Innovation Readiness in UK Foundation Industries

An ERC report for UKRI

ERC Report

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Enterprise Research Centre

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Executive Summary

About the project

This project was undertaken by the Enterprise Research Centre (ERC) on behalf of UKRI between February and November 2020 as firms were experiencing the impacts of the COVID-19 pandemic. The project focussed primarily on the longer-term position of the foundation industries but took pandemic impacts into account.

The research was concerned to provide an evidence-based understanding of the factors that shape innovation across six UK foundation industry sectors (metals, paper, chemicals, glass, ceramics, and cement). And in doing so to provide a better-informed basis for policy development.

The research comprised of a detailed literature review, a CATI survey of businesses in foundation industries as well as qualitative interviews with businesses and industry stakeholders.

The UK's foundation industries

Across the six foundation industry case-study sectors, there are approximately 7,000 businesses, which employ 253,825 people and generate a combined turnover of over £67.6 billion. As is the case more generally, the majority of businesses in the foundation industries are relatively small; there are just 700 medium-sized businesses (50 to 249 employees) and only 140 large businesses (250 or more employees).

Effective innovation is important to the performance of the UK's foundation industries directly including their ability to compete internationally, but also because these industries provide the basis for dynamism through a much wider segment of the economy – more than three quarters of their sales are to other businesses.

The UK's foundation industries are distinctive in a number of respects. For example, they underpin supply chains in manufacturing and construction, sending a high proportion of output for intermediate consumption. In addition, they tend to be energy intensive, which means they face profound pressures to reduce their carbon emissions and there are very few new entrants to these sectors which leads to exceptionally low levels of churn and little new competition for incumbents.

The performance of the UK's foundation industries

In the two decades up to 2016, the UK's foundation industries' share of GDP shrunk by 43 per cent, compared with an average decline across the OECD of 21 per cent. The UK now has one of the smallest foundation industry sectors relative to GDP in the OECD.

Findings from in-depth interviews with industry representative bodies confirmed findings in the literature that the two most significant challenges facing the foundation industry sectors are; increased international competition and high energy costs alongside associated regulatory pressures to reduce emissions and environmental impacts.

Despite the challenges faced by foundation industries in recent years, there are nevertheless opportunities for future growth from investment in infrastructure, demand for high-performance materials, improvements in productivity and further progress towards more resource efficient production processes.

Innovation activity in the UK's foundation industries

Innovation intensity in the UK's foundation industries is generally lower than that in key competitor countries.

Innovation is uneven throughout the UK's foundation industries: well over a third of businesses in these sectors had not introduced new products in the last three years and a similar proportion had not introduced new processes.

Smaller businesses are markedly less likely than larger ones to be innovation active. This is important because approximately 98 per cent of businesses in these sectors are SMