Region of Parent Company

I.6 Two thirds of businesses are UK-owned, and seven of these have overseas subsidiaries. Six businesses are foreign owned (five are large businesses and one is a small/micro business). Three businesses are part foreign/part UK-owned.

**Figure I-3: Is your business UK-owned or foreign-owned n=40**




*Source: SQW analysis of beneficiary survey[*

# Pre-intervention position

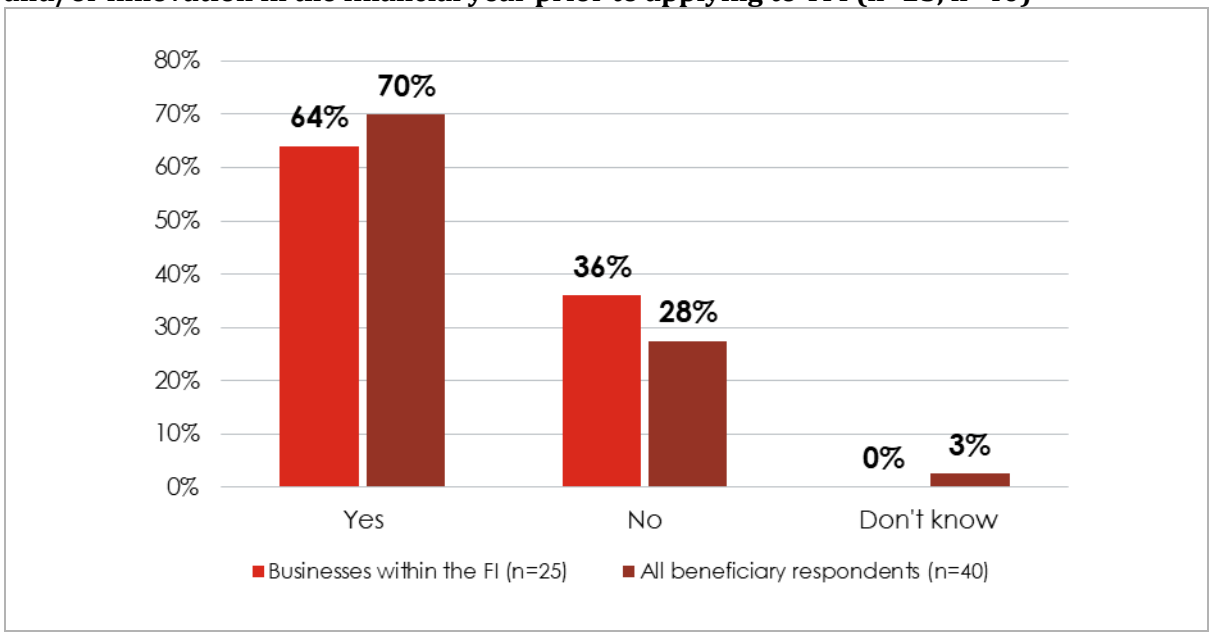
## Attitudes

### Indicator: Willingness among FI companies to invest in innovation

**I.7** Three quarters of beneficiary survey respondents (including businesses/organisations outside FI) had invested in R&D and/or innovation in the financial year prior to applying to TFI. This proportion goes down slightly to 64% when businesses/organisations outside the FI are removed.

- When considering all survey respondents, the ratio of small/micro organisations (n=23) investing in R&D prior to TFI to that of large organisations (n=12) is of around 0.8696. Encouragingly, the ratio is close to 1, showing that small/micro businesses and large businesses **in this sample** are innovative businesses with similar likelihoods of investing in R&D.

**Figure I-4: Proportion of beneficiary survey respondents who have invested in R&D and/or innovation in the financial year prior to applying to TFI (n=25, n=40)**



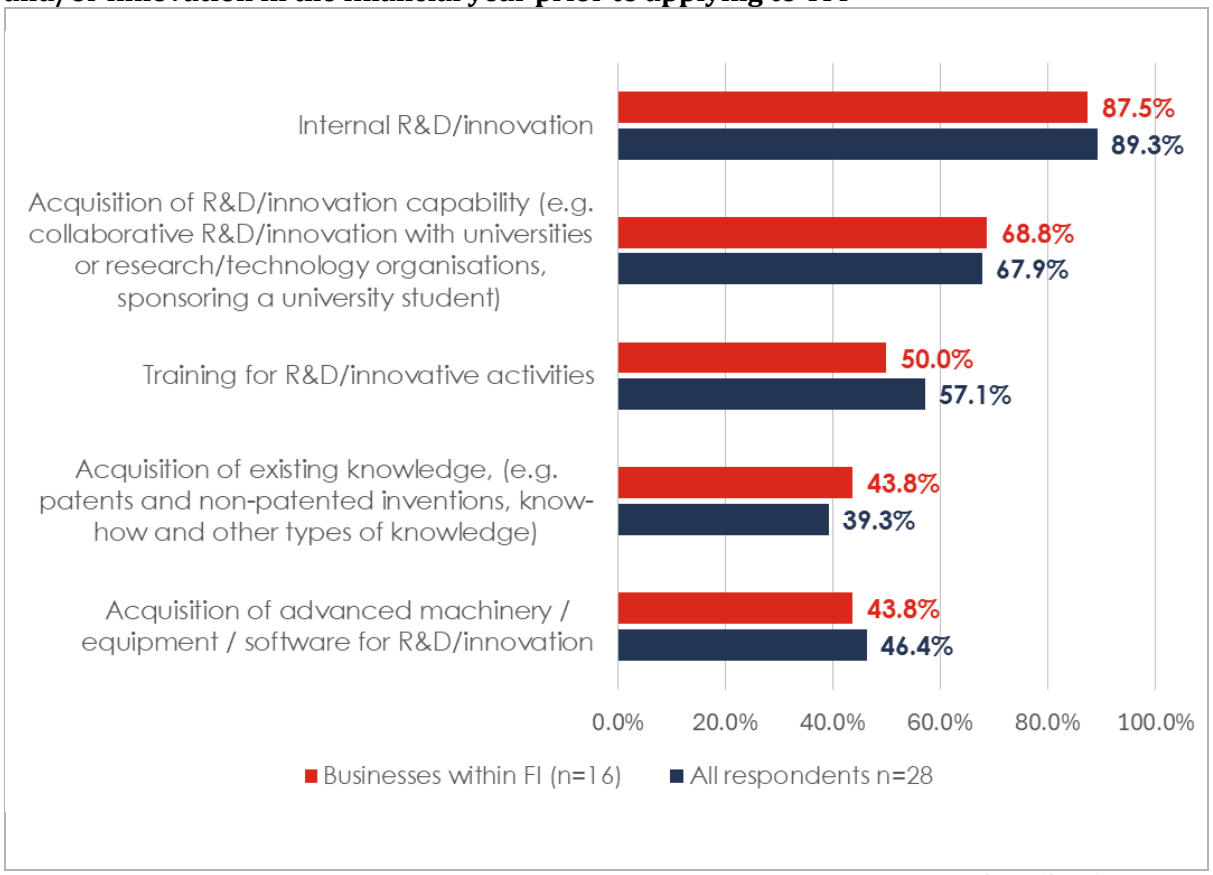

*Source: SQW analysis of beneficiary survey*

I.8 The most common investment focus for beneficiary respondents was on internal R&D/innovation (25 of the 28 for the total sample and 14 of the 16 when only considering businesses within the FI). This was especially important for the cement and ceramics businesses where three of the four for both sectors reported having invested in internal R&D/innovation. The spread across regions was balanced.

I.9 For the two factors respondents invested in the most (internal R&D/innovation and acquisition of R&D innovation/capability) the difference between businesses within the FI and all respondents is minimal. However, when excluding businesses outside the FI, training in R&D/innovation becomes relatively less important (from 57.1% to 50% and from 46.4% to 41.2%, respectively).

I.10 The acquisition of advanced machinery and equipment was voted the least (46.4% for all respondents and 43.8% for business respondents within the FI), but it was picked by nearly half of the metal businesses (3 of the 8).

**Figure I-5: Investment focus of beneficiary survey respondents who had invested in R&D and/or innovation in the financial year prior to applying to TFI**




*Source: SQW analysis of beneficiary survey*

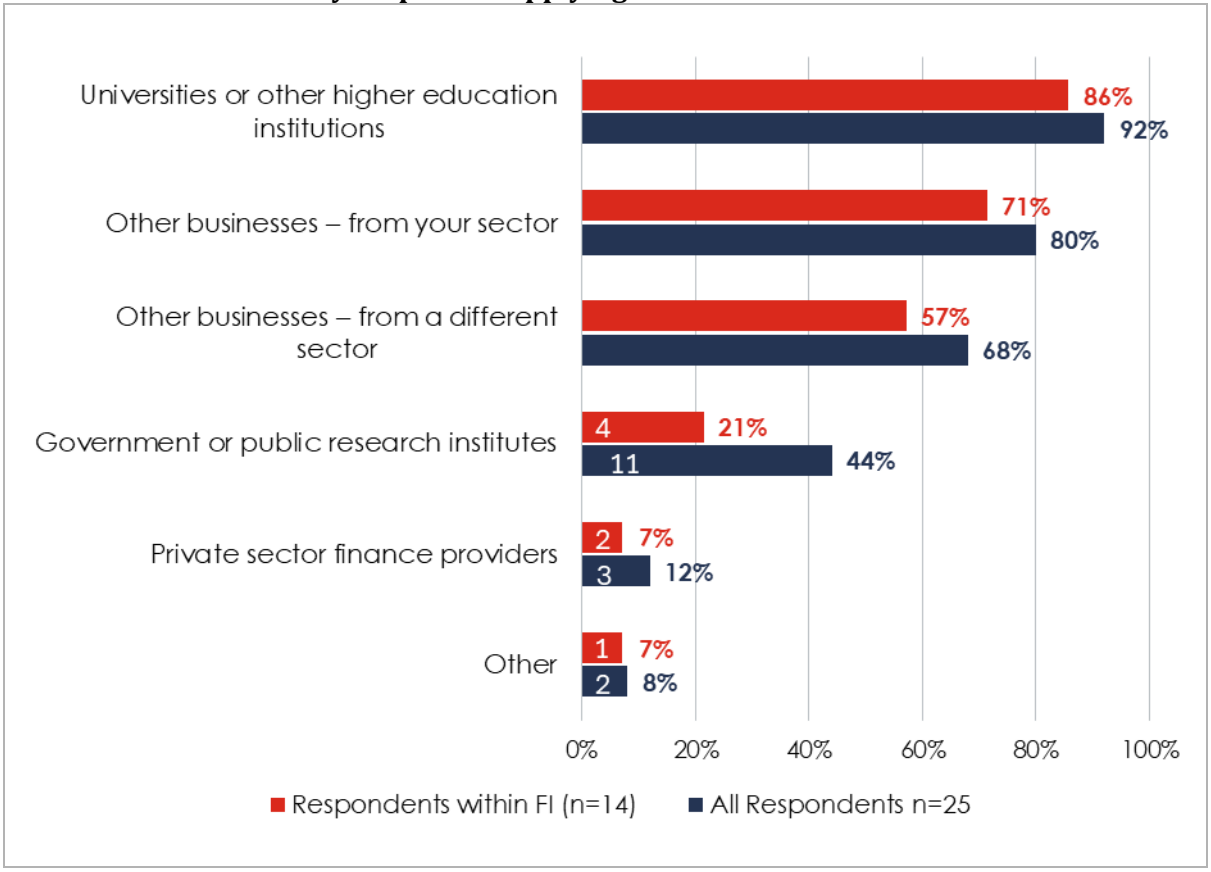
### Indicator: Willingness among FI companies and academics to collaborate

**I.11** Just over half of respondents within the FI (56%, n=25) reported collaborating with other organisations to develop new products, services, or processes in the year before applying to TFI. Similarly, when accounting for all respondents (n=40), 62.5% had collaborated.

- Most commonly, businesses collaborated with universities or other higher education institutions (92% of all respondents and 86% of those withing the FI).
- The proportion of respondents collaborating with government or public research institutes more than halves when excluding businesses from outside the FI (from 44% to 21%)

**I.12** For all beneficiary respondents, metal was the most common sector to be collaborated with (11 businesses), while the least common was paper (4 businesses).

**Figure I-6: Proportion of organisation types that beneficiary survey respondents had collaborated with in the year prior to applying to TFI**




*Source: SQW analysis of beneficiary survey*

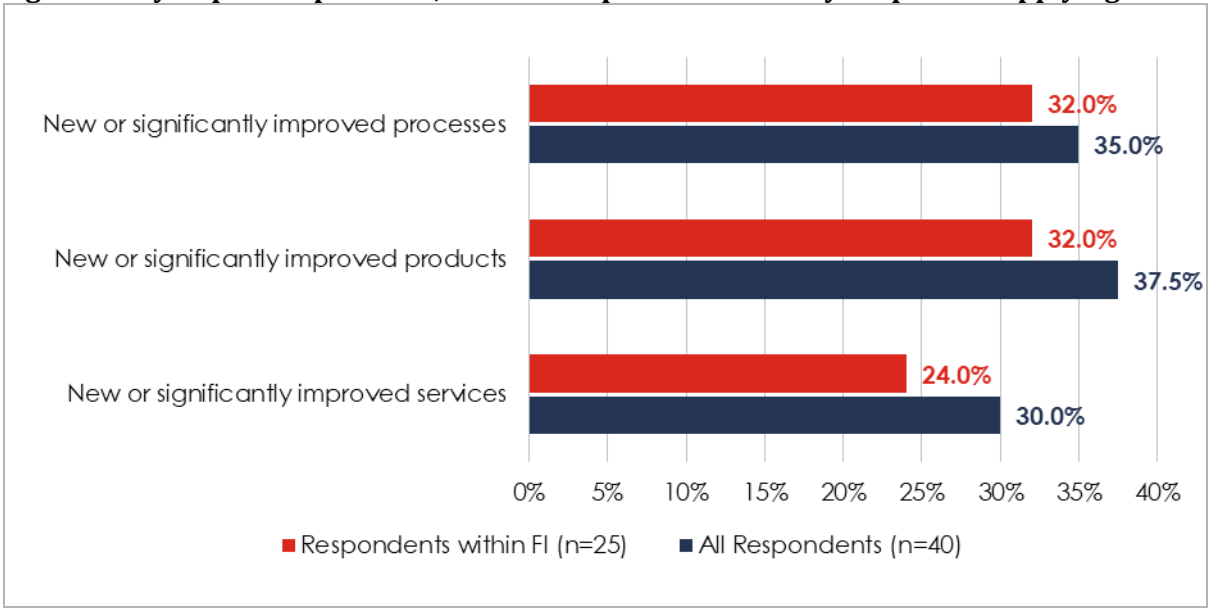
## Activities

I.13 Around a third of businesses within the FI have introduced new or improved products, services or processes, with improved services being the least common of the three (24%, n=25). When including all respondents, the introduction of products becomes more common (from 32% to 37%). As might be expected, the businesses introducing new or significantly improved products, services or processes were mostly the same.

- When respondents, including from outside and within the FI, were asked if the new or significantly improved products or services they had introduced (n=20) were new to the market or to the business, nine said they were new to both, while five said that they were new to the business only, and three said that they were new to the market only.

- When respondents were asked if the new or significantly improved processes they had introduced (n=14) were new to the industry or to the business, four said they were new to both, six said that they were new to the business only, and two said that they were new to the industry only.

**Figure I-7: Proportion of beneficiary survey respondents who have introduced new or significantly improved products, services or processes in the year prior to applying to TFI**




*Source: SQW analysis of beneficiary survey*

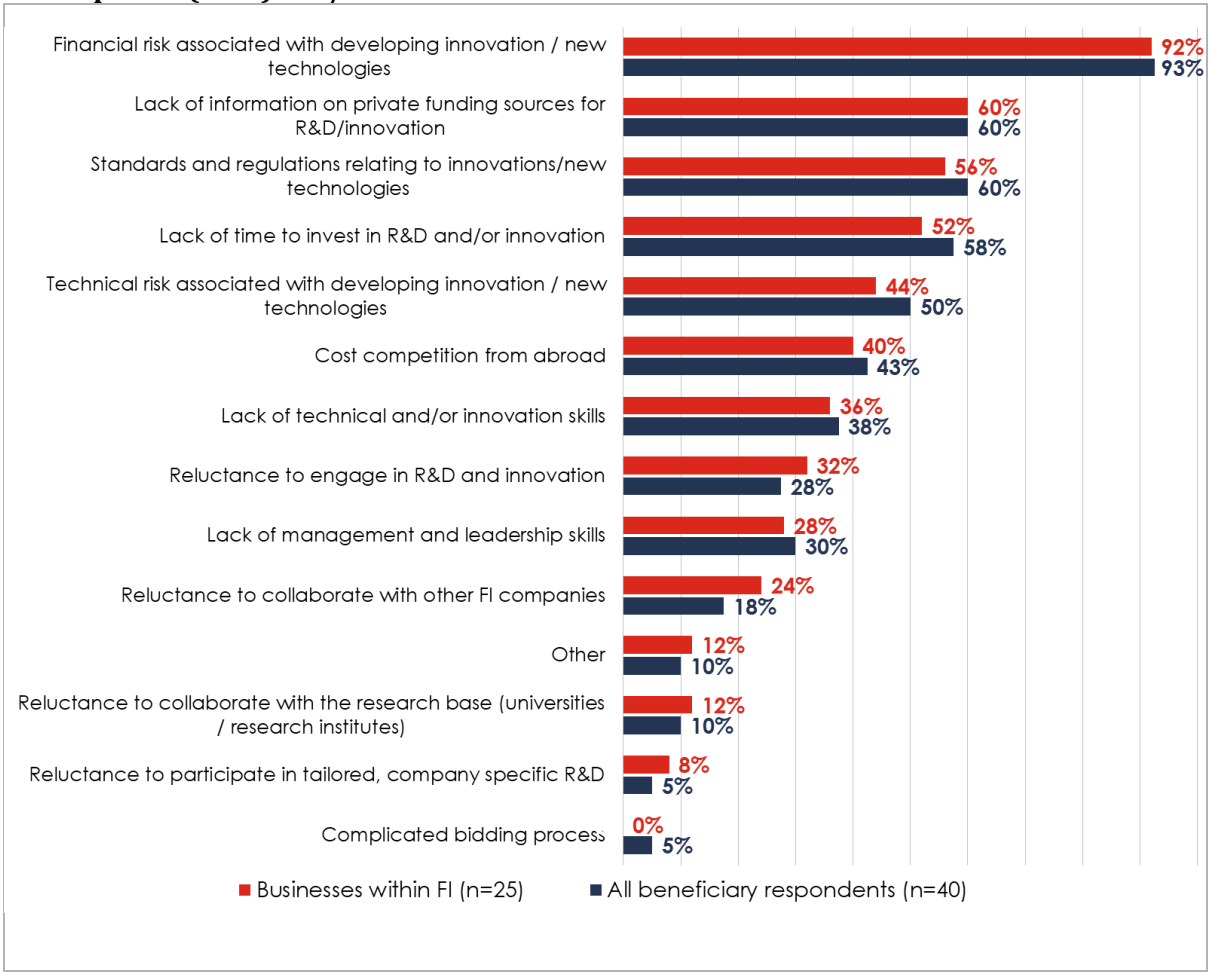
## Barriers to Innovation

**I.14** The most common barrier identified to research and development (R&D) and/or innovation was the financial risk associated with developing innovation / new technologies (92% when excluding businesses outside FI, 93% when including all respondents).

**I.15** The complicated bidding process was picked the least as a perceived barrier. It was picked by 2 respondents; one is a large business, and the other is small/micro. No business within the FI identified this factor as a barrier.

**I.16** The proportions of businesses within the FI selecting each factor compared to the proportions of all respondents are quite similar. The sample sizes (25 for businesses within the FI and 40 for all respondents) are also quite small, so differences in proportions are not very significant and should be interpreted with caution. Still, the reluctance to collaborate with other FI companies is surprisingly higher for businesses within the FI by 6 percentage points (p.p.). The technical risk associated with developing innovation/new technologies was also picked more often by all beneficiary respondents than when looking only at businesses within the FI (6p.p.).

**Figure I-8: Factors beneficiary survey respondents perceived as barriers to research and development (R&D) and/or innovation**




*Source: SQW analysis of beneficiary survey*

# Rationale for engagement with TFI

## How respondents became involved

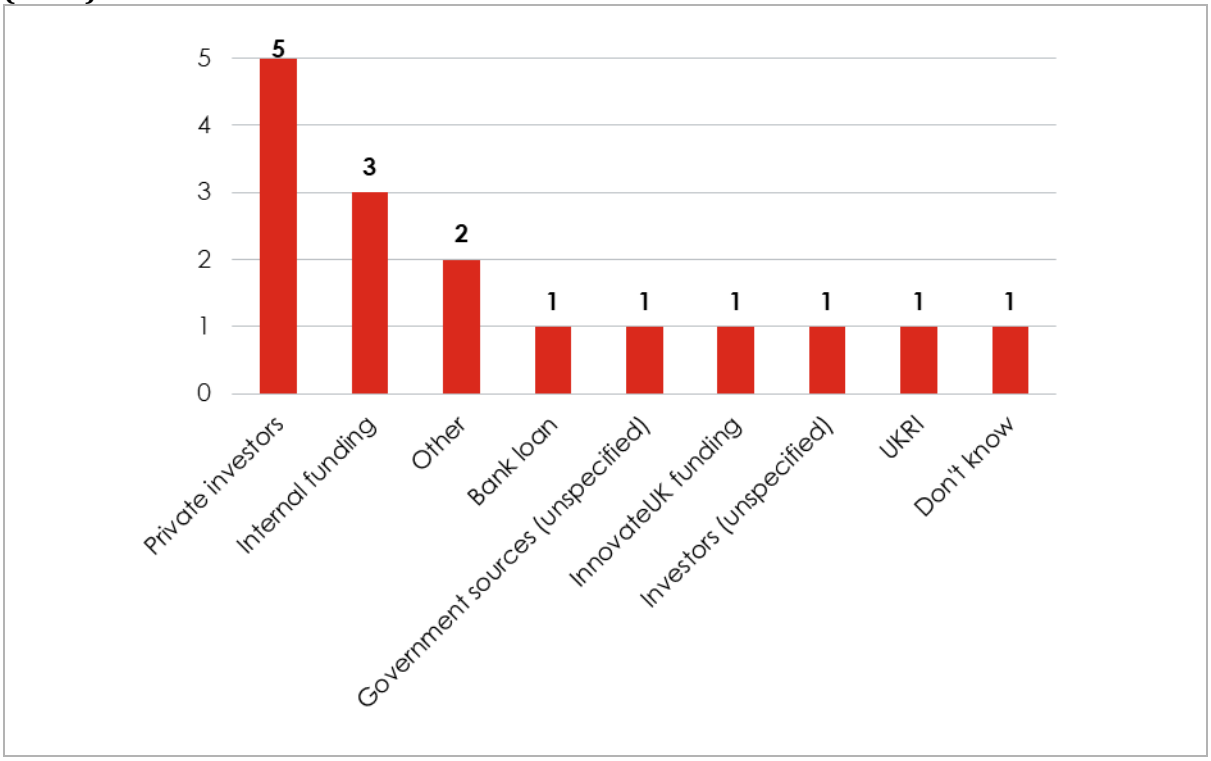
**I.17** When asked how their organisations became involved with the TFI project, just over a third of respondents indicated that they were the lead in the project (37.5%, n=40). A similar, though slightly lower, proportion (35%, n=40) became involved by being approached by the lead participant. Four survey respondents became involved at the inception of the project idea despite not being the lead. Of the remainder, six respondents do not know how their business became involved with the project, and one respondent picked "other".

## Other funding considered

**I.18** Amongst the 19 respondents who led the project or were involved in its inception, 14 (73.7%) had considered other sources of funding to progress the project. If only considering businesses within the FI, approximately 69.2% (n=13) considered other sources.

I.19 When asked which sources of funding they had considered, private investors were picked the most often (by five respondents). All five were small/micro businesses, four were within FI only, and one was outside FI.

**Figure I-9: Other sources of funding considered by beneficiary survey respondents (n=14)**




*Source: SQW analysis of beneficiary survey*

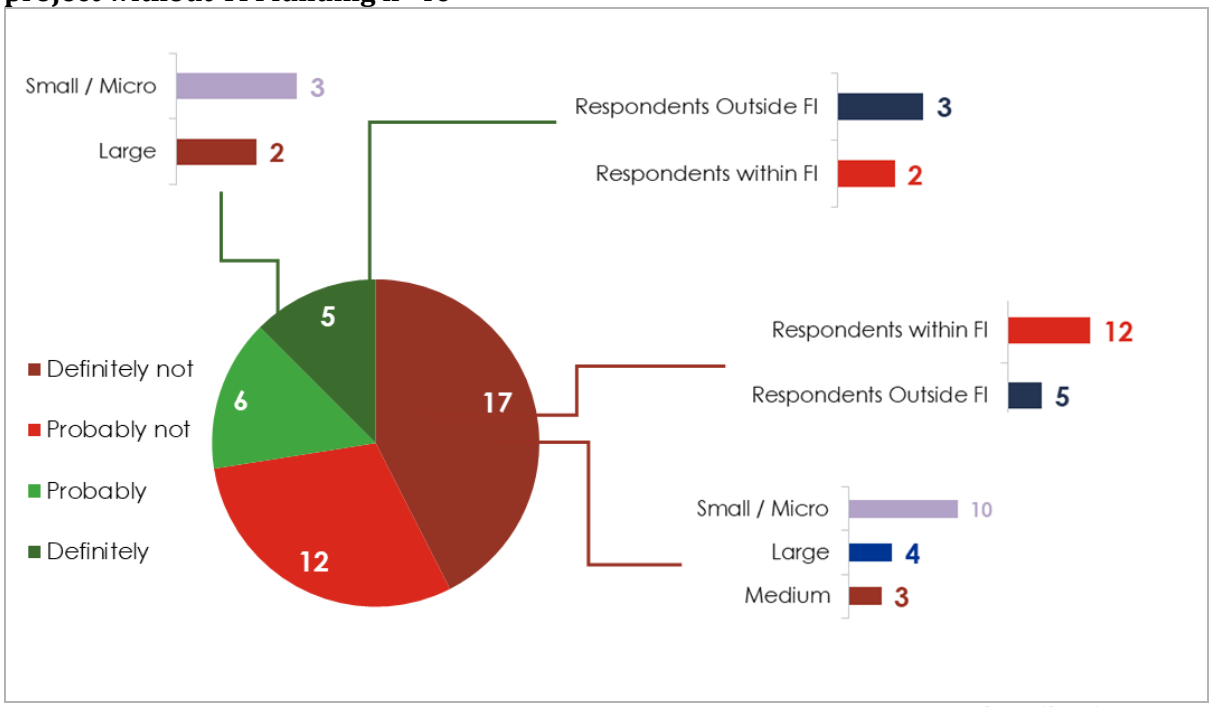
## Activity Additionality

I.20 When businesses were asked about whether they would have taken forward this or a similar project if they had been unsuccessful in their application for TFI funding, nearly half (17 of the 40) said definitely not. Of these, ten were small/micro businesses, four were large and three were medium-sized businesses.

I.21 Only five businesses said that they would have definitely taken this or a similar project forward, with three being small/micro businesses and two being large. In terms of sector, three were outside the FIs, including one university/research centre.

I.22 **In this sample,** businesses outside FI (n=15) have around 3 times more concentration of businesses saying they definitely would have taken the project forward than businesses within FI (n=25).

**Figure I-10: Count of whether businesses would have taken forward this or a similar project without TFI funding n=40**

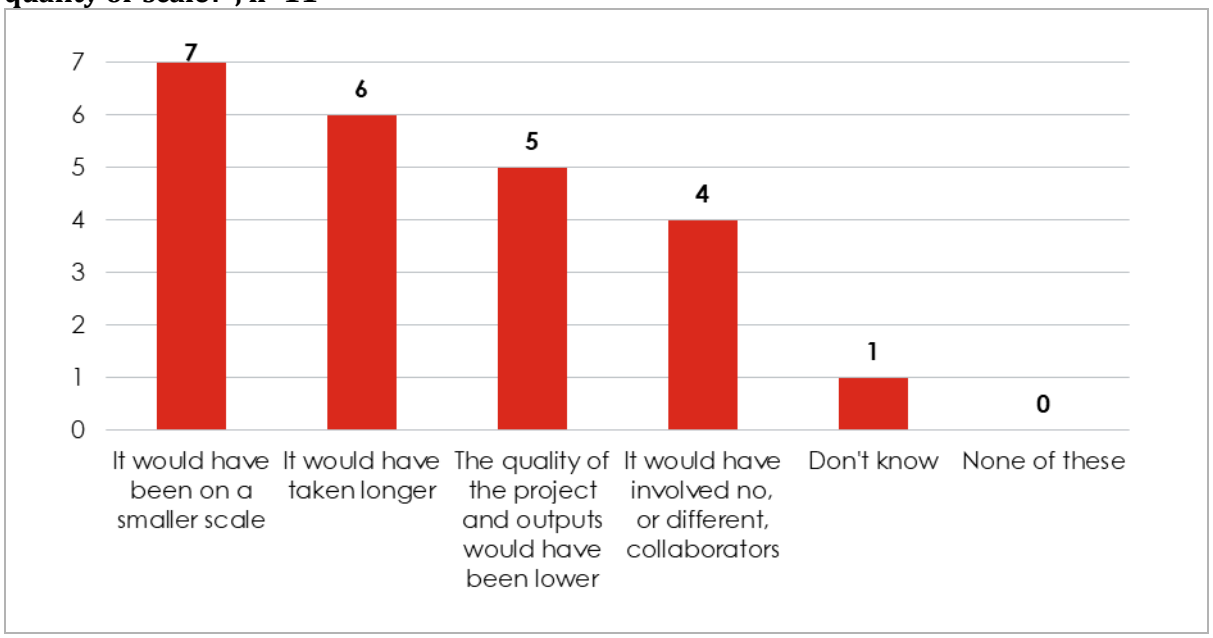



*Source: SQW analysis of beneficiary survey*

I.23 Respondents who had previously indicated that they probably or definitely would have taken forward that or a similar project (n=11) commonly said that it would have been on a smaller scale (seven), would have taken longer (six), and the quality of outputs would have been lower (five). Four of the 11 also said that it would have involved either no collaborations or different collaborations.

I.24 Small/micro businesses were 6 times more likely to have picked that the project would have happened at a smaller scale compared to large businesses. From those who said that it would have involved different or no collaborators (four), only one respondent was part of the FI (paper).

**Figure I-11: Count of responses to "If the project would have gone ahead anyway, did the TFI funding allow it to happen faster, involve different collaborators, or increase the quality or scale?", n=11**



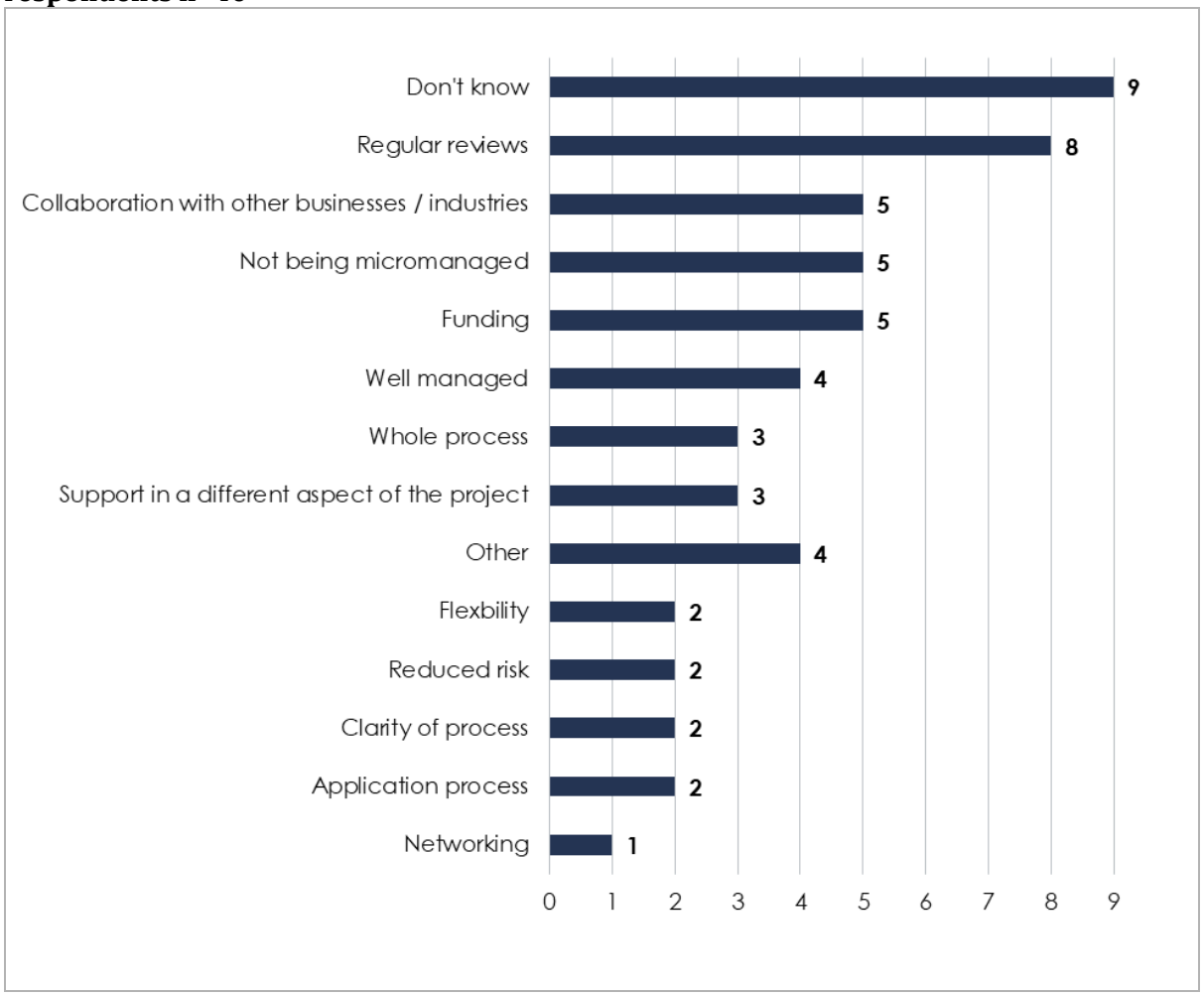

*Source: SQW analysis of beneficiary survey*

## Process

### Helped Delivery

**I.25** The most common response from beneficiary survey respondents was that they did not know which factors of TFI's design and delivery process worked well for their projects.

**Figure I-12: Factors of TFI's design and delivery processes have worked well for project respondents n=40**



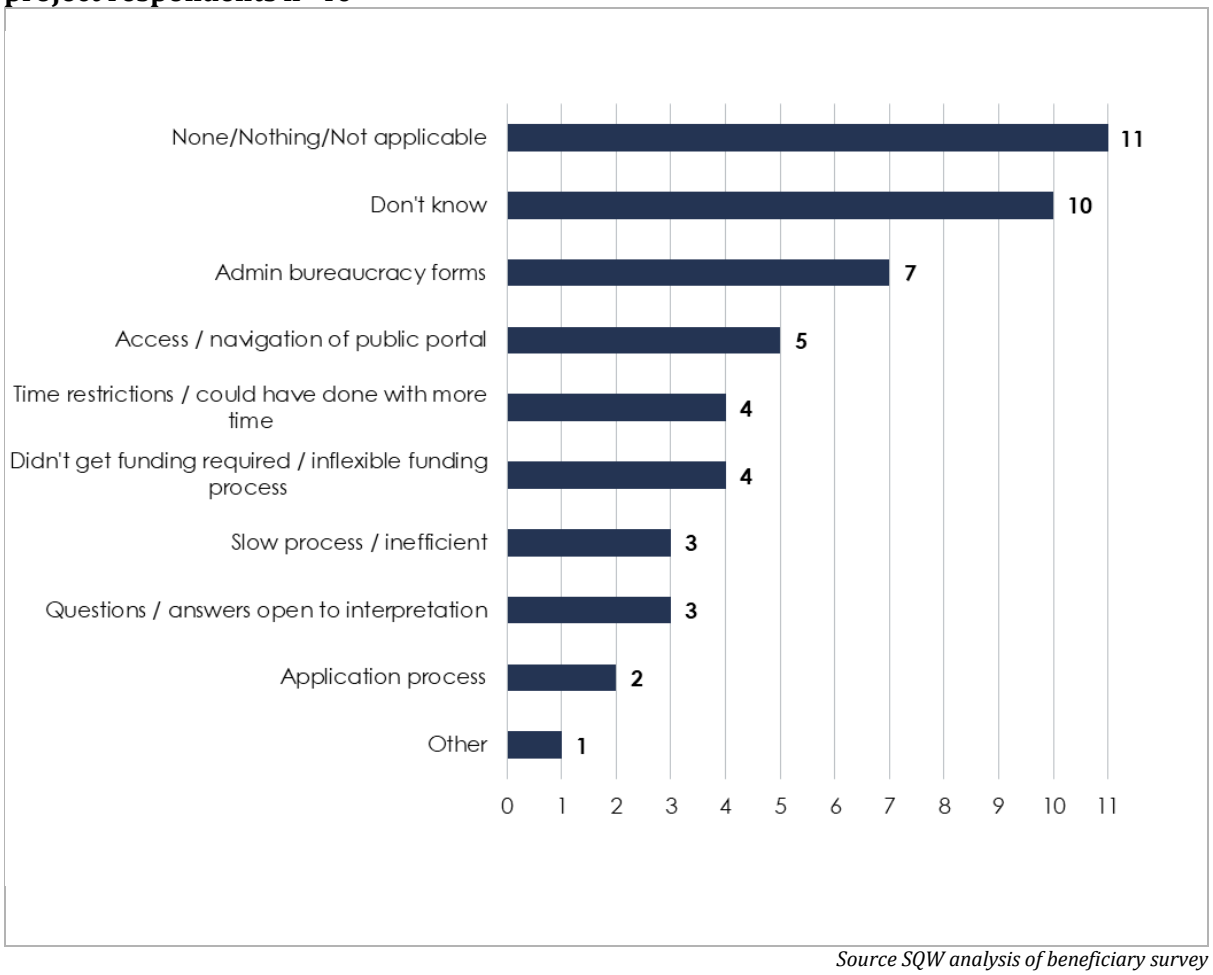

*Source: SQW analysis of beneficiary survey*

## Hindered Delivery

**I.26** Around a quarter of respondents (11) stated that there were no factors related to TFI's design and delivery processes that had hindered their projects or worked less well. A similar proportion (10) stated that they did not know.

**I.27** Of those who did identify factors which had worked less well, admin/bureaucracy was picked the most often (seven), followed by access/ navigation of public portal (five), time restrictions (four), and not having enough funding/inflexible funding process (four).

**Figure I-13: Factors of TFI's design and delivery processes have worked less well for project respondents n=40**




*Source SQW analysis of beneficiary survey*

# Progress to Close

## Innovation Stage

**I.28** The graphic below illustrates the progression through the TRLs, with darker colours indicating greater progression. The single instance in pink highlights a respondent who reported a decrease in TRL at the conclusion of the project compared to their status before participating in the TFI.

**I.29** Progress though the TRLs is encouraging: 17 of the 31 respondents who were able to provide a TRL for both prior to TFI and at the end of the project, have progressed **at least** 2 TRL stages.

- When looking at those respondents who moved three TRLs or more (six in total), three of them participated in Demonstrator projects, two of them in Collaborative R&D, and one in a Feasibility Study. All three relevant business sizes (large, medium small/micro) are represented, and their geographies are varied. Three of them are metals, however the metal subsector is frequently present in this sample of beneficiaries. The other three were from outside the FI, from the cement, and from the ceramics industries respectively. Interestingly,

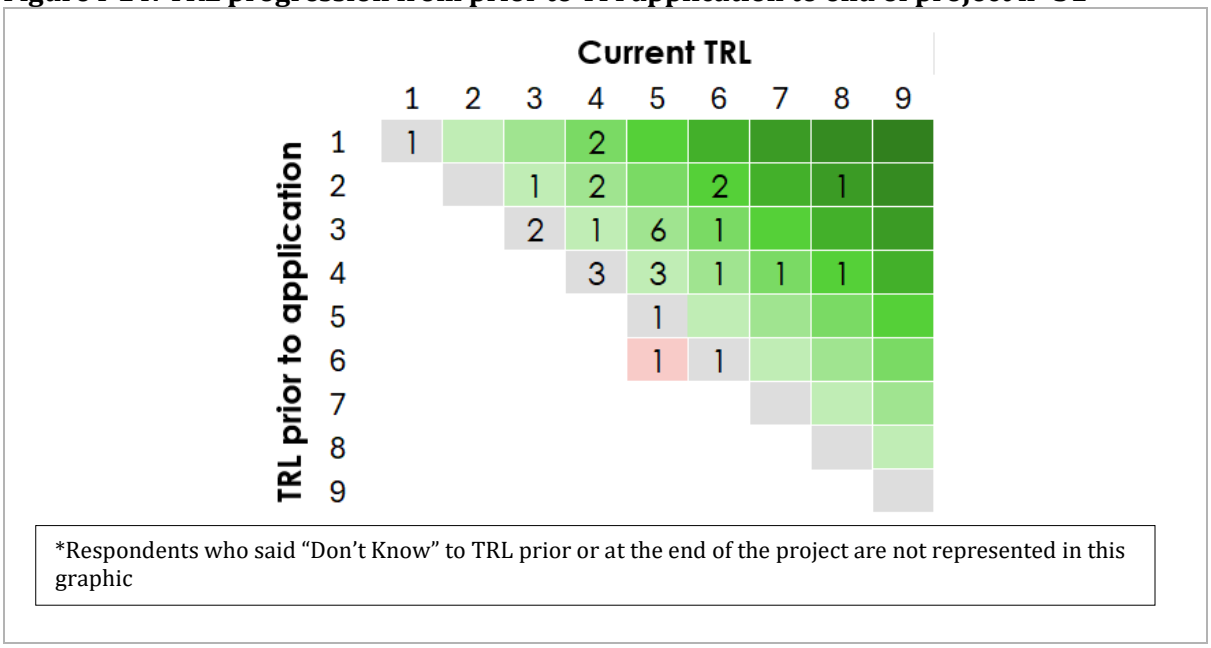
despite outside FI being the most frequent subsector, it is not equally represented in the respondents who achieved the most TRL progression.

**I.30** Most respondents progressed from TRL 3 (Specified and developed an experimental Proof of Concept (PoC)) prior to TFI, to TRL 5 (Technology/process validated in relevant environment) at the end of the project.

**I.31** TRL progression is influenced by a variety of factors, including the nature of the technologies being developed, and as such, it does not always serve as a direct indicator of overall project success. However, the absence of TRL progression, or in the case of one respondent, TRL regression, may suggest that certain aspects of the project could have been improved. The following analysis explores which strands of the programme have experienced limited progress the most in the context of the survey respondents, but it does not aim to identify these as definitive causes for the outcomes.

- 16 respondents, reported either one level increase in TRL (five respondents), no increase in TRL (eight respondents), regression in TRL (one respondent), or that the project had reached a dead end (two respondents).
  - Respondents participating in the Feasibility Studies had 25% more concentration of respondents in this group than other strands. Collaborative CR&D participants had a ratio of 1 and so were as represented in this group as in the group that more successfully moved through the TRLs. Demonstrators are only ever so slightly more concentrated in the group that more successfully moved through the TRLs with a ratio of around 0.96. The only Accelerator who responded to the survey progressed their technology at least 2 TRLs and as such is not part of this group.
  - The respondent who regressed from level 6 (Technology/process validated in operational environment) to level 5 (Technology/process validated in relevant environment) was part of the Demonstrator strand. It is important to note that respondents were not given numerical options for their TRL progression questions and so this could be due to their interpretation of the descriptions given as options.

**Figure I-14: TRL progression from prior to TFI application to end of project n=31**




*Source: SQW analysis of beneficiary survey*

## Additional Investment

I.32 Over a third of respondents (15, n=40) indicated that there had been more investment in the project beyond the initial amount from TFI. This was well balanced across different FI sub sectors and UK regions.

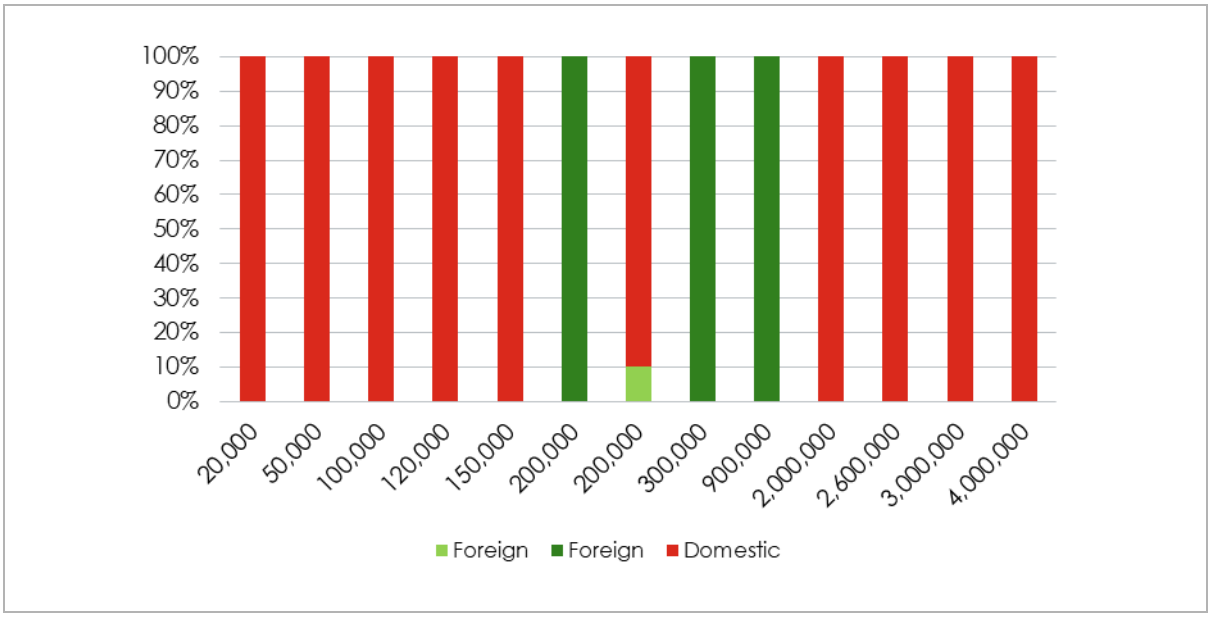
I.33 Two respondents did not indicate the amount of additional private investment, but the total amount across those who did (n=13) is £13,840,000. Of this:

- 10.4% (£1,420,000) is foreign private investment
- 89.6% (£12,220,000) is domestic private investment

I.34 Additional public funding has amounted to a total of £5,750,000, reported by three survey respondents. Of this:

- 99.1% of this was domestic public investment (£5,700,000)
- £50,000 was foreign investment

**Figure I-15: Additional private funding reported by different respondents and their sources n=13**



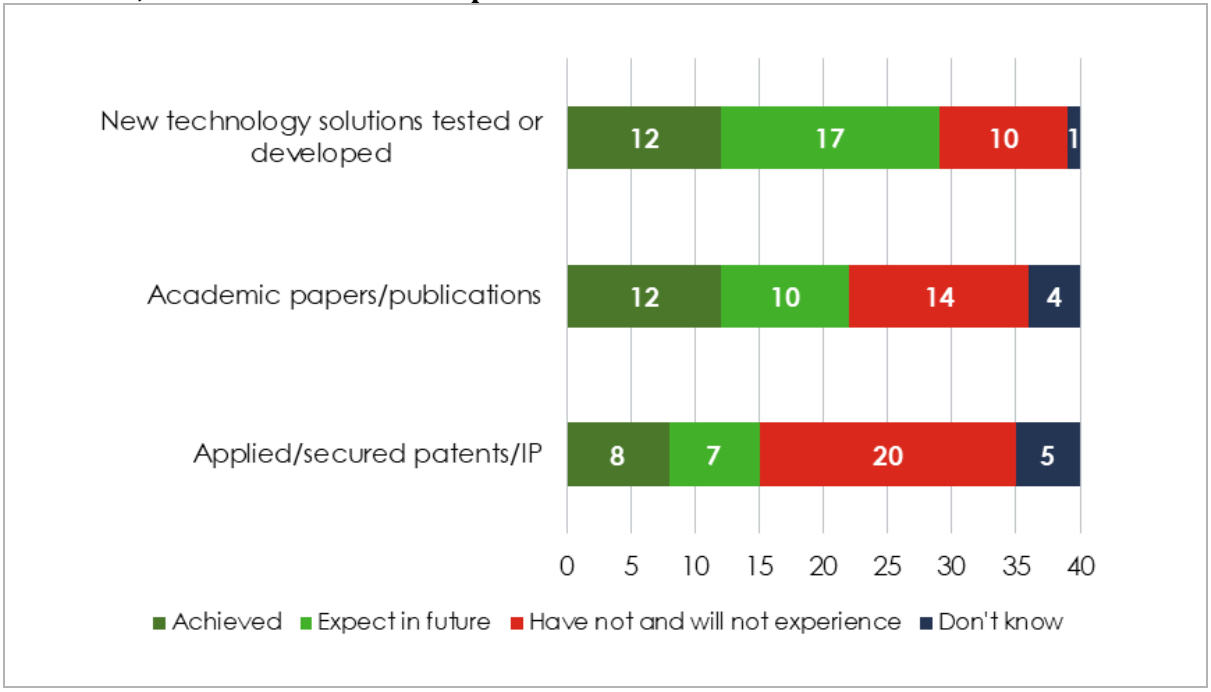

*Source: SQW analysis of beneficiary survey*

## Benefits Experienced

**I.35** The benefit respondents have experienced or expect to achieve in the future the most is new technologies tested or developed (29). A quarter of respondents (10), however, have not and will not experience this benefit. In terms of variation between the FIs, none of the four cement respondents achieved this benefit, but three expect to in the future. Otherwise, there was at least one business per sector focus experiencing this benefit.

**I.36** In addition, there are at least 12 respondents reporting that academic papers/publications have been published, whilst ten expect to in the future. The number of IPs/patents applied for/secured (eight) is also quite encouraging, although a higher proportion of respondents do not expect to achieve this in future compared to the other benefits.

**Figure I-16: Benefits beneficiary survey respondents have achieved, expect to achieve in the future, have not and will not experience n=40**




*Source: SQW analysis of beneficiary survey*

**1.3** A total of 57 companies have tested/are testing the technologies developed through the projects (n=16 respondents). The highest frequency of respondents (three) reported one or four companies having tested/testing the technologies developed through the project, as shown below.

**Figure I-17: Count of how many companies have tested/are testing the technologies developed through the project (n=16)**

| Number of companies | Frequency |
|---|---|
| **0** | 1 |
| **1** | 3 |
| **2** | 2 |
| **3** | 2 |
| **4** | 3 |
| **5** | 2 |
| **6** | 2 |
| **10** | 1 |

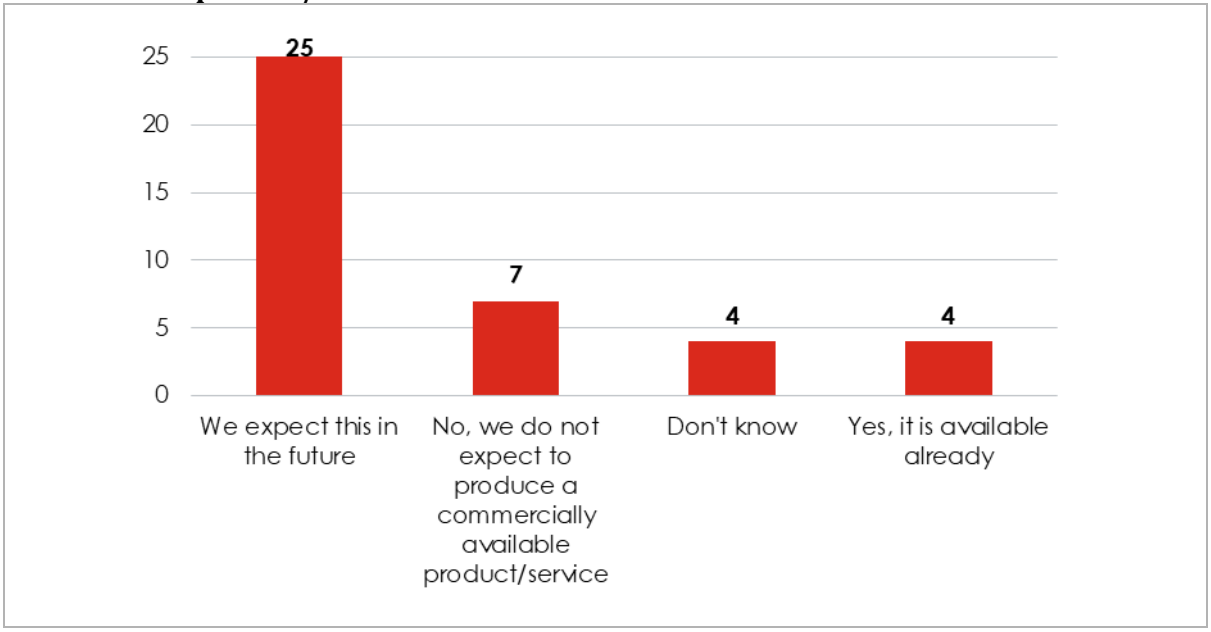
*Source: SQW analysis of beneficiary survey*

**I.37** Most respondents (25) expect their R&D projects to lead to commercially available new products/services in the market in the future. Four of these respondents expect this to happen in

the next 6 months from the time of the survey, and a total of 15 expect to achieve this in over 6 months but within 5 years. Only three said that they did not know when it would happen. Positively, four have achieved this already; three are large businesses and one is small/micro.

I.38 Seven do not expect to produce a commercially available service/product. There are no noteworthy patterns on sector, region or size for these.

**Figure I-18: Count of respondents who expect this R&D project to lead to a commercially available new product/service in the market n=40**




*Source: SQW analysis of beneficiary survey*

## Impacts Experienced

I.39 Only respondents who had self-identified as businesses were asked the following questions about employment, turnover, and productivity (n=35).

### Employment

I.40 Respondents were asked if they have achieved any impacts to date regarding their employment. Following on from this, respondents were asked if they expect any future impacts.

I.41 Around a third, 34.3% (12, n=35), have already experienced changes in employment to date. All reported that employment has increased and the rest did not answer this question. The most common increase is by two FTEs (six respondents).

**Figure I-19: Current change in employment for beneficiary respondents (n=12)**

| Number of new FTEs | Frequency |
|---|---|
| 2 | 6 |
| 5 | 2 |

| Number of new FTEs | Frequency |
|---|---|
| 7 | 1 |
| 9 | 1 |
| 15 | 1 |
| Unknown | 1 |

**Total current number of new FTEs: 53**

*Source: SQW analysis of beneficiary survey*

I.42 Of those who expect there to be a change in employment in the next three years, six expect there to be an increase in one FTE.

**Figure I-20: Expected change in employment for beneficiary respondents in the next three years (n=19)**

| Number of expected new FTEs | Frequency |
|---|---|
| 1 | 6 |
| 2 | 2 |
| 3 | 4 |
| 5 | 1 |
| 10 | 2 |
| 15 | 1 |
| 20 | 2 |
| Unknown | 1 |

**Total expected change in employment: +102**

*Source: SQW analysis of beneficiary survey*

## Turnover

I.43 Respondents were asked if they have achieved any impacts to date regarding their turnover. Following on from this, respondents were asked if they expect any future impacts.

I.44 Around a third 31.4% (11, n=35) have experienced changes in turnover to date. These have ranged from £30,000 to 2,000,000. Increases in turnover have totalled £3,280,000 to date. Increases in exports have accounted for 23.5% of total increase in turnover (£900,000).

**Figure I-21: Current change in turnover for beneficiary survey respondents (n=11)**

| Increase in turnover (£) | Frequency |
|---|---|
| 30,000 | 1 |
| 50,000 | 1 |
| 200,000 | 2 |

| Increase in turnover (£) | Frequency |
|---|---|
| 300,000 | 1 |
| 500,000 | 1 |
| 550,000 | 1 |
| 2,000,000 | 1 |
| Unknown | 3 |
| **Total current increase in turnover: £3,280,000** | |

*Source: SQW analysis of beneficiary survey*

I.45 Overall, 20 of the 35 who have answered this question expect that participation in the project will lead to changes in turnover in the next three years. The total expected increase in turnover is £23,570,000.

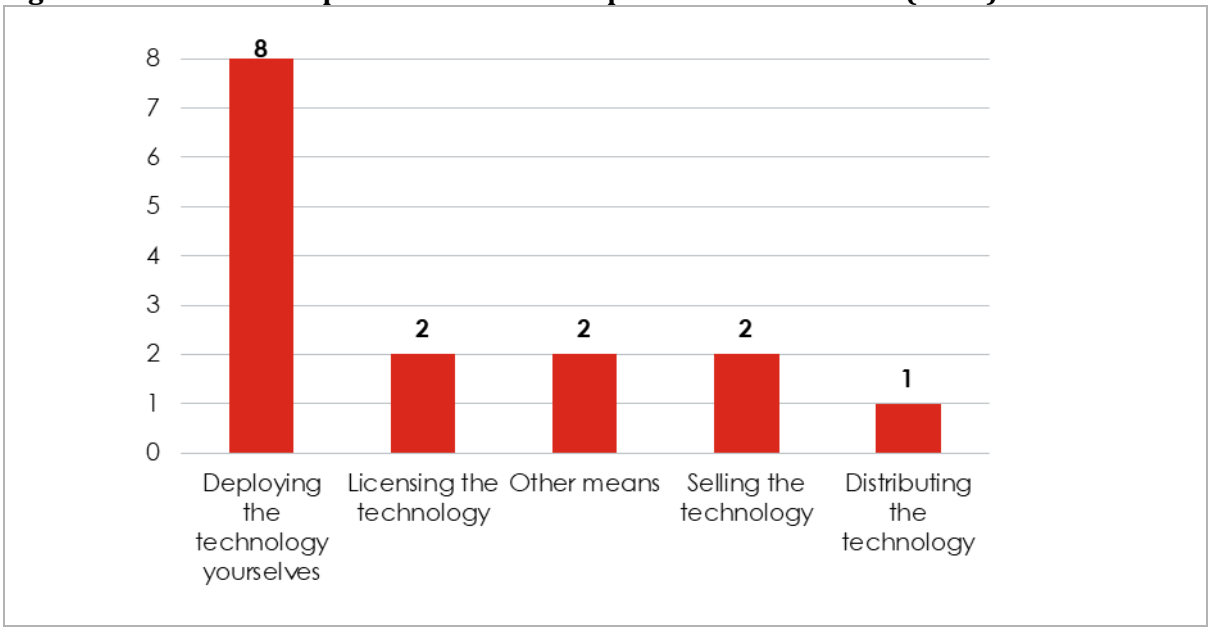
**Figure I-22: Expected change in turnover for beneficiary respondents in the next three years (n=5)**

| Increase in turnover (£) | Frequency |
|---|---|
| 20,000 | 1 |
| 50,000 | 1 |
| 100,000 | 2 |
| 300,000 | 3 |
| 500,000 | 2 |
| 1,000,000 | 2 |
| 3,000,000 | 1 |
| 3,600,000 | 1 |
| 5,000,000 | 1 |
| 10,000,000 | 1 |
| Unknown | 5 |
| **Total expected increase in turnover: 23,570,000** | |

*Source: SQW analysis of beneficiary survey*

I.46 The majority of respondents are expecting to realise an increase in turnover through deploying the technology themselves. Only one business is expecting to distribute the technology.

**Figure I-23: How this expected turnover is expected to be achieved (n=15)**




*Source: SQW analysis of beneficiary survey*

## Productivity

I.47 Respondents were asked if they have achieved any impacts to date regarding their productivity. Following on from this, respondents were asked if they expect any future impacts.

I.48 Overall, 31.4% (11, n=35) have experienced changes in productivity.

**Figure I-24: Current change in productivity for beneficiary survey respondents (n=11)**

| Increase in productivity (%) | Frequency |
|---|---|
| 1 | 1 |
| 5 | 1 |
| 20 | 1 |
| 25 | 1 |
| 30 | 1 |
| 50 | 1 |
| 100 | 1 |
| Unknown | 5 |

I.49 Around 62.5% (n=24) of those who have not achieved changes in productivity to date expect that participation in the project will lead to this outcome in the next three years.

**Figure I-25: Expected change in productivity for beneficiary respondents in the next three years (n=14)**

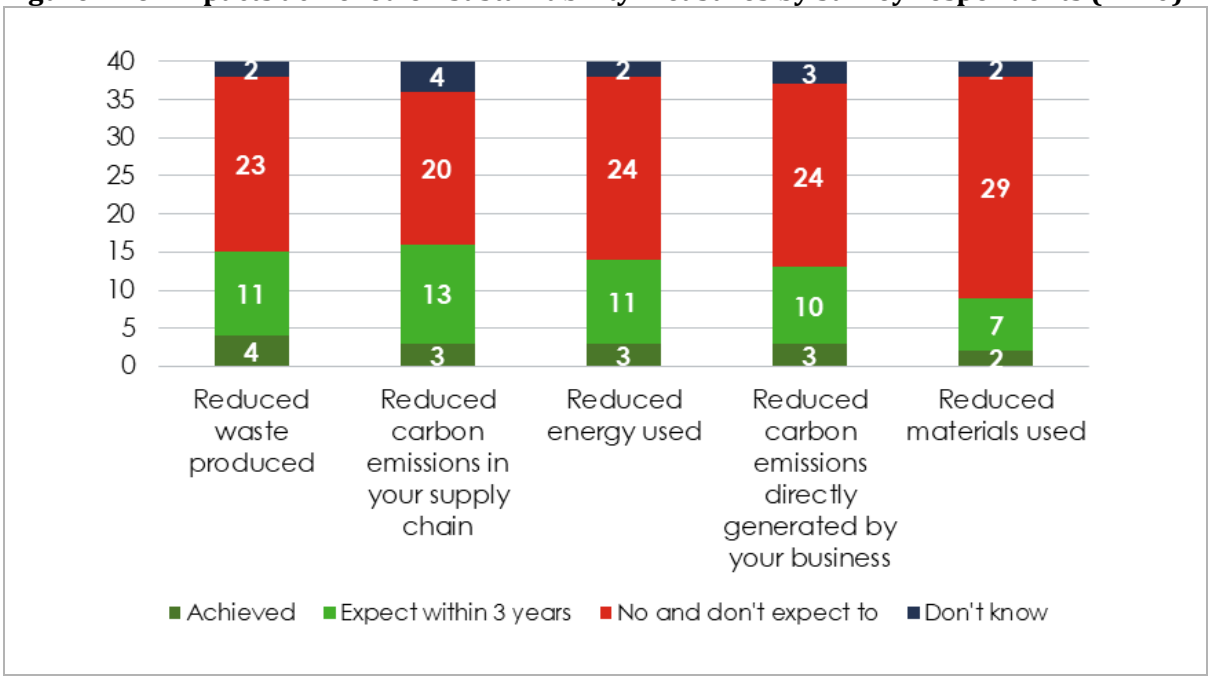
| Increase in Productivity (%) | Frequency |
|---|---|
| 1 | 1 |
| 3 | 1 |
| 5 | 2 |
| 10 | 1 |
| 15 | 2 |
| 25 | 1 |
| 40 | 1 |
| 50 | 1 |
| 100 | 1 |
| Unknown | 3 |

*Source: SQW analysis of beneficiary survey*

## Sustainability

I.50 On average, at least 13 respondents have achieved or expect to achieve within the next three years the sustainability metrics. Reduced waste has been achieved by the highest number of respondents (four), whereas reduction in materials used has been achieved by a lower proportion of respondents.

**Figure I-26: Impacts achieved on sustainability measures by survey respondents (n=40)**




*Source: SQW analysis of beneficiary survey*

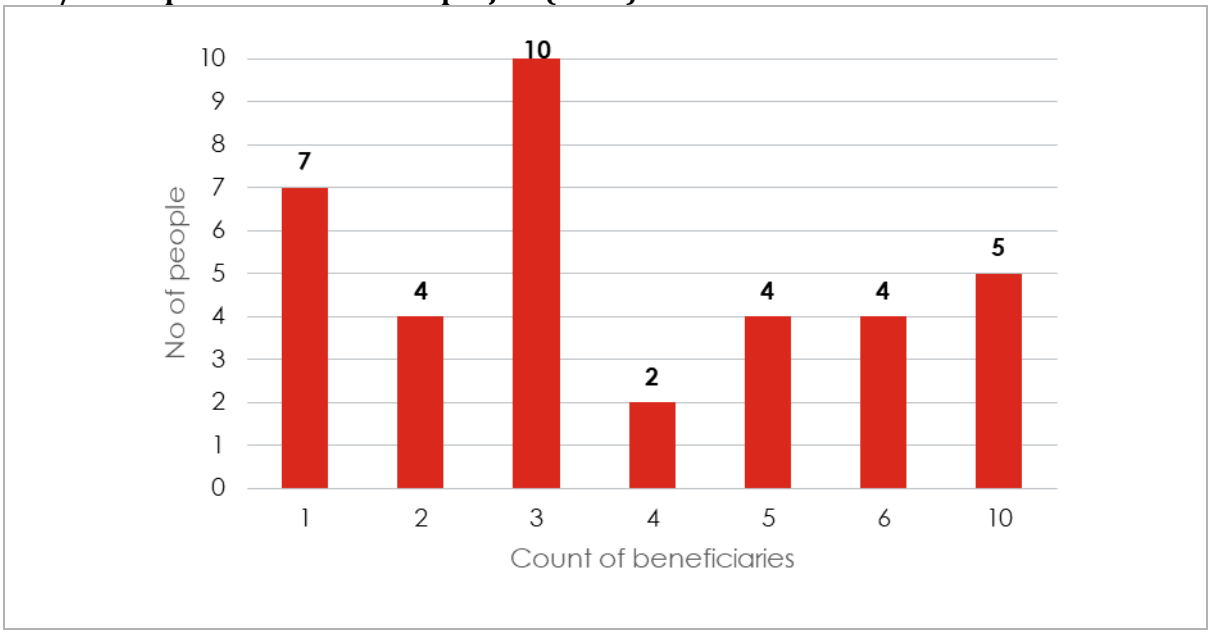
### Skills

I.51 36 beneficiaries have reported people have gained new or developed exiting skills due to the project. Four have not answered this question. Across all beneficiaries who responded, a total of 147 people have gained new or developed existing skills, an average of around 4 people per respondent.

I.52 Commonly, respondents (ten) say three people increase or acquire new skills due to the project. The highest number of people who have new/developed skills is ten, and this has been reported by five businesses.

I.53 There are no geographical or sectorial concentrations. However, from the five businesses that saw ten people increase their skills, three were from the Demonstrator strand and 2 from the Feasibility Studies strand.

**Figure I-27: Count of beneficiaries reporting increased number of people with new/developed skills due to the project (n=40)**




*Source: SQW analysis of beneficiary survey*

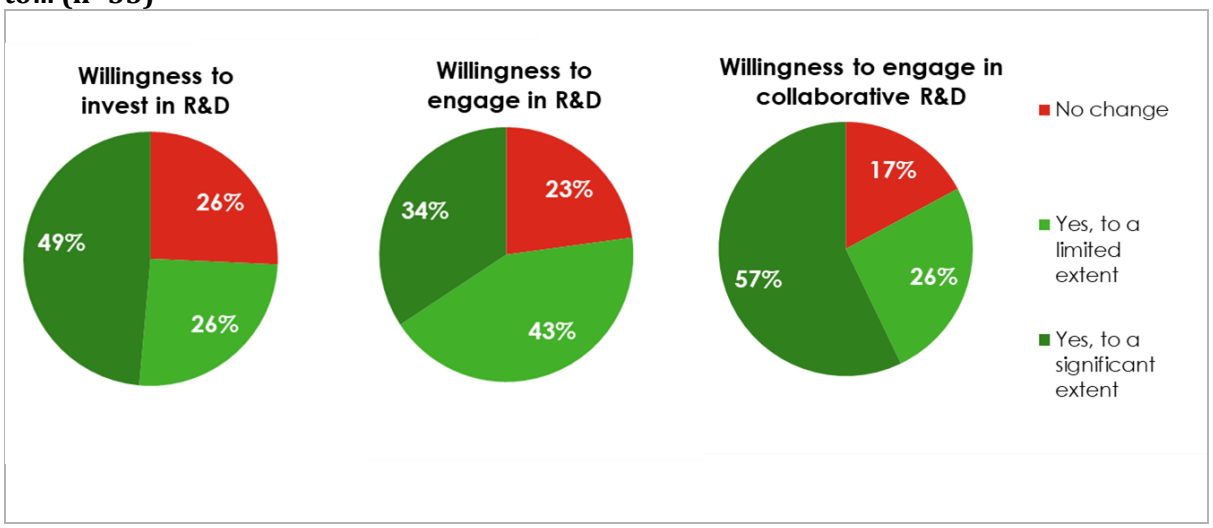
### Willingness to Collaborate, to Innovate and Invest

I.54 The analysis of willingness to engage and invest in R&D, and to engage in collaborative R&D has excluded respondents who do not self-identify as businesses (n=35).

I.55 Over two thirds of businesses have, for each factor, experienced an increase in willingness at least to a limited extent. The willingness to engage in collaborative R&D had the most expression, with over half (57%, n=35) of businesses having experienced this significantly.

I.56 A significant minority of businesses (between a quarter and a third) reported no change in the willingness no engage/invest or collaborate in R&D, perhaps because R&D activities were already important to their business.

**Figure I-28: Did/has engaging in the project increased your organisations' willingness to... (n=35)**




*Source: : SQW analysis of beneficiary survey*

## Additionality

I.57 Only respondents who had reported any changes in employment, turnover, productivity or people acquiring/developing new skills were asked this question.

I.58 Well over half the respondents indicated full additionality of the programme, and so without the TFI none of the benefits they experienced would have happened. The second most popular option was that, whilst the benefits would have happened, they would have occurred at a slower rate. In summary:

- Of the six who said that they would have taken longer to achieve, five said that it would take between 1 and 5 years more. One respondent said that it would have taken between 3 and 5 years longer.
- The two respondents who indicated benefits would have happened at a smaller scale, each said they would have been 25% smaller or between 26%-50% smaller.
- When the two respondents were asked how the quality would have been different, they both said that less time would have been spent on it. One of them also said that progress would have been slower / would have taken longer to find the funding, and that they would not have been able to get the right people / expertise on the project.

I.59 Only one respondent could be considered deadweight as they indicated that all the benefits would have occurred without TFI.

**Figure I-29: What would have happened to the benefits reported above without TFI? (n=19)**

| Additionality | | n | % |
|---|---|---|---|
| **Would not have occurred at all** | Full | 11 | 58% |
| **Would have occurred but at a slower rate** | Partial | 6 | 32% |
| **Would have occurred but at a lower scale** | | 2 | 11% |
| **Would have occurred but not the same quality** | | 2 | 11% |
| **All the benefits would have occurred** | Deadweight | 1 | 5% |

**Respondents could identify more than one type of partial additionality. In total, 7 respondents identified partial additionality.*

*Source: SQW analysis of beneficiary survey*

# Influencing Factors and Contribution

## Relating to design and delivery of TFI

**I.60** Overall, at least one third of respondents selected each factor as having helped to realise benefits.

**I.61** Collaboration with partners and inputs from partners were the two most effective factors in helping to achieve benefits:

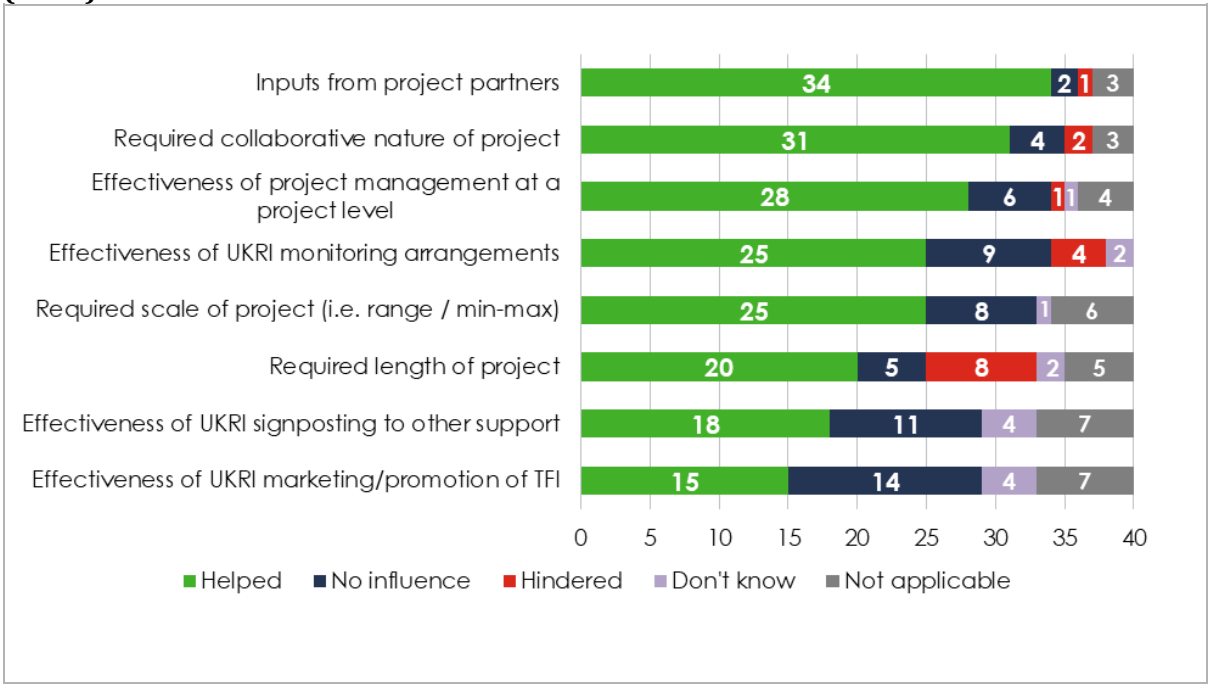
- Around 85% of respondents have picked the inputs from project partners as a factor that has helped delivery. Only one of the 20 collaborative R&D projects has said that it had no influence.
- Over two thirds (31, n=40) of respondents picked the required collaborative nature of the project

**I.62** The effectiveness of UKRI marketing/promotion of TFI was selected by the smallest proportion of respondents (by 38% of respondents) and a similar proportion said that this has had no influence. In addition, the required length of the project was identified the most often (eight respondents) as having hindered the ability to realise benefits, which could be linked to previous sentiments about needing more time to finish the project and achieve objectives.

**I.63** When given the opportunity to elaborate on other factors that have helped or hindered delivery, the following was said:

- Factors that have helped delivery:
  - Extension of the project (one respondent)
  - Portal worked well and helped with the application and claims procedures (one respondent)
  - Working with independent, not-for-profit organisations has helped (one respondent)
- Factors that have hindered delivery:
  - Duration of the project (one respondent)
  - Involvement of multiple sectors (one respondent)
  - Patents held by others (one respondent)

**Figure I-30: Factors relating to design and delivery of TFI that have helped/hindered/have had no influence in the ability to realise benefits from the project (n=40)**




*Source: SQW analysis of beneficiary survey*

## Relating to your organisation and/or the wider context

**I.64** The most relevant factors helping to realise benefits for survey respondents (n=40) selected by over half the respondents were: the availability of people with technical/innovation skills (60%), other R&D activities implemented (57.5%), the availability of information about new technologies (50%)

**I.65** Brexit was found to have hindered the ability to realise benefits by nearly half the respondents (19, 47.5%). Government policy/legislation and Covid-19 were also significantly harmful to respondents (picked by 11 and ten respondents respectively)

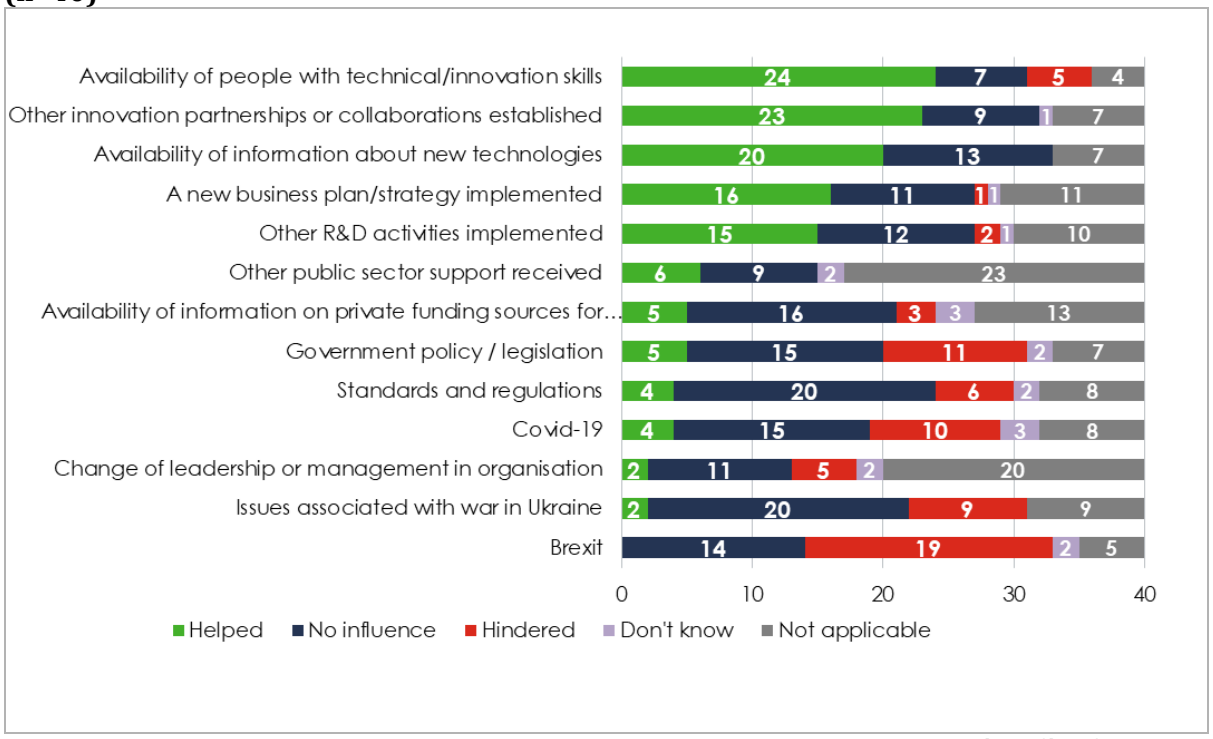
I.66 Standards and regulations and the war in Ukraine were the factors that were found to have made no difference to the highest number of respondents (20 for both, or half the respondents)

I.67 Businesses did not commonly experience changes in leadership or having received other support, and so these two options were marked as not applicable for half of the respondents.

I.68 The distribution of respondents picking each option amongst the sectors, sizes and regions is proportionate, with no substantive variation to note.

I.69 When asked to name any other factors that were not given as options, one respondent mentioned that competition from the EU has hindered their ability to realise benefits. Another respondent mentioned the increase in the price of materials and one respondent said that the 2022 budget announcement was a hindrance to realising benefits, whilst a different respondent mentioned unhelpful external attitudes towards the project.

**Figure I-31: Factors relating to the organisation and/or the wider context that have helped/hindered/have had no influence in the ability to realise benefits from the project (n=40)**



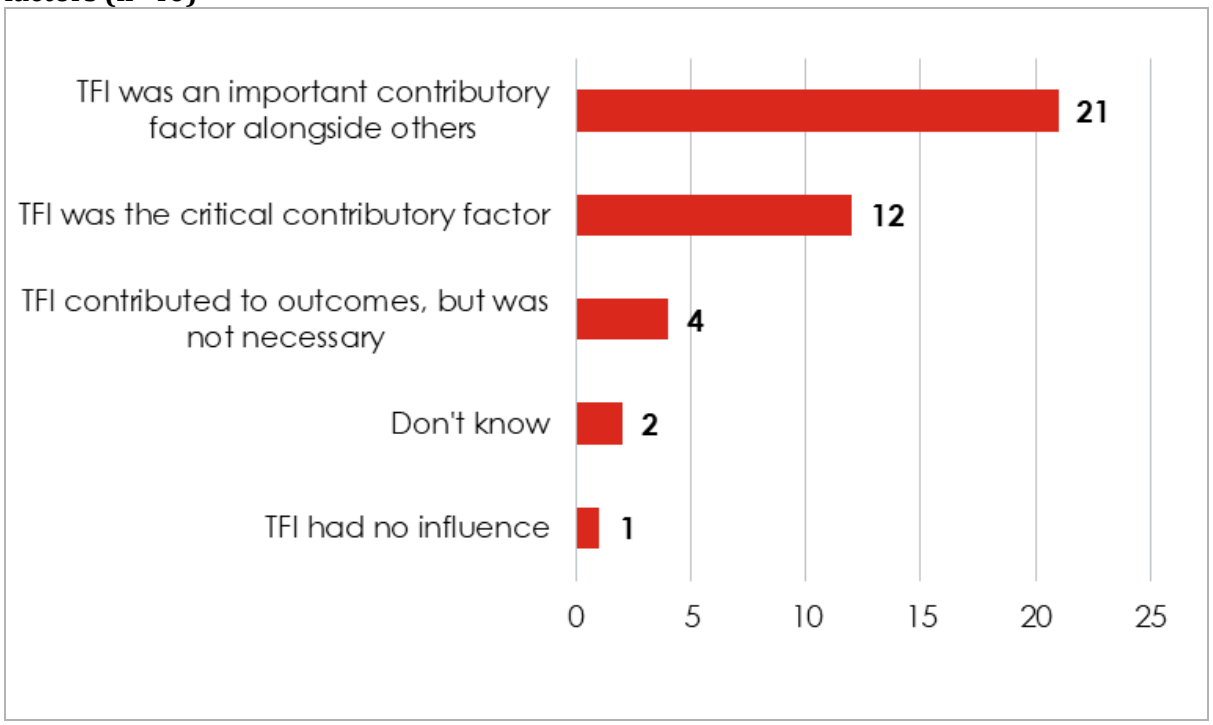

*Source: SQW analysis of beneficiary survey*

## Contribution

I.70 TFI had a very significant contribution to realising benefits according to the survey respondents. 82.5% of respondents found be an important contributor, with a third (12) saying it was the critical factor.

I.71 Only four businesses said that it contributed to outcomes but that it was not necessary (three of these were from within the FI), and one respondent said that TFI made no difference.

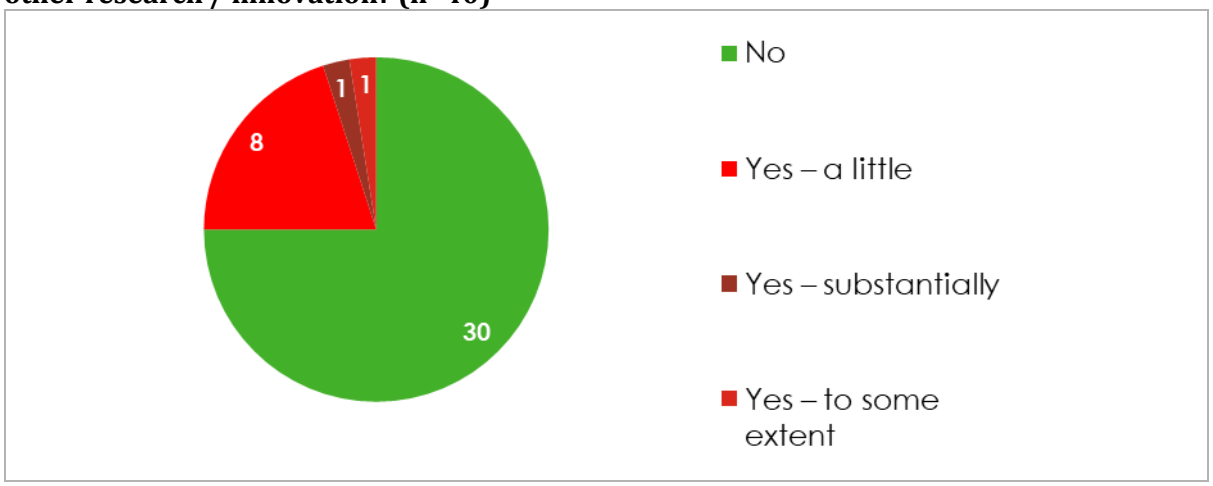
**Figure I-32: Importance of TFI contribution to realising benefits compared to other factors (n=40)**




*Source: SQW analysis of beneficiary survey*

**I.72** For three quarters of survey respondents, participating in the TFI has not prevented them from engaging in other research/innovation. Only two businesses stated it has decreased their ability to do so to some extent or substantially; these were both micro/small businesses.

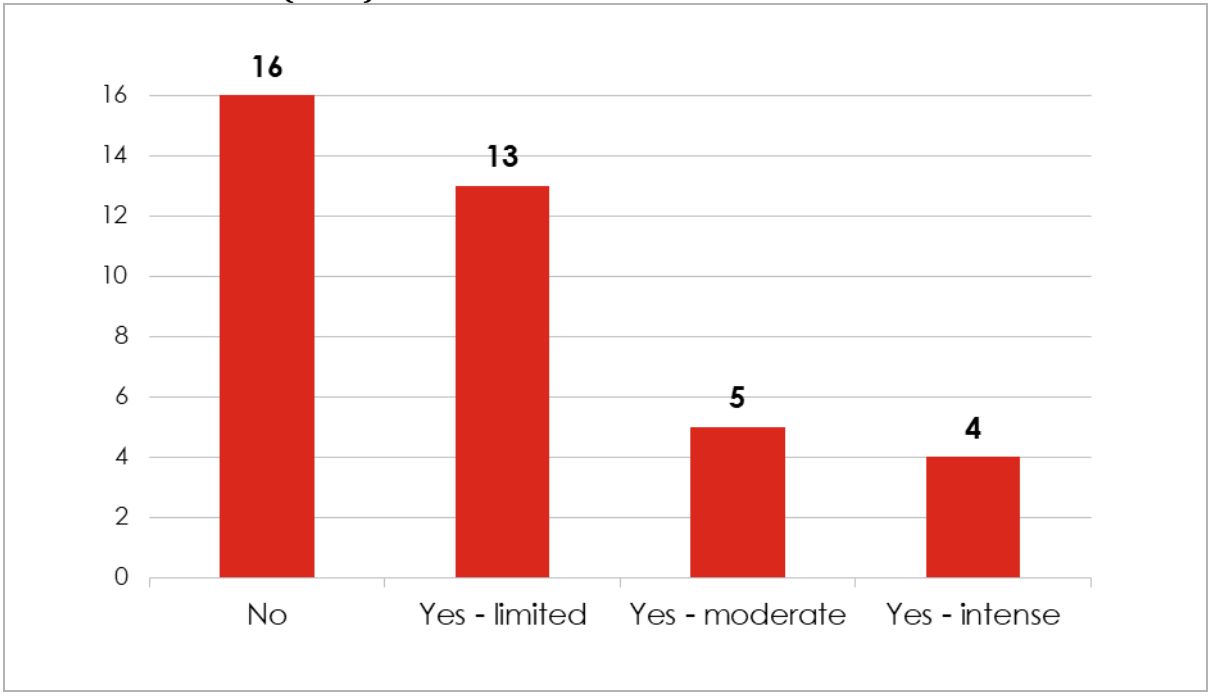
**Figure I-33: Did your participation in the TFI project mean that you could not engage in other research / innovation? (n=40)**




*Source: SQW analysis of beneficiary survey*

**I.73** Nearly half said that their technology or product does not compete and will not compete with other UK based firms, showing that a high proportion are truly innovative and new to the sector. A further 13 said that the competition would be limited. Only four have said that competition would be intense, and three of these were part of the metals sub sector.

**Figure I-34: Is your technology/innovation competing, or will it compete, with other UK-based firms? If so, please state whether the competition with UK-based firms is intense, moderate or limited (n=40)**




*Source: SQW analysis of beneficiary survey*

## Awareness & perceptions of FI

**I.74** When considering only the respondents that are part of the FI (n=25), 64% had heard of these sectors being called "foundation Industries".

- If including all business respondents (excluding RTOs, academics/research organisations, and trade association), 66% (n=35) recognise the term "FI industries", 12 do not.

**I.75** Of the ten businesses outside the FI sector, seven had heard about the FI sector being called as such.

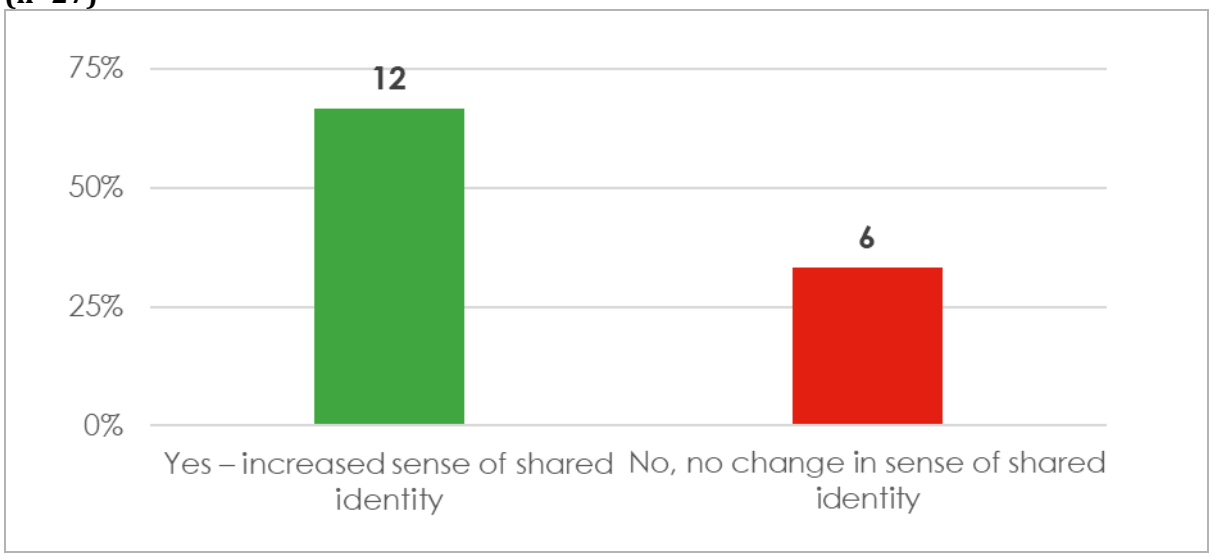
**I.76** When businesses classified as FI (n=25) were asked if they consider their business to be part of the Foundation Industries 44% said yes. This figure increases to 69% if non respondents are excluded (n=16).

- If including all business respondents (excluding RTOs, academics/research organisations, and trade association), 37% (n=35) feel part of the FI.

**I.77** 44% of business beneficiaries within the FI have felt an increased sense of shared identity. Encouragingly, three of the five that had previously said that they do not consider themselves as part of the sector have felt an increase sense of shared identity. Only five have said that it has not increased their sense of shared identity. However, three of them already considered themselves as part of the sector and this could explain why it has not increased.

- If including all business respondents (excluding RTOs, academics/research organisations, and trade association), 43% (n=35) have felt an increase in the sense of shared identity with the FI.

**Figure I-35: Have the respondents opinions changed because of engaging with the TFI? (n=27)**

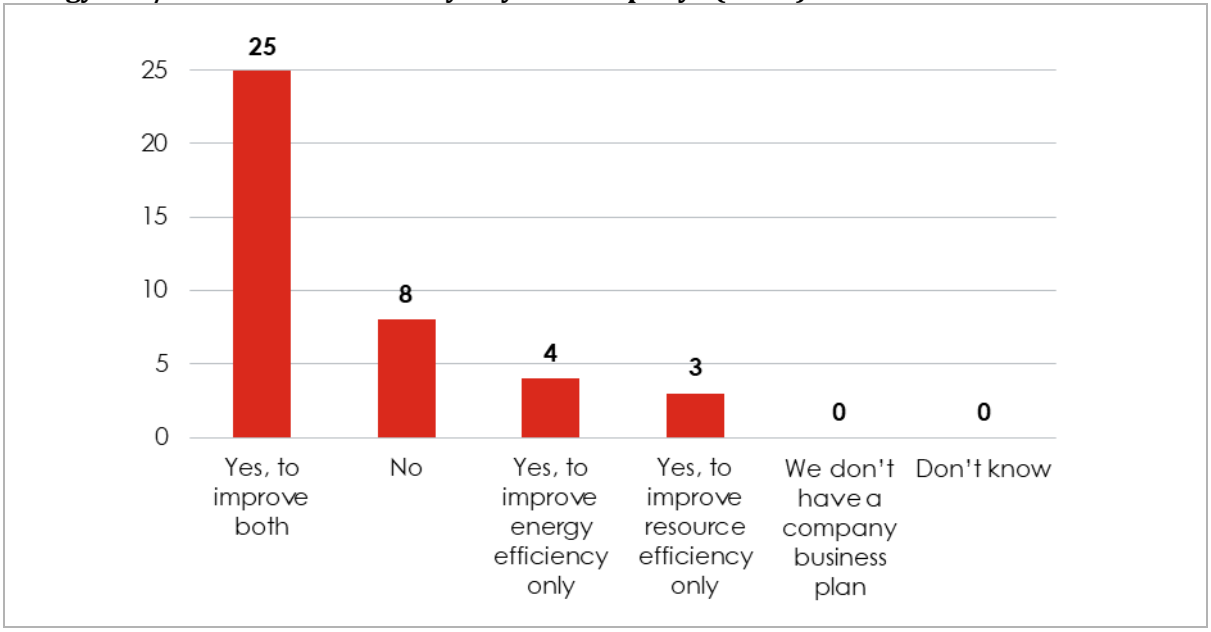



**Excluding 9 who did not answer* *Source: SQW analysis of beneficiary survey*

## Net Zero

I.78 Beneficiaries were asked whether their companies' business plans include actions intended to improve energy and/or resource efficiency in their company. Over half (25) have said yes, and that the plan aims to improve both. An additional seven (17.5%) aim to improve energy efficiency or resource efficiency. Of the remainder, 20% (eight) have said no; three of the eight are from outside the FI.

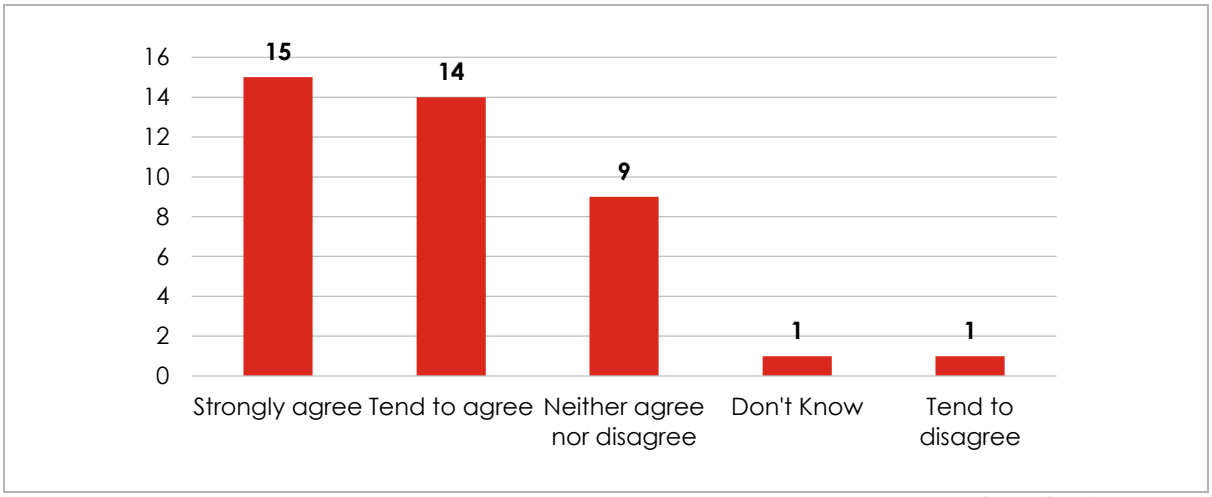
**Figure I-36: Does your company business plan include actions intended to improve energy and/or resource efficiency in your company? (n=40)**




*Source: SQW analysis of beneficiary survey*

I.79 Nearly two thirds of respondent either strongly agree or tend to agree that senior management in their business have the necessary skills to deliver innovation related to net zero. Only one respondent said that they tend to disagree, and no one completely disagreed with this statement.

**Figure I-37: To what extent do you agree with the statement: The senior management team within my business have the necessary skills to deliver innovation related to Net Zero? N=40**




*Source: SQW analysis of beneficiary survey*

# Annex J: Sector survey results

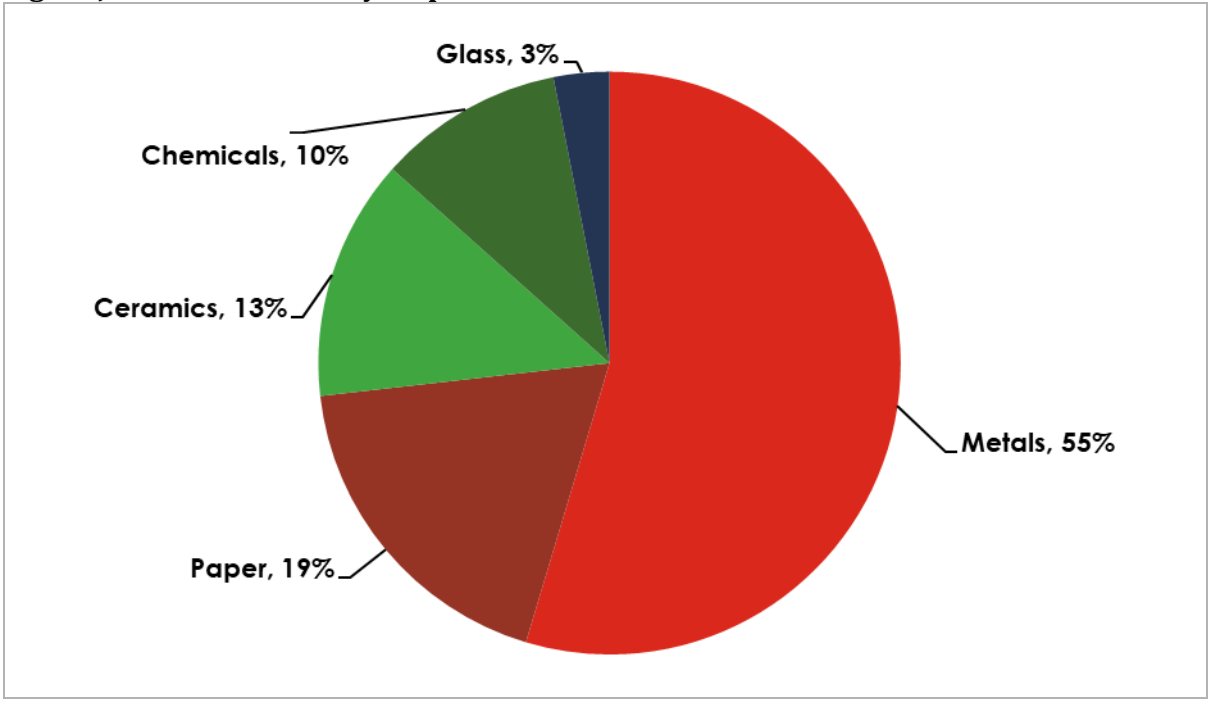
## Description of survey respondents

J.1 The business sector survey received 291 responses from organisations within the Foundation Industries. Below we give a description of the characteristics of the respondents.

### Sectors

J.2 Figure J-1 shows the proportion of the different FI sectors in the survey according to those who responded to the survey. Over half of all survey participants were operating within the metals sector (55%), followed by paper (19%), ceramics (13%), chemicals (10%) and glass (3%).

**Figure J-1: Sectors of survey respondents**

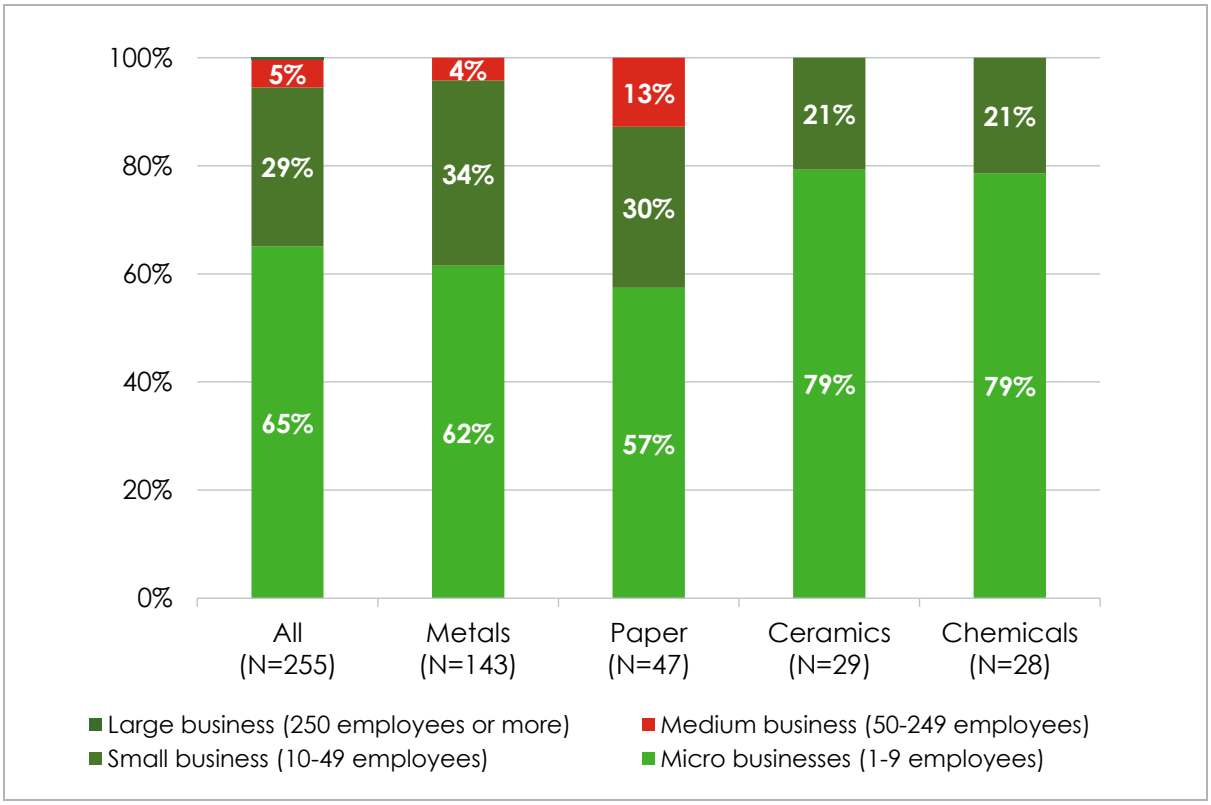



*Source: SQW analysis of business survey*
*Base: All survey participants (n=291)*

### Size

J.3 Across all FI, the majority of firms were either micro (65%) or small businesses (29%) with up to 49 employees (Figure J-2). Compared to other FI, ceramics and chemicals had a relatively higher proportion of micro businesses, accounting for over three quarters of the sector totals. Note that, as explained at the start of this section, results in the chart below are presented for the FI as a whole, and then each sector is compared against the FI rather than shown as part of the FI.

**Figure J-2: How many full-time employees did your business have on the payroll at the end of March 2025?**




*Source: SQW analysis of business survey*
*Base: Survey participants (n=255)*

## Ownership and age

**J.4** The majority (91%) of firms were UK-owned with no overseas operations (Table J-1). There was a relatively higher proportion of foreign owned companies within chemicals (13%) and glass (11%), compared with the proportion of 4% across all FI.

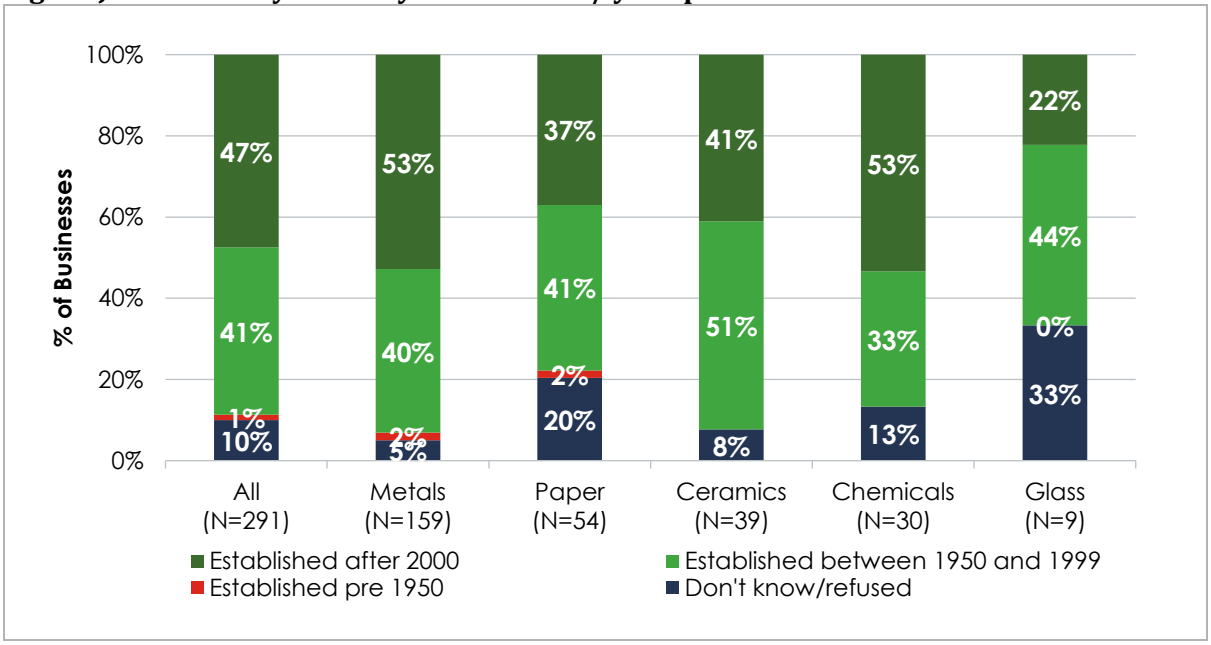
**Table J-1: Is your business UK-owned with no overseas operations, UK-owned with overseas subsidiaries, or foreign owned?**

| | Metals | Paper | Ceramics | Chemicals | Glass | All FI |
|---|---|---|---|---|---|---|
| UK-owned with no overseas operations | 97% | 80% | 92% | 77% | 89% | **91%** |
| UK-owned with overseas subsidiaries | 1% | 6% | 0% | 10% | 0% | **3%** |
| Part foreign / part UK-owned | 1% | 4% | 0% | 0% | 0% | **1%** |
| Foreign owned | 1% | 9% | 5% | 13% | 11% | **4%** |
| Don't know | 1% | 2% | 3% | 0% | 0% | **1%** |
| **Total no. of firms** | **159** | **54** | **39** | **30** | **9** | **291** |

*Source: SQW analysis of business survey*
*Base: All survey participants (n=291)*
**Note, totals may not sum correctly due to rounding errors*

**J.5** Around half (47%) of all firms were established after 2000, though the proportion of this was relatively higher within metals and chemicals (53% of both sectors). A further 41% were established between 1950 and 1999 (Figure J-3).

**Figure J-3: In which year was your business / your parent business first established?**




*Source: Source: SQW analysis of business survey*
*Base: All survey participants (n=291)*

# Financial performance

## Turnover

**J.6** In the 12 months up to March 2025, turnover varied across the firms from less than £100,000 to over £50 million (Table J-2). Turnover was relatively lower in glass and ceramics, with 63% and 60% of firms reporting turnover lower than £500,000 respectively (cf. FI proportion of 39%). Conversely, a higher proportion of firms in paper and chemicals reported a turnover of over £500,000: 64% and 67%, respectively (cf. all FI proportion of 52%).

**Table J-2: If you had to estimate the annual turnover of your business for the 12 months to the end of March 2025, what would it be?**

| | Metals (n=146) | Paper (n=50) | Ceramics (n=32) | Chemicals (n=27) | Glass (n=8) | All FI (n=263) |
|---|---|---|---|---|---|---|
| Less than £100,000 | 12% | 8% | 41% | 15% | 0% | 15% |
| £100,000 up to £500,000 | 28% | 20% | 19% | 4% | 63% | 24% |

| | Metals (n=146) | Paper (n=50) | Ceramics (n=32) | Chemicals (n=27) | Glass (n=8) | All FI (n=263) |
|---|---|---|---|---|---|---|
| Over £500,000 up to £2 million | 30% | 36% | 22% | 41% | 0% | 30% |
| Over £2 million up to £10 million | 15% | 18% | 6% | 22% | 0% | 15% |
| Over £10 million up to £50 million | 3% | 10% | 6% | 4% | 13% | 5% |
| More than £50 million | 2% | 0% | 0% | 0% | 13% | 2% |
| Don't know | 9% | 8% | 6% | 15% | 13% | 9% |

*Source: Source: SQW analysis of business survey*
*Base: Survey participants (n=263)*

**J.7** For the majority of firms (70%), over three quarters of their sales were to other businesses, which reflects the nature of FI as a supplier of key materials to other parts of the economy (Table J-3). Across all sectors, this proportion was higher for paper and metals (mean percentage scores of 89 and 81, respectively, cf. 77 across all FI) but much lower for glass and ceramics (mean percentage scores of 44 and 53, respectively).

**Table J-3: Approximately what percentage of your business' sales are to other businesses?**

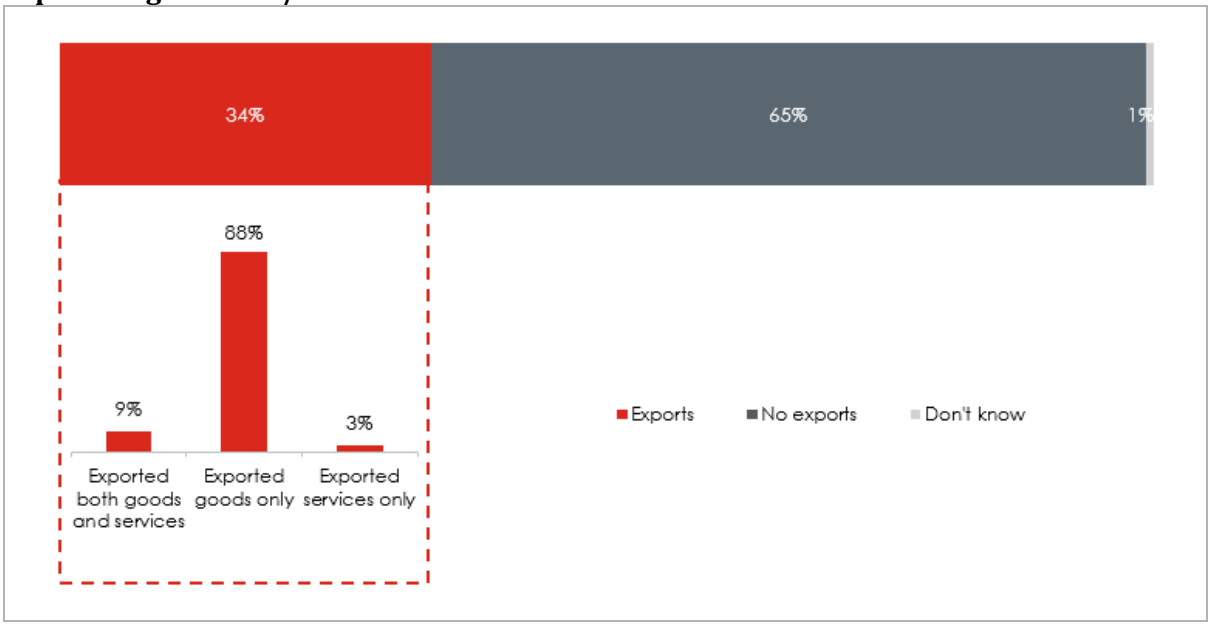
| | Metals (n=150) | Paper (n=52) | Ceramics (n=36) | Chemicals (n=29) | Glass (n=8) | All FI (n=275) |
|---|---|---|---|---|---|---|
| 0% | 5% | 6% | 22% | 14% | 13% | 8% |
| Up to 25% | 7% | 0% | 14% | 7% | 38% | 7% |
| Between 26% and 50% | 7% | 4% | 14% | 14% | 0% | 8% |
| Between 51% and 75% | 6% | 6% | 8% | 3% | 25% | 7% |
| Between 76% and 100% | 75% | 85% | 42% | 62% | 25% | 70% |
| **Mean percentage score** | **81.3** | **89.1** | **53.4** | **69.1** | **44.1** | **76.7** |

*Source: SQW analysis of business survey*
*Base: Survey participants (n=275)*

## Exports

**J.8** Around a third of the firms had exported goods or services in the year up to March 2025 (Figure J-4). The majority of exports were for goods with only 3% exporting any services.

**Figure J-4: In the year up to March 2025, did your business export any goods or services outside of the UK?. If yes, roughly what percentage of your turnover was accounted by exports of goods and/or services?**




*Source: SQW analysis of business survey*
*Base: Survey participants (n=289)*

**J.9** Table J-4 shows the breakdown of export activity by sector. Across the FI, the proportion of exporters was relatively lower in metals and glass with around a third of the firms exporting (24% and 22%, respectively) but higher in paper and ceramics (53% and 46%, respectively).

**Table J-4: In the year up to March 2025, did your business export any goods or services outside of the UK?**

| | Metals (n=159) | Paper (n=53) | Ceramics (n=39) | Chemicals (n=29) | Glass (n=9) | All FI (n=289) |
|---|---|---|---|---|---|---|
| Exported both goods and services | 1% | 9% | 0% | 7% | 0% | 3% |
| Exported goods only | 21% | 43% | 46% | 34% | 22% | 30% |
| Exported services only | 2% | 0% | 0% | 0% | 0% | 1% |
| No exports | 75% | 47% | 54% | 59% | 67% | 65% |
| Don't know | 1% | 0% | 0% | 0% | 11% | 1% |

*Source: SQW analysis of business survey*
*Base: Survey participants (n=289)*

J.10 For the majority of firms (86%), the exports of goods accounted for up to quarter of their total turnover (Table J-5). Services accounted for up to a quarter of total turnover for three quarters of the firms that had exported any services.[46]

**Table J-5: Roughly what percentage of your turnover was accounted by exports of goods?**

| | Metals (n=31) | Paper (n=25) | Ceramics (n=15) | Chemicals (n=11) | Glass (n=1) | All FI (n=83) |
|---|---|---|---|---|---|---|
| 1-25% | 84% | 76% | 73% | 36% | 0% | 72% |
| 26-50% | 13% | 8% | 13% | 27% | 100% | 14% |
| 51-75% | 0% | 8% | 13% | 9% | 0% | 6% |
| 76-100% | 3% | 8% | 0% | 27% | 0% | 7% |

*Source: SQW analysis of business survey*
*Base: Survey participants (n=83)*

## Costs

J.11 For just under half of the firms (49%), business costs were up to £500,000 in the year to March 2025 (Table J-6). Costs were relatively lower in ceramics with 47% of firms saying their annual business costs were less than £100,000 (cf. proportion of 20% across all FI).This reflects the size of businesses in ceramics (i.e. larger proportion of micro businesses). On the other hand, costs for paper businesses were higher with 46% reporting costs of over £500,000 (cf. FI proportion of 38%).

**Table J-6: If you had to estimate the annual costs of your business for the 12 months to the end of March 2025, what would it be?**

| | Metals (n=142) | Paper (n=48) | Ceramics (n=32) | Chemicals (n=27) | Glass (n=7) | All FI (n=256) |
|---|---|---|---|---|---|---|
| Less than £100,000 | 15% | 13% | 47% | 22% | 29% | 20% |
| £100,000 up to £500,000 | 32% | 27% | 19% | 30% | 43% | 29% |
| Over £500,000 up to £2m | 29% | 21% | 6% | 15% | 0% | 22% |
| Over £2m up to £10m | 9% | 17% | 9% | 15% | 0% | 11% |
| Over £10m up to £50m | 2% | 8% | 3% | 4% | 14% | 4% |

[46] The results for percentage of turnover accounted for by exports of services is not presented as a table because of a low number of responses (n=11).

| | Metals (n=142) | Paper (n=48) | Ceramics (n=32) | Chemicals (n=27) | Glass (n=7) | All FI (n=256) |
|---|---|---|---|---|---|---|
| More than £50m | 1% | 0% | 0% | 0% | 0% | 1% |
| Don't know | 11% | 15% | 16% | 15% | 14% | 13% |

*Source: SQW analysis of business survey*
*Base: Survey participants (n=256)*

### Profit

**J.12** For around half of the firms (45%), profitability was lower than £500,000 in the year to March 2025 (Table J-7). Firms were relatively more profitable in the chemicals sector with 12% of firms reporting a profit of over £500,000 (cf. proportion of 8% across all FI) but were less profitable in ceramics (3%) and glass (3%).

**Table J-7: If you had to estimate the annual operating profit of your business for the 12 months to the end of March 2025, what would it be?**

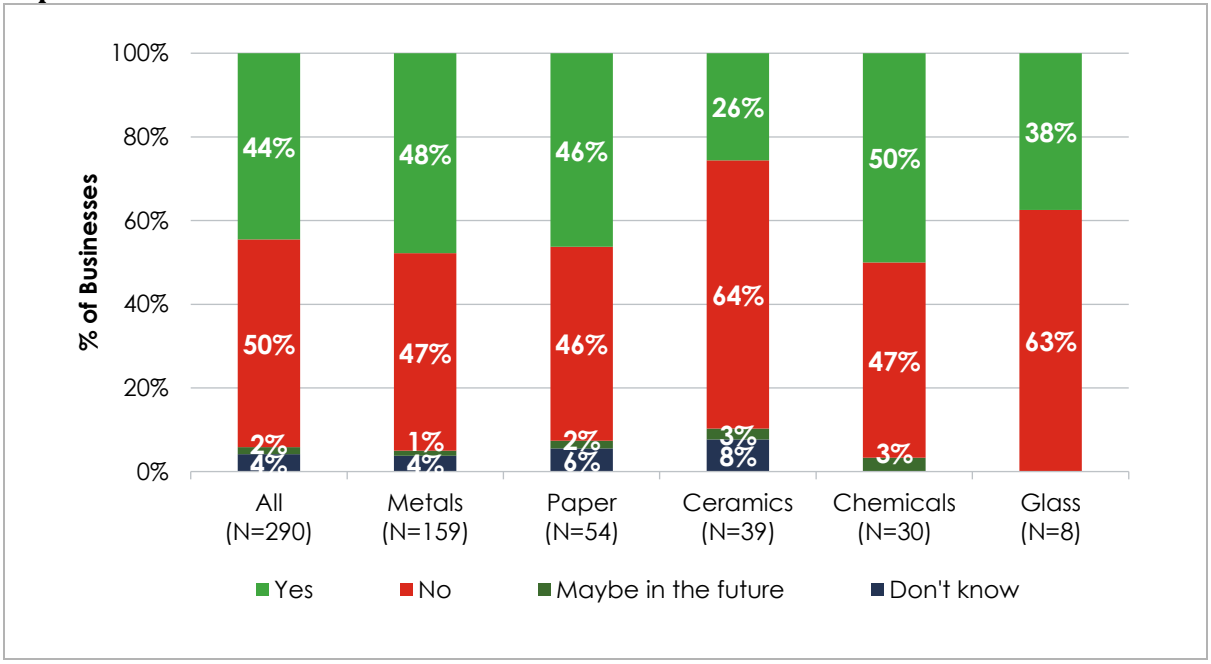
| | Metals (n=138) | Paper (n=46) | Ceramics (n=30) | Chemicals (n=25) | Glass (n=8) | All FI (n=247) |
|---|---|---|---|---|---|---|
| Less than £100,000 | 44% | 48% | 67% | 24% | 38% | 45% |
| £100,000 up to £500,000 | 30% | 22% | 13% | 48% | 25% | 28% |
| Over £500,000 up to £2 million | 7% | 7% | 0% | 4% | 0% | 6% |
| Over £2 million up to £10 million | 1% | 0% | 3% | 8% | 0% | 2% |
| Over £10 million up to £50 million | 1% | 0% | 0% | 0% | 0% | 0% |
| More than £50 million | 1% | 0% | 0% | 0% | 0% | 0% |
| Don't know | 16% | 24% | 17% | 16% | 38% | 18% |

*Source: SQW analysis of business survey*
*Base: Survey participants (n=247)*

## Equality, diversity & inclusion

**J.13** Just under half of all firms (44%) had an equality, diversity and inclusion (EDI) plan or strategy in place (Figure J-5). The proportion of firms without an EDI strategy was relatively higher in ceramics (64%) and glass (63%), but lower in paper (46%).

**Figure J-5: Does your business have an equality, diversity and inclusion plan or strategy in place?**

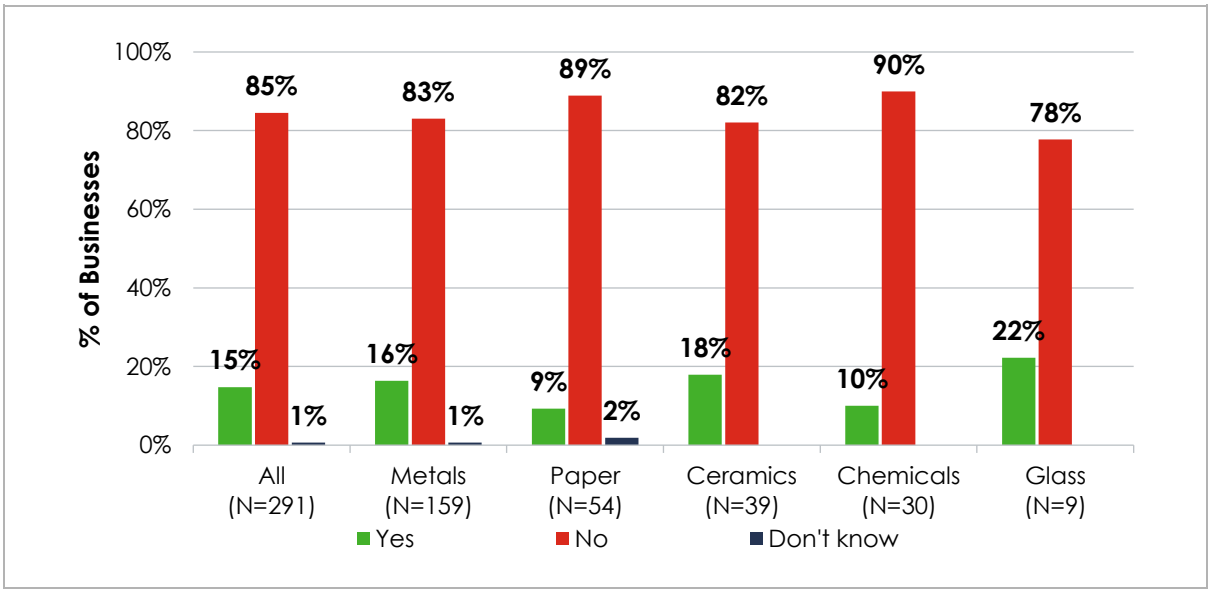



*Source: SQW analysis of business survey*
*Base: Survey participants (n=290)*

## Perceptions of Foundation Industries

**J.14** The large majority of firms had not heard of the ceramics, glass, cement, metals, paper and chemicals sectors being described as 'Foundation Industries' (Figure J-6). Across each of the sectors, the proportion of firms which had not heard of the sectors as being described as FI was relatively consistent.

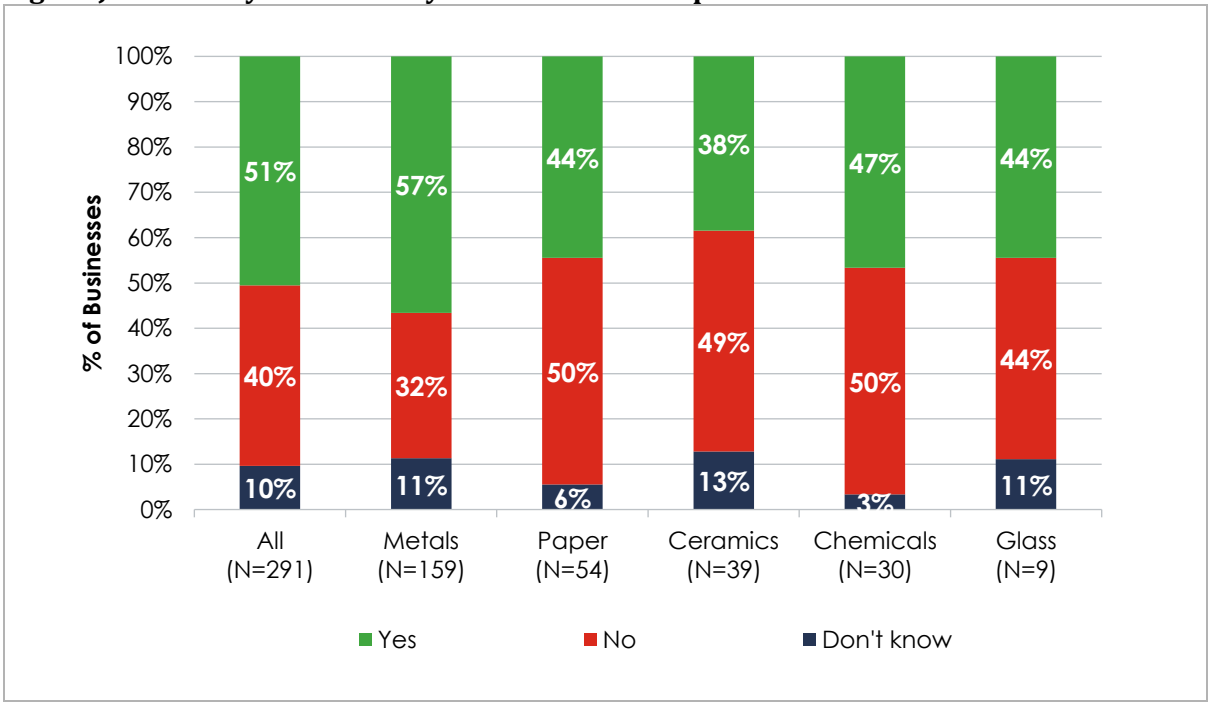
**Figure J-6: Have you ever heard of these sectors being described as 'Foundation Industries'?**




*Source: SQW analysis of business survey*
*Base: All survey participants (n=291)*

**J.15** Although the majority of firms had not heard of the sectors being described as FI around half considered themselves as part of FI but over one-third did not (Figure J-7).

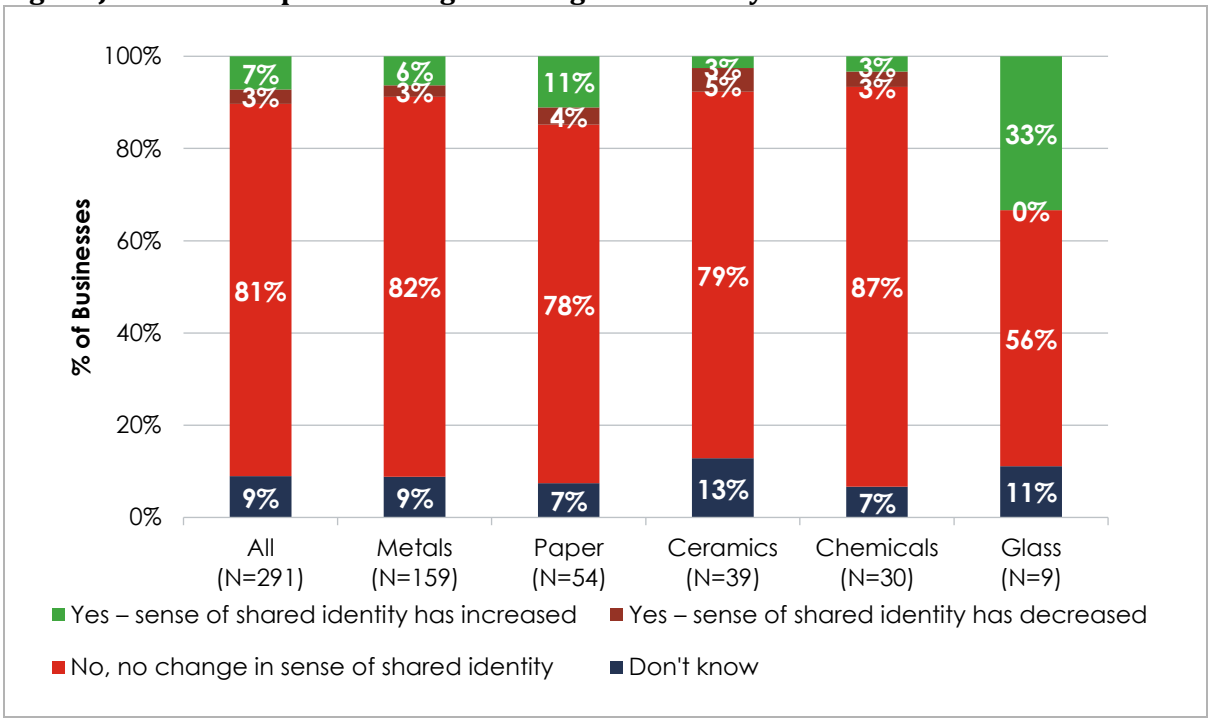
**Figure J-7: Would you consider your business to be part of the Foundation Industries?**




*Source: SQW analysis of business survey*
*Base: All survey participants (n=291)*

**J.16** Across the FI, the majority of respondents stated that their opinion on whether they would consider their business to be part of the Foundation Industries had not changed in the last 3-4 years (Figure J-8). Across each of the sectors, the proportion of firms which stated this had not changed was relatively consistent, with the exception of glass where a third stated it had increased.

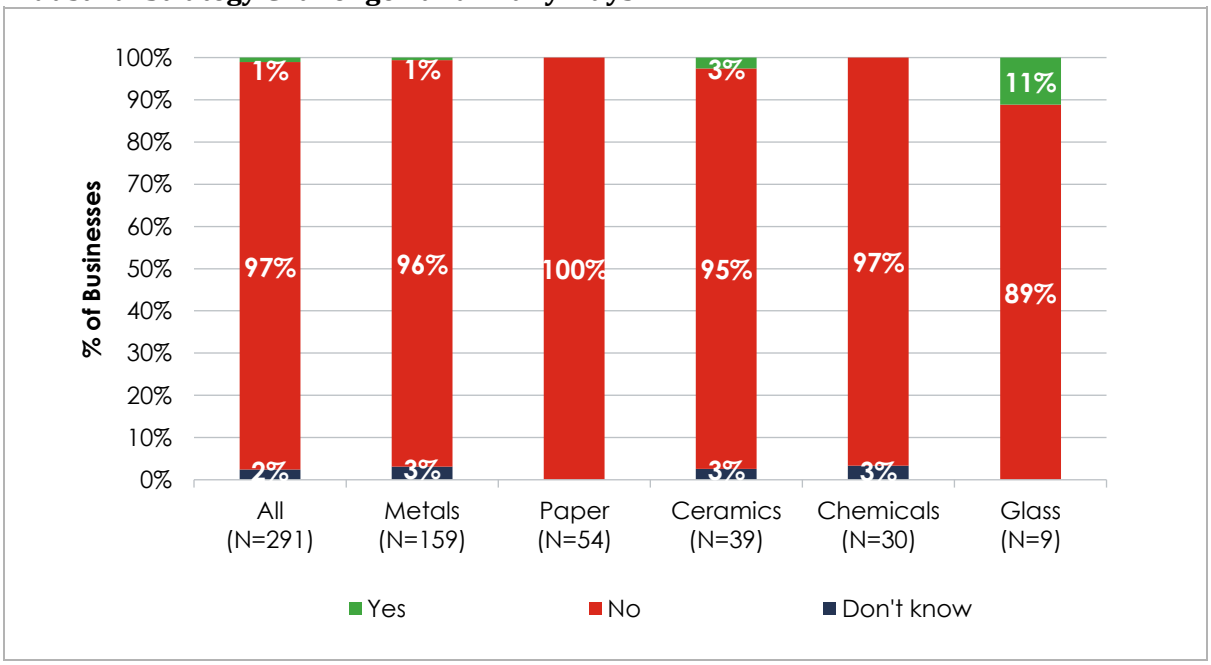
**Figure J-8: Has this opinion changed during the last 3-4 years?**




*Source: SQW analysis of business survey*
*Base: All survey participants (n=291)*

**J.17** Across all FI, the majority of businesses had not participated in the TFI ISCF in any way (Figure J-9), for example through reading TFI material, applying to TFI competitions or attending TFI events.

**Figure J-9: Has your business participated in the Transforming Foundation Industries Industrial Strategy Challenge Fund in any ways?**

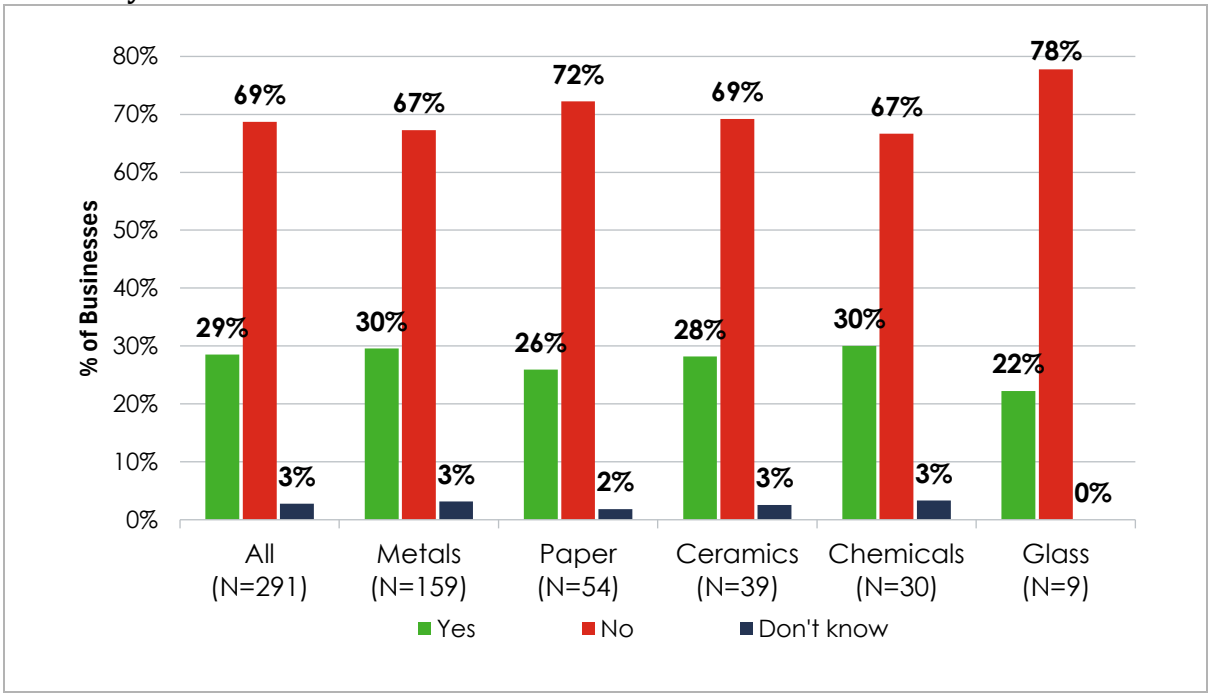



*Source: SQW analysis of business survey*
*Base: All survey participants (n=291)*

# Innovation attitudes and activity

**J.18** Across the FI, just under a third of businesses had invested in R&D and/or innovation in the financial year up to March 2025 (Figure J-10). The metals and chemicals sectors had the highest percentage of businesses investing in R&D and/or innovation (both 28%). This was followed by (in order): ceramics, paper and glass.

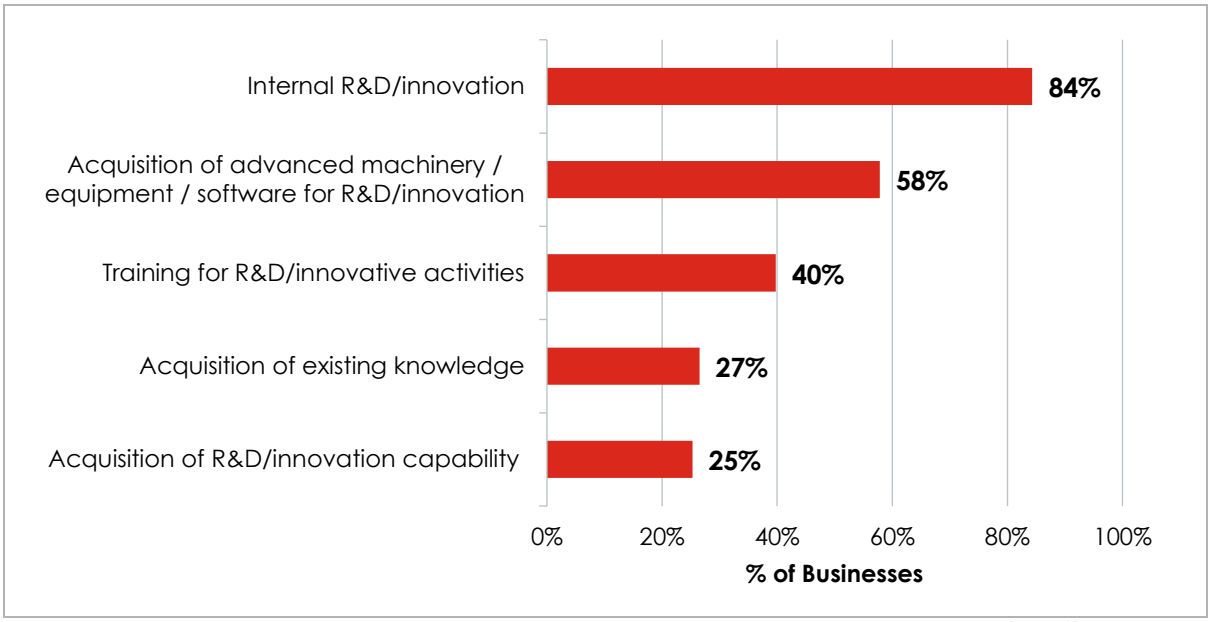
**Figure J-10: Has your business invested in R&D and / or innovation in this current financial year to March 2025 or will it do so?**




*Source: SQW analysis of business survey*
*Base: All survey participants (n=291)*

**J.19** The majority of businesses had invested in internal R&D and/or innovation and acquisition of advanced machinery/equipment/software (Figure J-11).

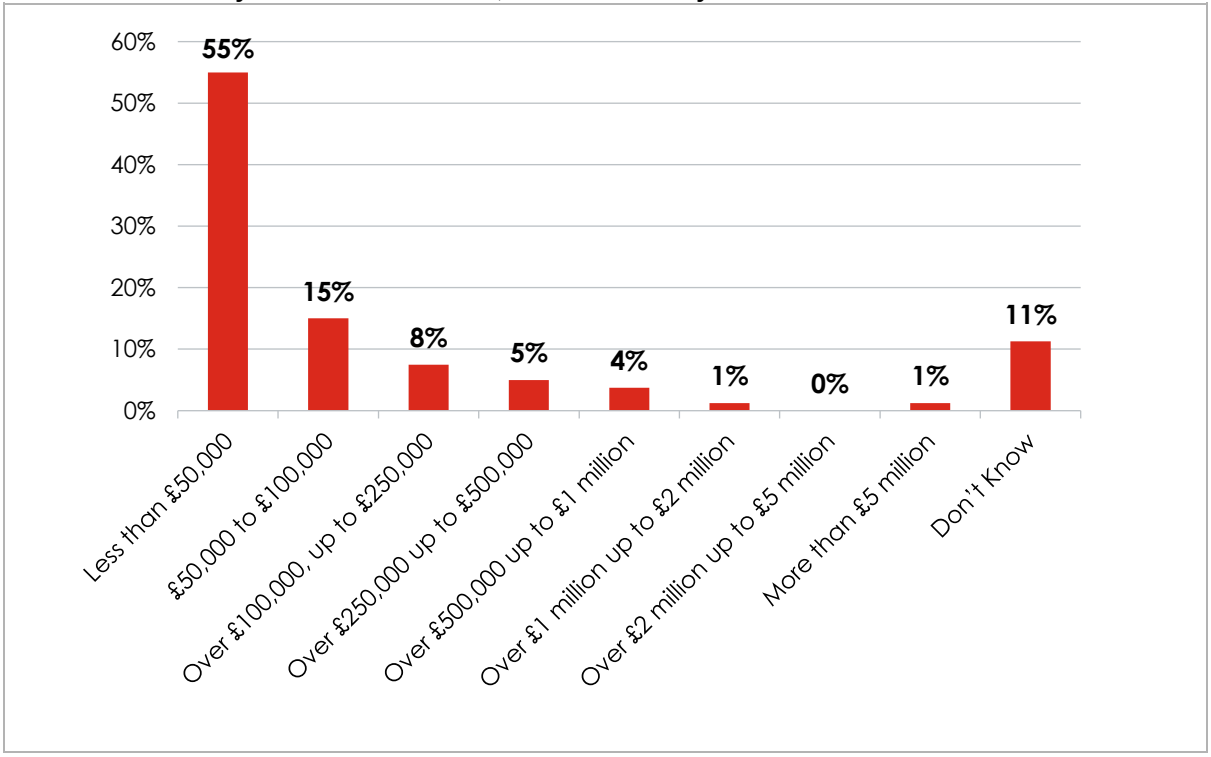
**Figure J-11: Which of the following did / will your business invest in from April 2024 to March 2025?**




*Source: SQW analysis of business survey*
*Base: All survey participants that invested in R&D/innovation (n=83)*

**J.20** Business investment in R&D covered a wide range from less than £50k to more than £5m. Over three quarters (78%) of businesses invested less than £250k and over half (55%) of businesses invested less than £50k.

**Figure J-12: If you had to estimate the value of R&D investment by your business in this current financial year to March 2025, how much do you think that would be?**




*Source: SQW analysis of business survey*
*Base: All survey participants that invested in R&D/innovation, minus those who refused (n=80)*

**J.21** There is some variation between sectors by level of investment - a small proportion of firms in metals, paper and ceramics invested over £500,000 (between 4% and 9% from each of these sectors).

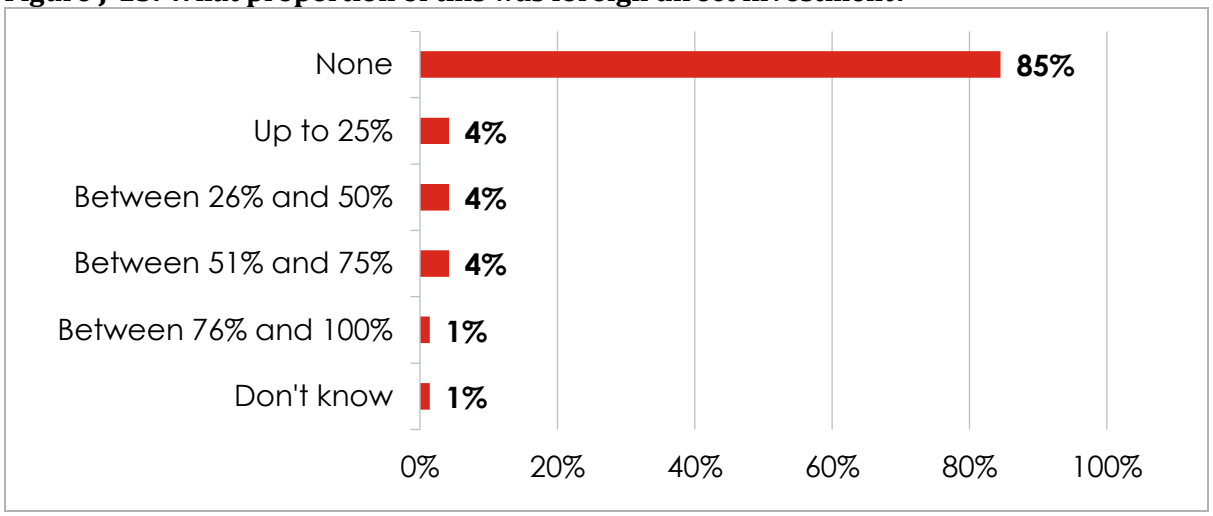
**Table J-8: If you had to estimate the value of R&D investment by your business in this current financial year to March 2025, how much do you think that would be? By sector**

| | Metals (N=46) | Paper (N=12) | Ceramics (N=11) | Chemicals (N=9) | Glass (N=2) | All (N=80) |
|---|---|---|---|---|---|---|
| Less than £50,000 | 59% | 42% | 64% | 56% | 0% | 55% |
| £50,000 to £100,000 | 17% | 25% | 0% | 11% | 0% | 15% |
| Over £100,000, up to £250,000 | 7% | 0% | 0% | 33% | 0% | 8% |
| Over £250,000 up to £500,000 | 2% | 8% | 9% | 0% | 50% | 5% |
| Over £500,000 up to £1 million | 4% | 0% | 9% | 0% | 0% | 4% |
| Over £1 million up to £2 million | 0% | 8% | 0% | 0% | 0% | 1% |
| Over £2 million up to £5 million | 0% | 0% | 0% | 0% | 0% | 0% |

*Source: SQW analysis of business survey*
*Base: All survey participants that invested in R&D/innovation, minus those who refused (n=80)*

**J.22** Of the companies that invested in R&D and/or innovation, less than 20% involved foreign direct investment (Figure J-13). However, for a small proportion of companies in metals, ceramics and glass, between 51% and 100% of their investment was from FDI (Table J-9).

**Figure J-13: What proportion of this was foreign direct investment?**




*Source: SQW analysis of business survey*
*Base: All survey participants that invested in R&D/innovation, minus those who refused (n=71)*

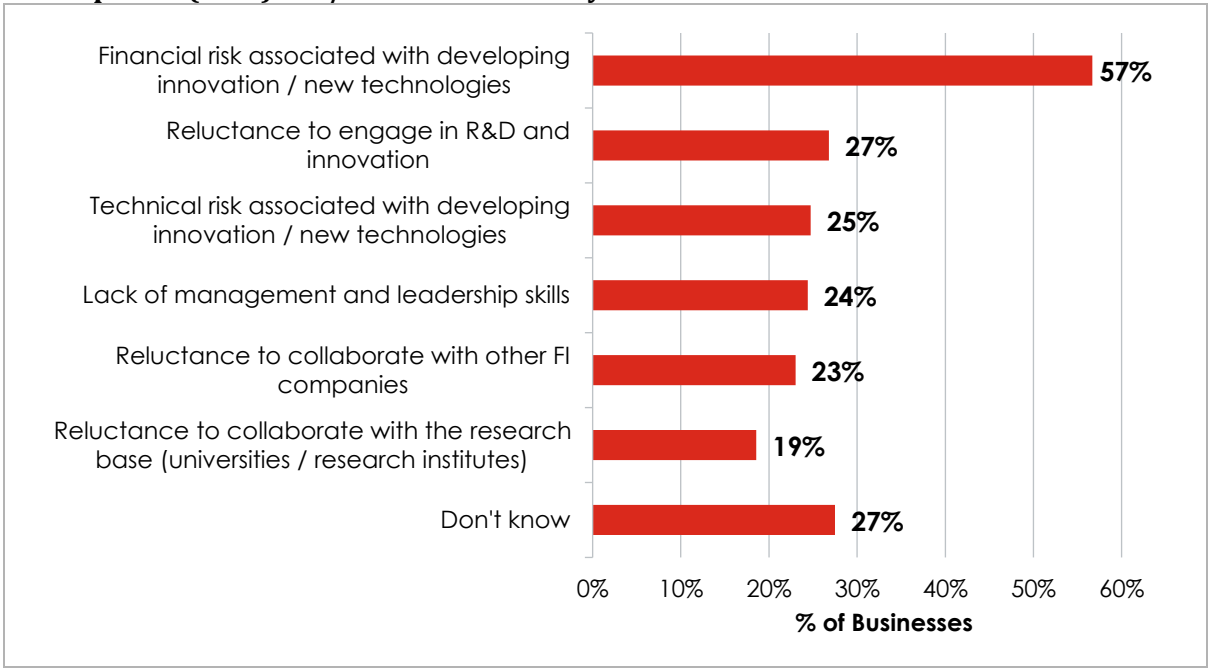
**Table J-9: If you had to estimate the value of R&D investment by your business in this current financial year to March 2025, how much do you think that would be? By sector**

| | Metals (N=46) | Paper (N=12) | Ceramics (N=11) | Chemicals (N=9) | Glass (N=2) | All (N=80) |
|---|---|---|---|---|---|---|
| None | 90% | 90% | 78% | 67% | 50% | 85% |
| Up to 25% | 2% | 0% | 0% | 22% | 0% | 4% |
| Between 26% and 50% | 2% | 10% | 0% | 11% | 0% | 4% |
| Between 51% and 75% | 5% | 0% | 11% | 0% | 0% | 4% |
| Between 76% and 100% | 0% | 0% | 0% | 0% | 50% | 1% |
| Don't know | 0% | 0% | 11% | 0% | 0% | 1% |

*Source: SQW analysis of business survey*
*Base: All survey participants that invested in R&D/innovation, minus those who refused (n=71)*

J.23 Businesses reported a wide range of perceived barriers to R&D and/or innovation.[47] These commonly included (in order): financial risk, reluctance to engage in R&D and innovation, technical risks, lack of management and leadership skills and reluctance to collaborate with other FI companies. Reluctance to collaborate with the research base was also considered a perceived barrier, although this was not felt as strongly.

**Figure J-14: Which of the following, if any, do you perceive as barriers to research and development (R&D) and/ or innovation for your business?**




*Source: SQW analysis of business survey*
*Base: All survey participants (n=291)*

[47] The perceived barriers were prompted.

**J.24** There was general consensus amongst businesses from different sectors on the perceived barriers to R&D and/or innovation i.e. there was not much variation between sectors in relation to particular barriers (Table J-10).

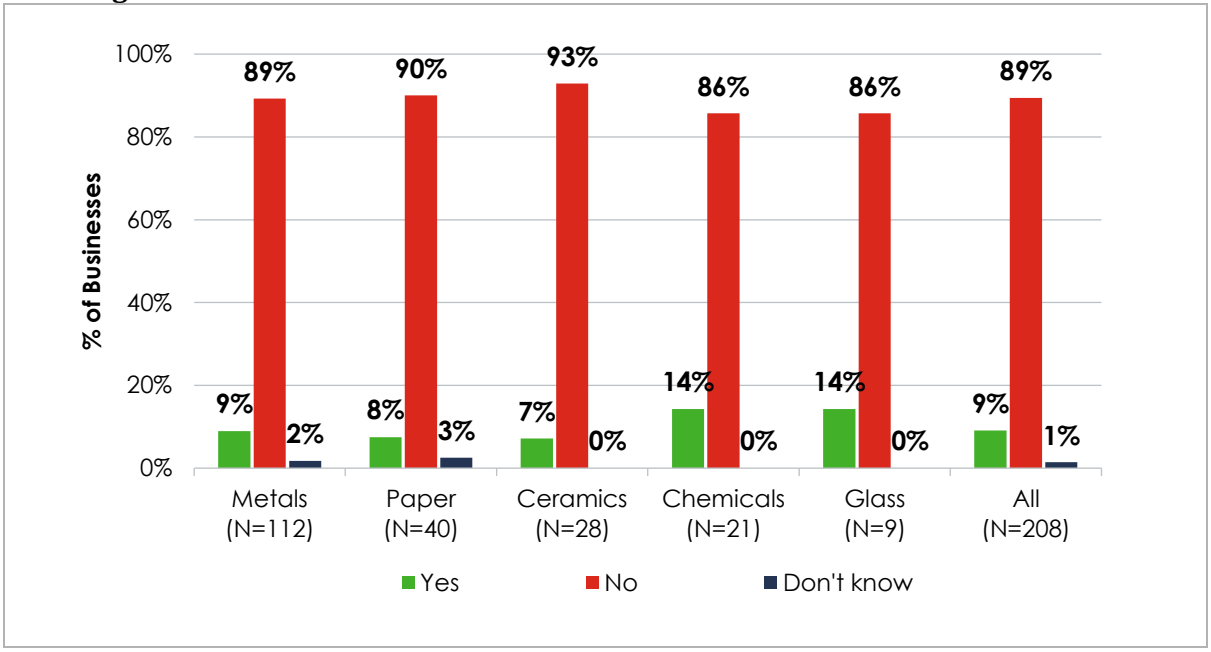
**Table J-10: Which of the following, if any, do you perceive as barriers to research and development (R&D) and/ or innovation for your business? By sector**

| | Metals (N=159) | Paper (N=54) | Ceramics (N=39) | Chemicals (N=30) | Glass (N=9) | All (N=291) |
|---|---|---|---|---|---|---|
| Financial risk associated with developing innovation / new technologies | 57% | 61% | 44% | 60% | 78% | 57% |
| Reluctance to engage in R&D and innovation | 28% | 26% | 21% | 30% | 33% | 27% |
| Technical risk associated with developing innovation / new technologies | 26% | 24% | 18% | 27% | 22% | 25% |
| Lack of management and leadership skills | 26% | 28% | 21% | 17% | 22% | 24% |
| Reluctance to collaborate with other FI companies | 21% | 19% | 31% | 27% | 33% | 23% |
| Reluctance to collaborate with the research base | 18% | 22% | 15% | 23% | 11% | 19% |
| Don't know | 27% | 30% | 33% | 23% | 11% | 27% |

*Source: SQW analysis of business survey*
*Base: All survey participants (n=291)*

**J.25** Figure J-15 shows that a large majority of companies had not even considered investing in R&D during the period April 2024 to March 2025.

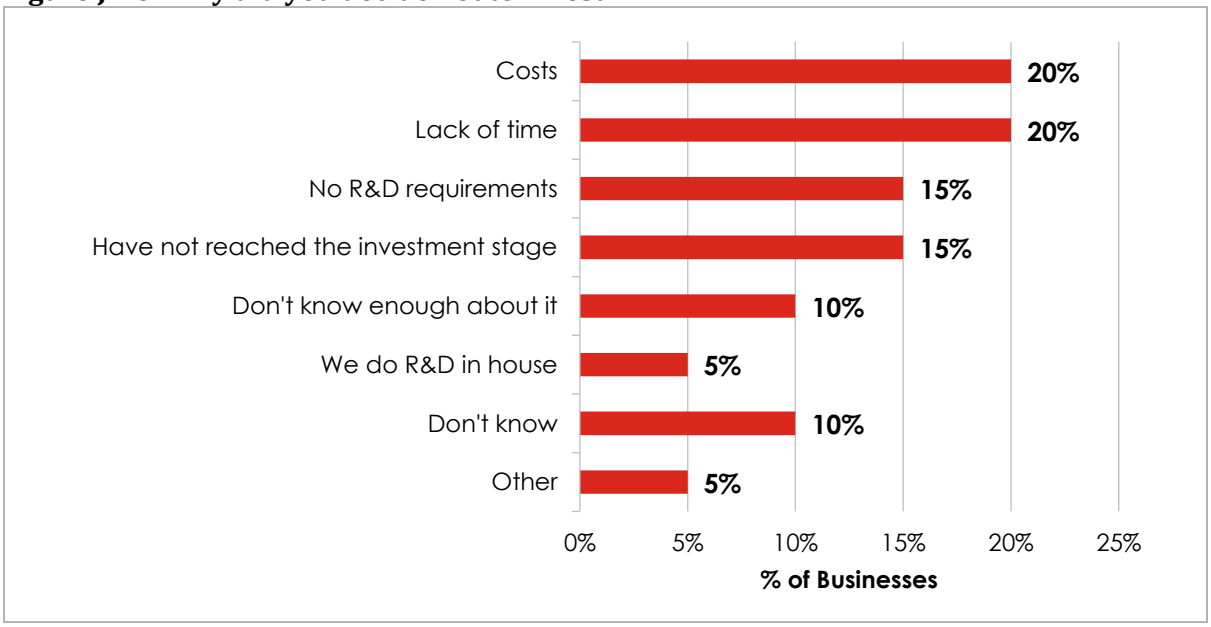
**Figure J-15: In the period April 2024 to March 2025, have / are you seriously considering investing in R&D?**




*Source: SQW analysis of business survey*
*Base: Survey participants (n=208)*

**J.26** Of those companies that had seriously considered investment in R&D and/or innovation but decided not to invest, the top three reasons related to: financial risk, lack of time to invest, and a lack of R&D requirements. However, these figures are based on a small number of survey responses and should be interpreted with caution (Figure J-16: Why did you decide not to invest? ).

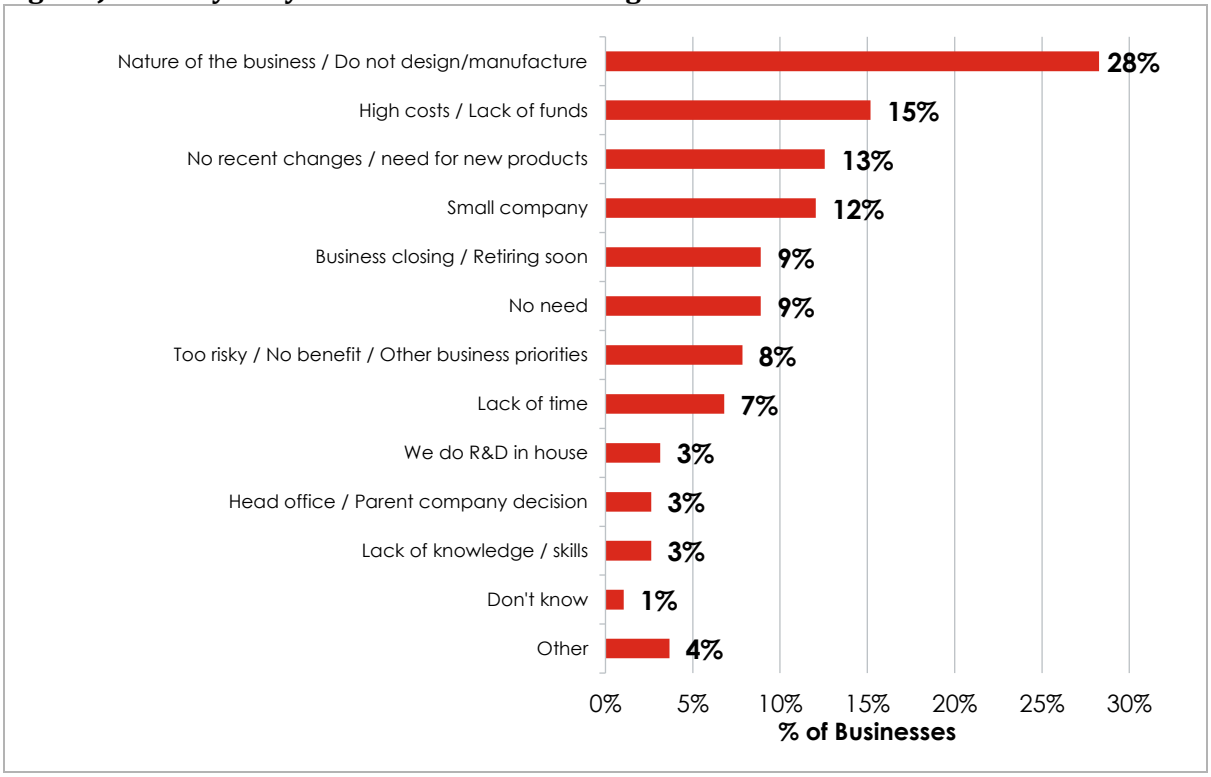
**Figure J-16: Why did you decide not to invest?**




*Source: SQW analysis of business survey*
*Base: Survey participants (n=18)*

**J.27** Of those companies that did not consider investment in R&D and/or innovation, almost a third cited a lack of need due to the nature of the business (Figure J-17).

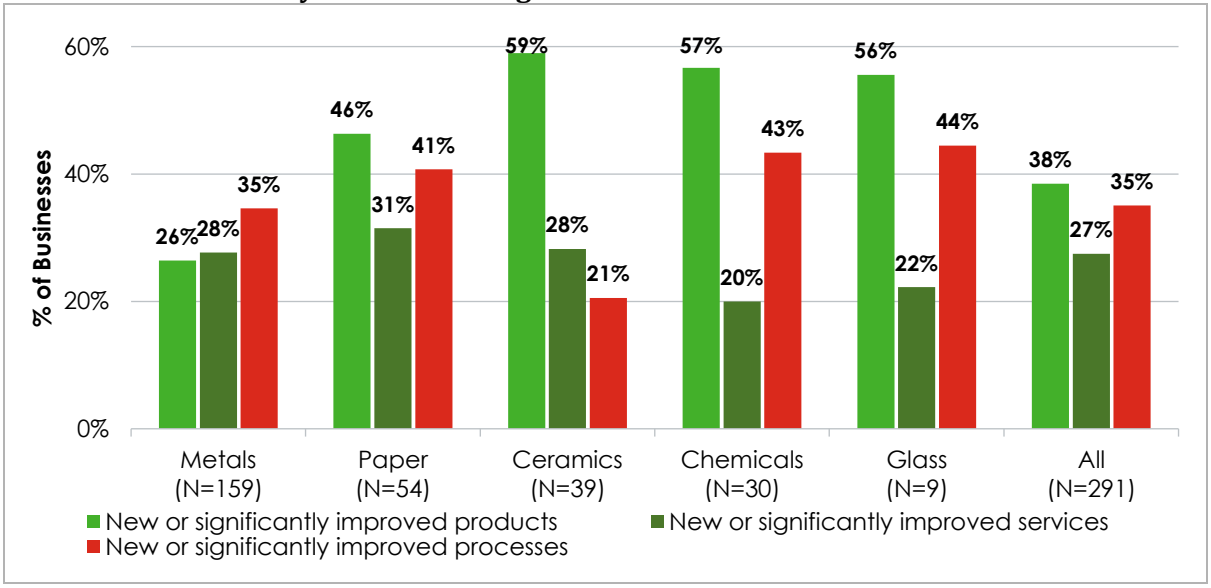
**Figure J-17: Why did you not consider investing in R&D?**




*Source: SQW analysis of business survey*
*Base: Survey participants (n=187)*

**J.28** Over a third (55%) of FI companies introduced new or significantly improved products from April 2024 to March 2025 and a similar proportion (35%) introduced new or significantly improved processes, indicating a reasonable level of innovation. Ceramics companies were most likely to have introduced new or significantly improved products (59%) and metals were least likely (26%). Glass and chemicals companies were most likely to have introduced new or significantly improved processes (44% and 43% , respectively) and ceramics the least (21%) (see Figure J-18).

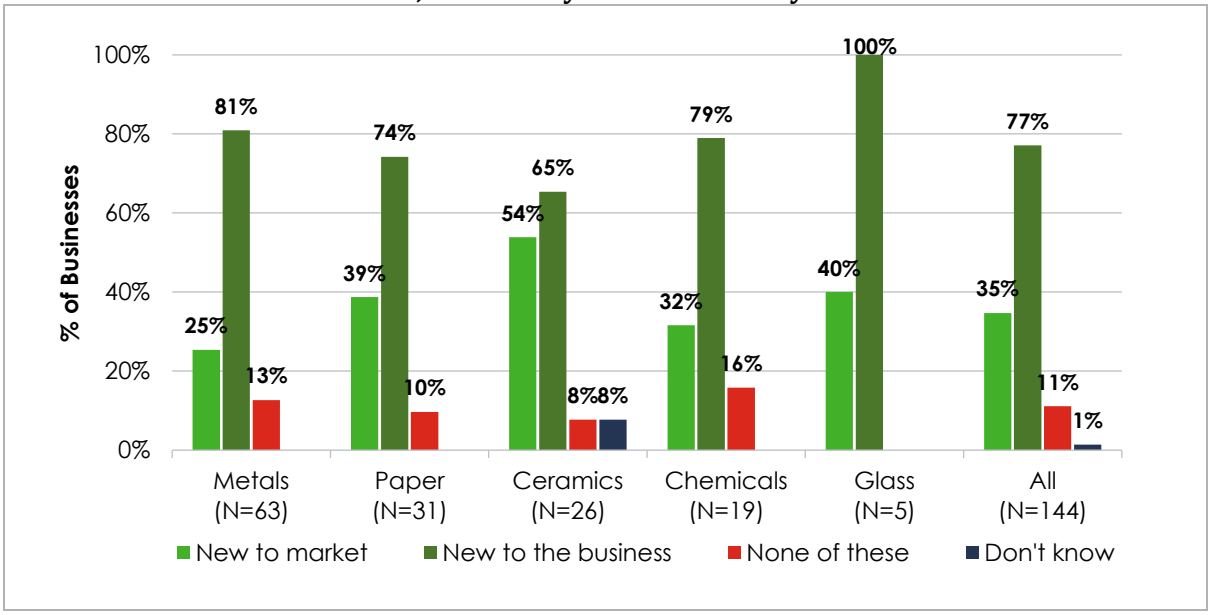
**Figure J-18: In the current financial year, April 2024 to March 2025, did / will your business introduce any of the following?**




*Source: SQW analysis of business survey*
*Base: All survey participants (n=291)*

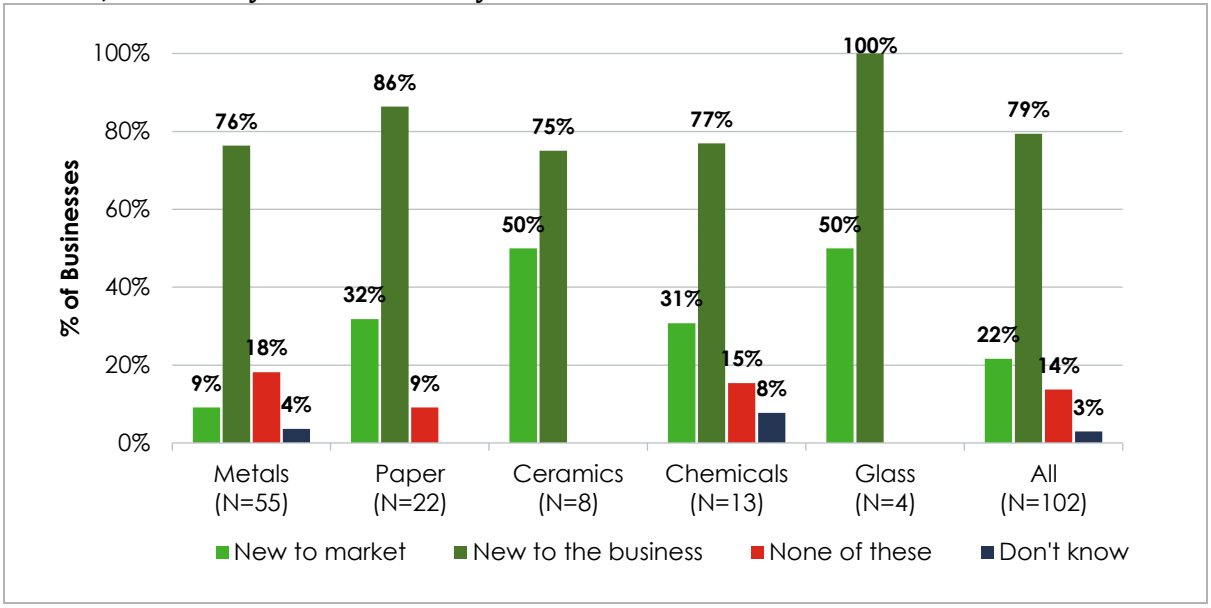
J.29 The vast majority of businesses reported that new or significantly improved products or service innovations were new to their business, but around a third were reported as new to the market (see Figure J-19). This is fairly consistent by sector. A similar picture emerges for new or significantly improved processes – a higher proportion were new to the business rather new to their industry (Figure J-20).

**Figure J-19: Were any of these new or significantly improved products or service innovations new to the market, or new to your business? By sector**




*Source: SQW analysis of business survey*
*Base: All survey participants excluding those respondents who did not indicate that they had introduced new or improved product or service innovations (n=144)*

**Figure J-20: Were any of these new or significantly improved processes new to the market, or new to your business? By sector**

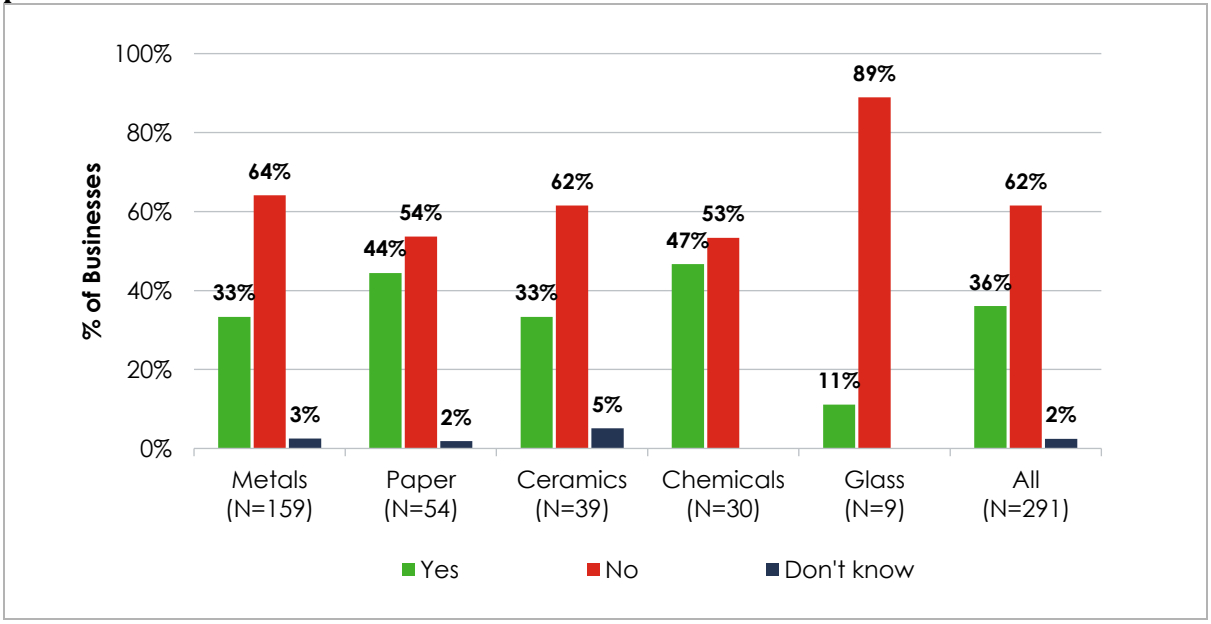



*Source: SQW analysis of business survey*
*Base: All survey participants excluding those respondents who did not indicate that they had introduced new or improved processes (n=102)*

## Collaboration

**J.30** Figure J-21 illustrates that around one-third of businesses collaborated with other organisations to develop new products, services or processes but the majority did not (36% collaborating versus 62% not). The gap between those collaborating and those that did not was most profound in metals, ceramics and glass. The gap is closer in paper and chemicals.

**Figure J-21: In the current financial year, April 2024 to March 2025, did / will your business collaborate with other organisations to develop new products, services or processes?**



*Source: SQW analysis of business survey*
*Base: All survey participants (n=291)*

**J.31** Collaboration was most common with other businesses, with more collaborating with businesses in the same sector than a different sector (79% and 58%, respectively). There were much lower levels of collaboration with universities (28%) and other research institutes (17%) (Table J-11).

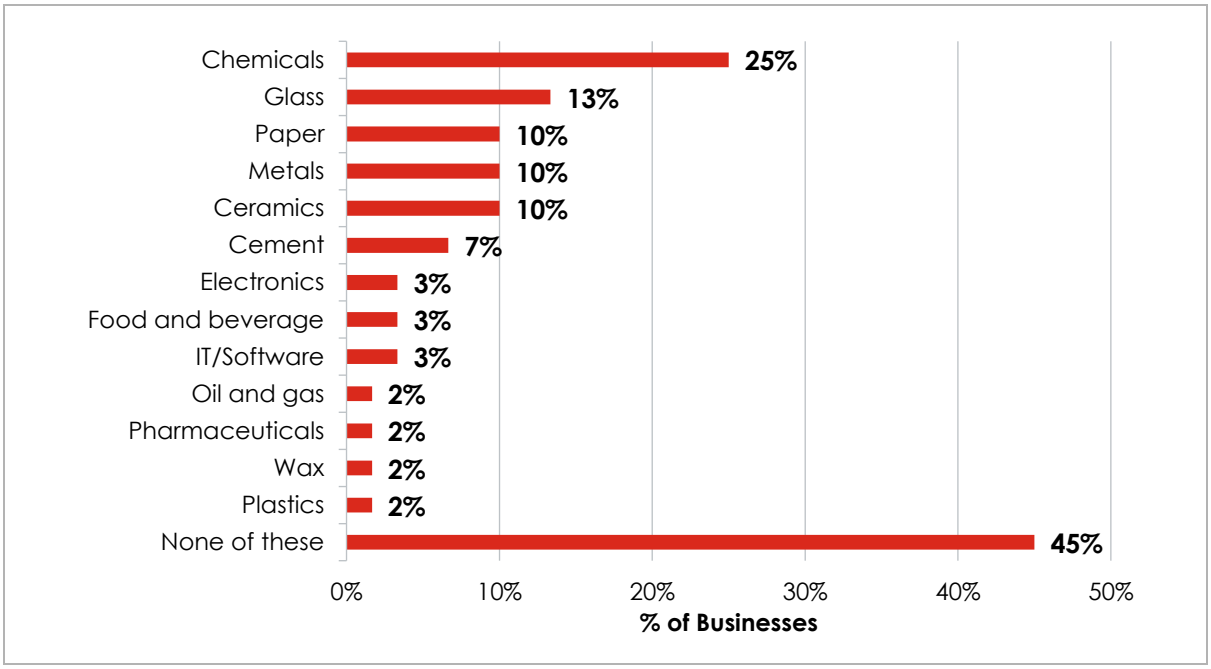
**Table J-11: Which of the following types of organisations did / will you collaborate with?**

| | Metals (N=53) | Paper (N=24) | Ceramics (N=13) | Chemicals (N=14) | Glass (N=1) | All (N=105) |
|---|---|---|---|---|---|---|
| Other businesses – from your sector | 72% | 75% | 92% | 100% | 100% | 79% |
| Other businesses – from a different sector | 72% | 50% | 54% | 29% | 0% | 58% |
| Universities or other higher education institutions | 28% | 17% | 23% | 50% | 0% | 28% |
| Government or public research institutes | 19% | 13% | 15% | 21% | 0% | 17% |
| Private sector finance providers | 13% | 4% | 23% | 14% | 0% | 12% |
| Local authority funding | 2% | 0% | 0% | 0% | 0% | 1% |
| None of these | 2% | 4% | 0% | 7% | 0% | 3% |

*Source: SQW analysis of business survey*
*Base: All survey participants who had collaborated with another organisation to develop their new products/processes/services (n=105)*

**J.32** The majority of businesses survey respondents had collaborated with outside of their own sector were from one of the FIs, with the chemicals sector being the most common (Figure J-22).

**Figure J-22: Were / are the businesses you collaborated with from any of the following sectors?**

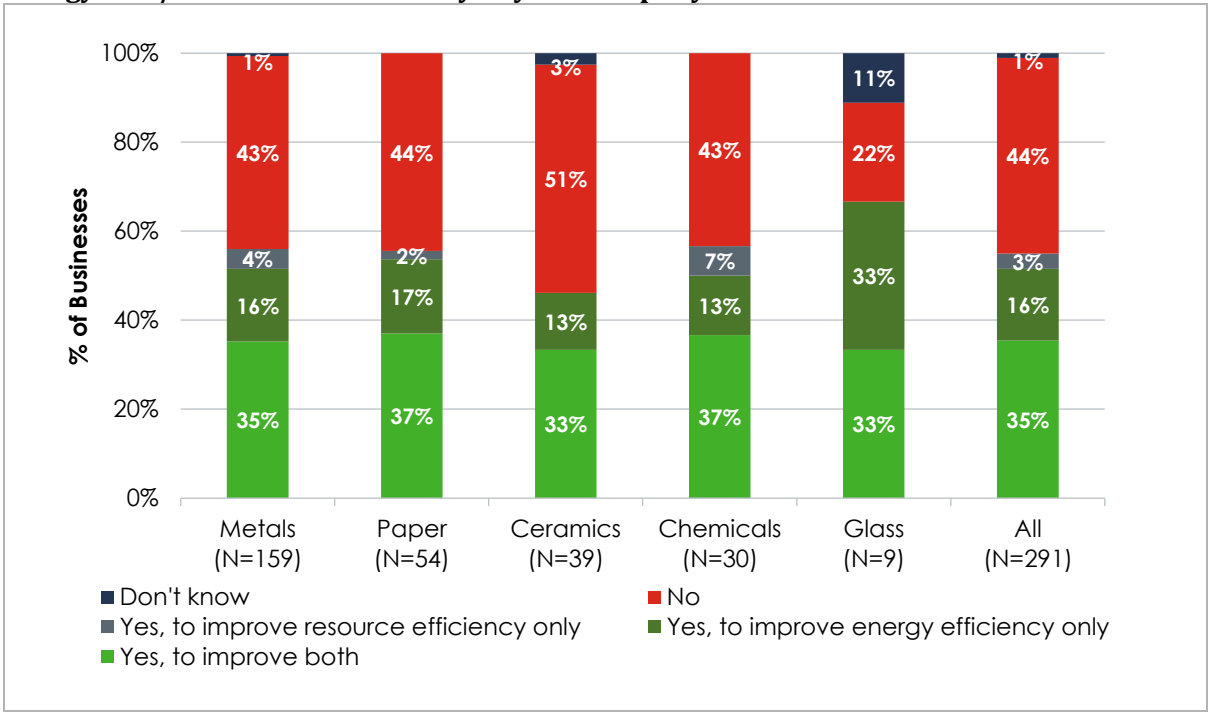



*Source: SQW analysis of business survey*
*Base: All survey participants who had engaged with businesses from another sector (N=60)*

## Net Zero

**J.33** Overall, half of businesses reported that their business plan included actions intended to improve both energy and resource efficiency in their company (Figure J-23). This was highest amongst businesses in glass, chemicals, metals and paper.

**Figure J-23: Does your company business plan include actions intended to improve energy and / or resource efficiency in your company?**




*Source: SQW analysis of business survey*
*Base: All survey respondents (n=291)*

**J.34** Table J-12 provides a breakdown of responses to the statement '*The senior management team within my business have the necessary skills to deliver innovation related to Net Zero*'. In summary, across all FI, around a third of all firms agreed that their senior management team have the necessary skills to deliver innovation related to Net Zero, while a similar proportion did not.

**Table J-12: To what extent do you agree with the statement: The senior management team within my business have the necessary skills to deliver innovation related to Net Zero**

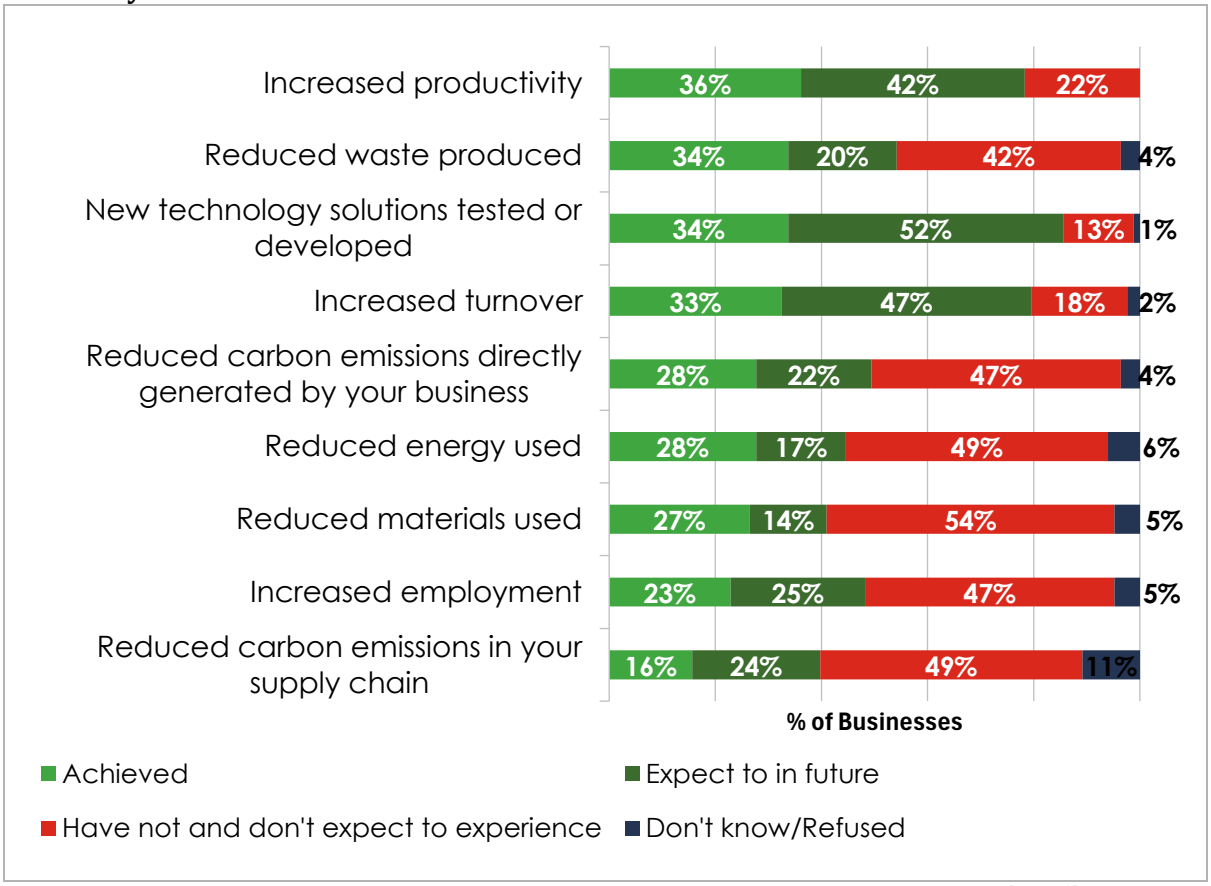
| | Metals (N=158) | Paper (N=54) | Ceramics (N=36) | Chemicals (N=29) | Glass (N=7) | All (N=284) |
|---|---|---|---|---|---|---|
| 1 - Strongly disagree | 18% | 20% | 19% | 21% | 14% | 19% |
| 2 | 15% | 7% | 17% | 10% | 0% | 13% |
| 3 | 34% | 26% | 17% | 28% | 29% | 29% |
| 4 | 16% | 28% | 11% | 17% | 14% | 18% |
| 5 - Strongly agree | 12% | 17% | 22% | 21% | 43% | 16% |
| Don't Know | 5% | 2% | 14% | 3% | 0% | 5% |

*Source: SQW analysis of business survey*
*Base: All survey participants minus those who refused (n=284)*

# Emerging benefits from R&D investment

**J.35** Businesses reported a wide range of emerging benefits from their R&D/innovation investment.[48] These commonly included (in order): increased productivity, reduced waste produced, new technology solutions tested or developed and increased turnover.

**Figure J-24: Have/do you expect to, or have you not/do not expect to, achieve any of the following benefits from your R&D/innovation investment/planned investment in this financial year?**

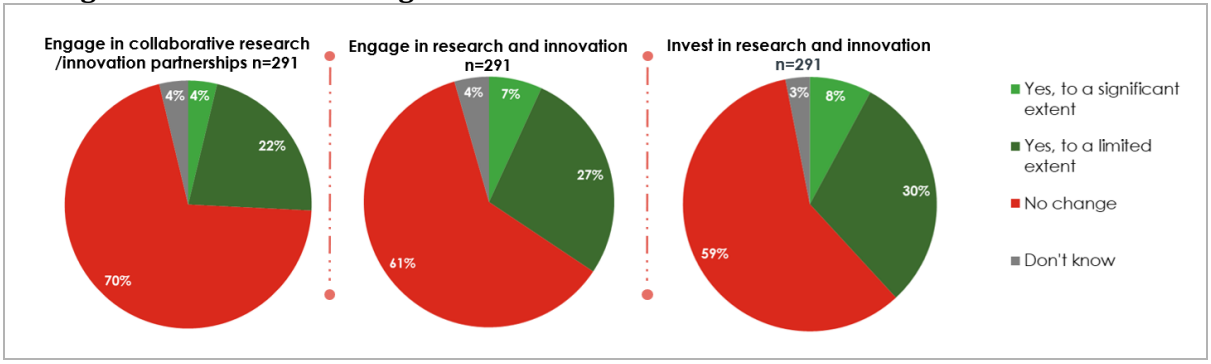



*Source: SQW analysis of business survey*
*Base: All survey participants who had invested in R&D and innovation (n=83)*

**J.36** Some respondents stated that engaging in R&D since 2019/20 had increased their willingness to engage in collaborative research/innovation partnerships, engage in research and innovation, or invest in research and innovation (between 26-38%; see Figure J-25). However, the majority stated that it had not, with this trend relatively consistent across the FI sectors (see Table J-13).

[48] The emerging benefits were prompted.

**Figure J-25: Did / has engaging in R&D since 2019/20 increased your organisation's willingness to do the following...?**




*Source: SQW analysis of business survey*
*Base: All survey participants who had invested in R&D and innovation (n=291)*

**Table J-13: Did / has engaging in R&D since 2019/20 increased your organisation's willingness to do the following...? By sector**

| | Willingness to engage in collaborative research / innovation partnerships | Willingness to engage in research and innovation | Willingness to invest in research and innovation |
|---|---|---|---|
| **Metals (N=159)** | | | |
| Yes, to a significant extent | 3% | 5% | 6% |
| Yes, to a limited extent | 26% | 35% | 32% |
| No change | 67% | 58% | 61% |
| Don't know | 4% | 3% | 1% |
| **Paper (N=54)** | | | |
| Yes, to a significant extent | 2% | 9% | 11% |
| Yes, to a limited extent | 22% | 19% | 30% |
| No change | 72% | 69% | 54% |
| Don't know | 4% | 4% | 6% |
| **Ceramics (N=39)** | | | |
| Yes, to a significant extent | 8% | 10% | 10% |
| Yes, to a limited extent | 10% | 15% | 23% |
| No change | 79% | 67% | 64% |
| Don't know | 3% | 8% | 3% |
| **Chemicals (N=30)** | | | |

| | Willingness to engage in collaborative research / innovation partnerships | Willingness to engage in research and innovation | Willingness to invest in research and innovation |
|---|---|---|---|
| Yes, to a significant extent | 3% | 7% | 10% |
| Yes, to a limited extent | 17% | 23% | 37% |
| No change | 73% | 60% | 47% |
| Don't know | 7% | 10% | 7% |
| **Glass (N=9)** | | | |
| Yes, to a significant extent | 11% | 11% | 11% |
| Yes, to a limited extent | 11% | 22% | 11% |
| No change | 78% | 56% | 67% |
| Don't know | 0% | 11% | 11% |
| **All (N=291)** | | | |
| Yes, to a significant extent | 4% | 7% | 8% |
| Yes, to a limited extent | 22% | 27% | 30% |
| No change | 70% | 61% | 59% |
| Don't know | 4% | 4% | 3% |

*Source: SQW analysis of business survey*
*Base: All survey participants who had invested in R&D and innovation (n=291)*

# Annex K: Case studies

**K.1** Six case studies were completed and signed off by consultees. These focused on the experiences of businesses involved in projects funded through CRD (W2) and IVP (W5) workstreams. The case studies were developed based on findings from consultations with key contacts in each business and a review of UKRI's background data for projects (e.g. application forms, monitoring reports, survey responses).

# Case study 1: BASF - Flue2Chem

BASF is the world's largest chemical producer, manufacturing approximately 60,000 different chemical products. BASF operates on a global scale, with six major manufacturing sites—soon to be seven—and over 300 smaller sites around the world, this includes 10 sites in the UK which employ over 700 people.

## Aims and objectives

BASF was involved as a collaborator in the TFI Demonstrator project 'Flue2Chem', a project which sought to redesign and validate a UK value chain to convert valuable carbon emissions into sustainable materials for consumer products. BASF's role in this consortium of 17 partners was to develop a catalyst to convert captured CO2 to ethanol. BASF's previous research had demonstrated technical feasibility, however, the catalyst developed worked for carbon monoxide only; it was not suitable for the utilization of carbon dioxide. Moreover, the precious metal content required made the cost of the overall process too volatile for commercial deployment. BASF therefore aimed at developing a new catalyst that would work on carbon dioxide and require less precious metal to reduce the volatility of processing cost.

## Delivery

BASF worked within the Flue2Chem project to adapt the catalyst to convert CO2 from flue gas into ethanol in a single step as well as to assess the volatility of overall production costs of the state of the art catalyst, aiming to successfully demonstrate the conversion of CO2 from waste gasses into base chemicals. The research phase introduced a novel digital modelling workflow which allowed BASF to create a catalyst with greater selectivity and efficiency. BASF was then able to confirm those results and scale them up to produce ethanol from carbon dioxide with a catalyst with significantly reduced precious metal content, in line with their agreed deliverables.

## Key benefits

As part of the project, BASF successfully developed a novel process for catalytic conversion to yield ethanol in a sustainable way. The production of ethanol using captured CO2 is attractive for using captured CO2 as a sustainable raw material for producing chemicals for a net zero future.

By integrating computational modelling, machine learning, and high-throughput experimentation, BASF was able to develop promising catalyst compositions that were proven to work in a small plant over extended periods of time and delivered a demonstrator sample of ethanol from carbon dioxide. Actual CO2 from flue gas captured in British paper mills was shipped to BASF and used in this step for making ethanol.

Important insights that can be used to inform future investment decisions were gained from Life Cycle Analysis and Techno-Economic Benchmarking.

Working with project partners led to wider benefits for BASF as it strengthened relationships with existing customers and academic partners and identified ways in which they could become research partners. The Flue2Chem consortium is an example of how transformative innovation can be driven in collaboration with academic and industrial partners across the value chain from carbon emitting industries (paper mills like Holmen and UPM) to consumer goods manufacturers (Unilever).

### Additionality & contribution of TFI

These benefits were seen to be fully additional. TFI funding and the consortium framework have undoubtedly been instrumental to the success of the project as a whole. The structure of TFI required BASF to work collaboratively with other companies, bringing together a broader group where relationships didn't previously exist and uniting organisations with a common purpose.

### Learning

Whilst very satisfied with what was achieved, BASF had some suggestions for how TFI could be improved in the future. A more flexible approach to funding was seen as potentially being advantageous. It was noted that enabling short project extensions or access to additional funding could be helpful if research teams find themselves close to a breakthrough. Complex projects with multiple partners and ambitious targets could find short, fixed deadlines challenging and future projects could benefit if these could be extended and revised to accommodate the unpredictable nature of innovation.

# Case study 2: i3D Robotics - Intelligent Robotic Inspection for Foundation Industry Optimisation (IRIFIO)

i3D Robotics, founded in 2013, is a software engineering business that develops 3D 'smart vision' imaging technology for heavy industry environments. Its systems can be integrated with various other technologies[49] to enable users to capture 3D models in bespoke settings. **This enables advanced data analysis to inform process optimisation,** with i3D having interests in supporting the sustainability of their clients operations.

i3D has proven its technology in industrial settings of metals manufacturing, nuclear, construction and medical. It prioritises broad adoption of its technology and therefore continually undertakes R&D to enable product development for new settings. The firm has six employees, with a core engineering team (all with academic backgrounds) supported by wider business functions. Over the last decade, the firm has received over 20 grants manged by Innovate UK (valued at c. £2.5m).[50]

## Aims and objectives

Between August 2020 and October 2021, i3D delivered their first TFI Collaborative R&D (CR&D) project, IRIFIO, through the Fast Start competition (with two industry partners and a total grant of £112.4k). This directly led to IRIFIO:D2, a Demonstrator project (with over 10 partners and total grant of £2.1m), starting in October 2022 and is due to end in March 2025.

The aims of both TFI CR&D projects were to **develop several new 'smart vision' technologies that could identify production defects in Foundation Industry (FI) settings.** This built on a sensor system i3D already developed for monitoring steel plate manufacturing. The two rounds of funding **enabled a successive programme of R&D, helping i3D progress technologies from proof of concept stages to (mostly) nearing commercialisation**. The key objectives are below:

- **The Fast Start project** focused on early stage proof of concept development (c. TRL 3/4), by creating new systems designed for glass and ceramics production and assessing feasibility for different use-cases (with inputs from industry partners).
- **The Demonstrator project** focused on testing the glass and ceramics prototypes in 'live' settings (each having reached TRL 5 and 7) at scale, to support commercialisation. It also added an additional focus on metals to add capabilities into i3D's pre-existing system (TRL 7). It drew on extensive collaboration with industry and Research and Technology Organisations (RTOs).

A wide variety of activities were delivered, with **partner collaboration being critical to almost all stages of work**. i3D collaborated with multiple **FI businesses** (e.g. Glass Technology Services

[49] Robotics, spectrometers, thermal and radiation sensors, artificial intelligence (AI), machine learning and artificial reality (AR).
[50] As tracked by the Beauhurst database.

(GTS), Lucideon, Wienerberger, Ibstock Brick, Forterra and Sarginsons Industries), **academics** (University of Sheffield/AMRC) and **RTOs** (STFC's Hartree Centre, Glass Futures). i3D led the design and development of prototype systems, while partner's expertise and facilities enabled feasibility assessments, helped further refine designs, enabled 'live' testing in industry settings and supported final analysis and interpretation of findings.

**Reflections on delivery were generally positive.** It was recognised that projects set ambitious objectives (particularly the Demonstrator), with i3D maximising the funding opportunity to deliver activities that genuinely sought to *"push boundaries of FI industry capabilities"*. Both projects were thought to be well managed, especially as delivery contexts were challenging (i.e. Covid-19, energy crises, inflationary pressures). **Plans did pivot at times**, with major changes presented below:

- **Refinements to how I3D's technology could be applied to ceramics.** During the Fast Start project, i3D's concept was proven but Lucideon advised there was limited value in using it to test compositions of ceramic slurries, and that there could be more value at the post-production stage – to support analysis and categorisation of bricks by colour. After more feasibility testing, the use case was amended – informing all subsequent work in the Demonstrator project.
- **Delays in opening the Glass Futures facility slowed progress in the Demonstrator**, but alternative activities were still progressed, benefitting both the project and i3D's wider R&D work. The initial plan was for the RTO to use its furnace to produce model float glass with artificially induced surface defects, and then act as a key testing site for i3D's vision sensors. But due to delays in lighting the furnace, Glass Futures was unable to produce glass in required timings. To mitigate this, GTS' completed some lab testing of alternative defected glass, but not at the same scale, meaning TRL progression was much lower than expected. In closing months of the project, i3D identified an alternative route to gaining value from other equipment Glass Futures did have commissioned. In a different, but related, R&D project i3D and GTS were completing with Encirc (a Glass Futures member), the Glass Futures facility and glass vision system developed in TFI were used to deliver 'cold trials' for detecting defects caused by nickel sulphide inclusions in container glass (rather than surface defects in float glass).[51]

## Key benefits

With delivery of the Demonstrator project still underway, consultees were only able to comment on the expected benefits that both projects are likely to create:

- **TRL progression of three technologies** for application in the glass, ceramics and metals sectors. Tech aimed at these sectors are extremely close to commercialisation as a result of

[51] Delivered via the Tenfold Net Zero Accelerator programme, funded by the Digital Catapult and Ireland's Department of Agriculture, Environment and Rural Affairs (DEARA). To date, trials have proved highly successful and findings are expected to support Encirc to move to light weight bottle production, help save production energy and reduce product and transport costs

successful delivery of most planned activities, and value added from partner inputs. These innovations are described as both 'new-to-firm' and 'new-to-market'.

- **Follow-on investment and continued collaboration.** The Demonstrator has proven the case for **i3D's continued internal investment** in technologies across all three sectors. In the near-term, i3D have plans to continue to work with several industrial partners in ceramics and metals to achieve commercialisation. In glass, i3D are likely to still collaborate with Glass Futures after TFI to complete testing in a float glass context (and potentially via other collaborative projects such as that with Encirc). However, given the TRL of the float glass system is now behind systems for ceramics and metals sector (and container glass), this work may be a slightly lesser priority.
- **High potential for near-term revenue generation and growth at i3D** once commercialisation is achieved. Once technologies are adopted, they will contribute to **improved efficiencies of FI industry processes, reduced waste** and **enhanced productivity.** In ceramics, this will help manufacturers improve post-production brick sorting, increase sales and reduce wastage. In metals, i3D's system has been optimised with new analytical methods, improving abilities to spot more detailed defects in the castings process.

TFI led to wider benefits associated with increasing partner's **understanding of the FI sectors, and its growth opportunities and constraints.** The funding has also supporting n**ew connections between partners,** which is also leading to follow-on work (outside of I3D's plans).

*"Working with the partners has really improved our knowledge of the FI sectors. We have basically learned a new language – which will benefit how we work with them going forward"* ***I3D consultee***

### Additionality & contribution of TFI

Consultees indicated **the TFI funding had high levels of additionality,** stating that without it, only a minority of activities would have been delivered with much less collaborative input. i3D would have likely continued some activities, but with fewer, or no partners, meaning benefits associated with **progression of TRLs and reaching commercialisation would have been achieved later, and at a smaller scale and lower quality. TFI was critical for enabling delivery,** alongside other key factors including partner's willingness to innovate, previous R&D activities at i3D and a current market context within the FI that is supportive of improving efficiencies and improved sustainability**.**

### Learning

Receiving two rounds of TFI funding, at different scales, has enabled i3D to deliver a *relatively* continuous programme of collaborative R&D, and achieve significant progression towards commercialisation of new technologies in two of three targeted FI. Once finalised, technologies are expected to enable industries to improve efficiencies, reduce waste and achieve sustainability benefits – all of which directly align to the TFI programme's original aims.

*"It has been a real learning process, and by no means straight-forward [..] despite not achieving all aims in all sectors, the benefits we expect to achieve when we release the ceramics and metals tech are extremely important and make it entirely worthwhile"* ***i3D consultee***

Under the context of both IRIFIO projects requiring highly complex technical activities in multiple industries, collaboration with various partners and high levels of financial input, consultees felt the key lesson learned related to sufficiently balancing ambitions and objectives against (often evolving) practicalities of delivery. This was relevant at both pre-delivery application stages – in setting out what could realistically be achieved, as well as on an ongoing basis during delivery – enabled by through close monitoring of progress and willingness to adapt plans, to relatively significant scales, if required.

# Case study 3: Biopower Technologies - HIFib

Biopower Technologies is a UK SME which produces micronized biomass from waste biomaterials, primarily for the energy and food sectors. Micronized biomass can be used in a variety of ways, ranging from as a food additive to use in bioplastics. Biopower was a collaborator in 'HiFib: Innovative Fibre Technology for Sustainable Papermaking' a £711k project funded through the Large Collaborative R&D competition. The project aimed to explore how agricultural food byproducts could be used as a source of pulp in the manufacture of recycled paper.

## Aims and objectives

Each time paper is recycled its strength diminishes. Eventually it is necessary to add additional pulp to address this. The new pulp is often virgin non-recycled wood pulp. Using non-recycled wood pulp increases the overall environmental and energy cost of recycled paper. The project aimed to reduce the role of virgin wood pulp in the recycled paper manufacturing process by replacing it with agricultural food byproducts, which would be a lower-carbon alternative.

Biopower's intended role was to supply and preprocess waste biomaterials for the project. The project offered Biopower an opportunity to fill an emerging income stream gap and to further research some of the technologies it was developing.

## Delivery

After successfully supplying project partners with raw materials, the project team discovered that Biopower's bioprocessing equipment particularly their hydrodynamic cavitator was more effective for processing waste materials into usable pulp than the ultrasound equipment project partners had originally intended to use. This led to a major reshaping of the project, with Biopower becoming a major partner and carrying out significant materials research. The project was extended by six months to accommodate these changes.

## Key benefits

The project successfully developed new production line processes for using agricultural byproducts in the manufacture of paper, the potential commercialisation of this process is being explored by Biopower and project partners, DS Smith and AgrifoodX. The new processes have the potential to improve the sustainability of paper manufacture while also increasing the quality of the paper product, for example being lighter and stronger. As a result of the project and the exposure to companies working in other sectors, Biopower is now pursuing new opportunities in the paper, plastics and chemicals sectors, something it had not considered previously and that has the potential to improve business performance.

## Additionality & contribution of TFI

Biopower do not think they would have worked in the paper sector without the project: the company had no internal plans or strategies for pivoting into the foundation industries.

Therefore, all the project benefits are seen as entirely additional. However, the company's internal expertise and previous experience in non-paper packaging along with the increasing demand for sustainable materials were both contributing factors to the success of the project and the opportunities available for post-project exploitation.

### Learning

The key lesson from the project was the value of bringing SMEs together with larger companies to undertake technical activities and build new commercial relationships. A diverse consortium allowed Biopower to explore a new sector, introducing a new business to the foundation industry supply chain. For future research and development programmes Biopower felt it would be helpful to have a clearer route to follow-on funding, to help speed up commercialisation of the new processes.

# Case study 4: Kenoteq - Low carbon innovative composite material for construction

Kenoteq is a spin-out of Heriot-Watt University. It develops low-carbon sustainable building materials. Kenoteq's core product is the K-BRIQ, a clay brick alternative made from recycled materials. In 2022 Kenoteq led the 'Development of low carbon innovative composite material for the construction industry' project, which received £197k through the 'Transforming Foundation Industry - Small Scale R&D Strand 2'.

## Aims and objectives

Kenoteq is a small company, with less than 10 employees, it is focused primarily on growing the market for the K-BRIQ. It is difficult for them to spend time on low-medium TRL research and development while still progressing the K-BRIQ. Kenoteq was signposted to TFI funding by Heriot-Watt, who also introduced them to CelluComp, a packaging company that has developed processes to turn waste from the food industry into various building and commercial materials. The project aimed to bring together Kenoteq's work on the K-BRIQ with Cellucomp's work on a cellulose replacement for cement to develop a more sustainable alternative to conventional cement blocks. The product aimed to significantly reduce the carbon emissions associated with the manufacture of cement bricks while also creating a domestic production supply chain for building materials, which would increase the resilience of the UK construction industry.

## Delivery

During the project Kenoteq successfully prototyped and benchmarked a composite brick, completed a life cycle assessment of the brick, determining its environmental impact, and undertook an economic viability study to determine whether the brick could be commercialised. Kenoteq hired a new staff member specifically to work on this project, which was delivered effectively and largely on time. However, project team illness within the small research meant the project was granted a short extension by UKRI.

## Key benefits

The project successfully developed a prototype composite cement brick alternative that could be commercialised. Kenoteq is hoping to take the composite brick to market in partnership with CelluComp. however, neither business currently has the immediate capital to pursue this. Consequently, Kenoteq have been unable to retain the staff member hired during the project. This has been compounded by Kenoteq receiving further investment specifically for the K-BRIQ, this means most internal resources are now focused on progressing the K-BRIQ instead of the new composite brick. CelluComp has similarly returned to focusing on their packaging business.

Some research activities undertaken during the project may benefit work on the K-BRIQ, with Kenoteq exploring how may be able to improve the manufacturing process for the K-BRIQ using findings from the project. These refinements and the possible future commercialisation of the

new composite brick, have the potential to increase turnover and grow Kenoteq as a business. Kenoteq are also considering publishing academic papers linked to the project.

## Additionality & contribution of TFI

Kenoteq would not have been able to dedicate the capital and resources needed for this project without TFI funding, so the benefits experienced to date are almost entirely additional. While the company has a strong interest in research and development, they are typically unable to do this type of work at scale without external funding.

## Learning

The mix of commercial and academic support facilitated by the TFI programme was considered useful by Kenoteq and better than other grant programmes. Bringing academic expertise and industrial partners together helped the project focus on both technical and commercial development of the product. However, Kenoteq would value more post-programme support from UKRI, particularly how to maintain progress to commercialisation.

# Case study 5: Puraffinity – IVP funding

Puraffinity is an advanced materials company developing solutions to remove toxic chemicals from water. Puraffinity spun out from Imperial College London and is based at the Imperial White City Innovation Campus. Puraffinity focuses on per- and polyfluoroalkyl substances (PFAS), chemicals used in a range of consumer products that do not break down easily in the environment and can subsequently build up in waterways. These build-ups pose risks to both human and animal health. Puraffinity's main product is Puratech G400, a selective absorbent technology for removing PFAS from water. Puraffinity has developed an industry-leading database for identifying PFAS in water as well as a method for removing PFAS from water.

Puraffinity took part in the Transforming Foundation Industries Industrial Strategy Challenge Fund through the Investor Partnerships (IVP) workstream, with HG Ventures as the investor partner.

## Aims and objectives

Puraffinity's existing process is effective at extracting PFAS from relatively clean water, however they had not previously developed a method for extracting PFAS in harsh industrial environments. The aim of the project was to develop a method for working in industrial conditions and scale up the manufacturing of this process to Technology Readiness Level (TRL) 7.[52] While global water cleanup is an expanding market and is necessary to support the UK foundation industries by limiting their negative environmental impact, Puraffinity had struggled to secure funding for scaling up their technology. They identified that most investors having little appetite for high-risk tech scale-ups. This made the IVP strand of TFI especially appealing, as it would allow them to secure an investor partnership at a stage for company development where it was difficult to find private funding otherwise.

## Delivery

The project was successful in delivering a new process for removing PFAS from industrial wastewater. Puraffinity secured third party-validation of their PFAS removal process and began to scale up the manufacture of their product with a reverse osmosis membrane partner. The project was completed both in time and on budget.

## Key benefits

The main outcome for Puraffinity was proving the technical and commercial feasibility of their innovation. This has allowed Puraffinity to successfully seek out further financing and commercial partnerships to help take this product to market. This has included an additional £17 million in investment from a subsequent funding round and a commercial partnership with one of the largest global manufacturers of reverse osmosis membranes. This investment and

[52] TRL 7: technology prototype demonstration in an operational environment

partnership are forecast to create 7 to 8 direct jobs in the company specifically related to the commercialisation of this innovation in addition to indirect jobs in supplier companies.

### Additionality & contribution of TFI

HG Ventures, the investor partner, believed that the project would not have occurred without the support of TFI, and that the IVP programme was the critical factor in progressing the innovation to where it is now. Though the success of the project was also influenced by Puraffinity's location in an emerging clean-tech cluster as well as existing connections with academia and universities were crucial to this success of the project, giving theme access to technical facilities essential for research tasks.

### Learning

Puraffinity were very satisfied with their experience of taking part in TFI. They particularly valued the role of the investor who added vital sector experience and was essential to the success of the project. Despite this primarily positive experience Puraffinity did feel that were was insufficient focus on Equality, Diversity and Inclusion (EDI) and it would be valuable to see a top-down push to improve EDI within similar initiatives into the future. It was suggested that future metrics could include tracking leadership diversity in terms of gender, ethnicity, or neurodiversity, as well as evaluating the participant strategies for working with smaller or disadvantaged suppliers.

# Case study 6: Becker Industrial (Com2Coat)

Becker Industrial Coatings (Becker) is an industrial coating manufacturer operating across the metals, chemicals and glass sectors. They have over 20 sites across the globe, including a UK facility in Liverpool. Becker was a partner in the 'Computational formulation technique for developing resource and energy efficient functional coatings for foundation industry', a project funded through the Large Collaborative R&D competition. The project had a total value of £922k and aimed to develop tools and techniques for the digitisation of the formulation, manufacture and application of coatings to materials. Becker's role was in developing more energy efficient formulations for metals coatings.

## Aims and objectives

Industrial coatings can add function and commercial value to a range of materials. For example, an antimicrobial coating can be added to a metal used in counters or desks to reduce the rate at which bacteria grow, with obvious benefits in healthcare or laboratory settings. Developing new coatings currently relies on a labour-intensive trial and error process in which different chemical formulations and application methods are iteratively tested. This project explored how computer modelling could speed up the development of coatings to reduce the energy and time costs of formulation.

The project was led by Pilkington Technology and involved seven further partners, including Becker. Becker was invited to participate in the project by TATA Steel, who were already involved in the project and with whom Becker have a longstanding commercial partnership. Becker had not sought public funding for research and development before and were not aware of the TFI programme. Becker typically struggles to fund research that is not immediately marketable so TFI represented an opportunity to explore research aligned with its long-term sustainability targets. This project also offered the chance to further develop its commercial relationship with TATA.

## Delivery

Becker developed formulations for coatings that were shared with STFC Hartree Centre. Hartree built computer models that could predict how the formulations would function, reducing the need for real world testing. Becker then supplied the coatings to TATA steel for in-line testing. The project was successful in developing a new coating formulation that could be applied to metals and other materials. The project took six months longer than originally planned due to a range of factors including delays in the supply of raw materials, unfamiliarity with UKRI procedures, and the need to test more coating formulations than initially anticipated.

## Key benefits

The immediate benefit from the project for Becker was the successful development of a new, potentially patentable, coating formulation that TATA were interested in taking into commercial production. In the longer-term the computational approach to developing the coating entailed

less physical prototyping and so was less energy and resource intensive. If applied more widely, this approach could reduce the cost of and speed up the development of new coating formulations, with positive implications for business performance at Becker and the potential to reduce waste and energy usage across the sector.

The collaborative nature of the project successfully led to Becker improving its knowledge of the foundation industries and a strengthening of supply chains in the sector. Through being a part of the consortium Becker has forged connections with new potential partners such as project partner Spraying Systems, strengthened an existing relationship with TATA, and are pursuing future collaborations with both companies.

### Additionality & contribution of TFI

Becker saw the project benefits as entirely additional: they were certain they would not have undertaken any of this research without being involved in this project. For Becker, the involvement of TATA was crucial to the success of the project, particularly in creating a clear route to exploitation. Becker's own research and development capacity and ability to bring in expertise from across the business was also important in allowing them to overcome some of the technical challenges in the project and adapt to new findings.

### Learning

The key lesson from the project was the importance of having the right partners in the consortium, with expertise relevant to the various technical elements and having a route to commercialisation. The challenges associated with the administration and reporting required by UKRI were partly due to Becker's inexperience of working on these publicly funded projects. In future they would value more support from UKRI on monitoring expenses processes.

SQW

## Contact

For more information:

**Osman Anwar**
*Director, SQW*
T: 0131 225 4007
E: oanwar@sqw.co.uk

9 Coates Crescent
Edinburgh
EH3 7AL

**www.sqw.co.uk**

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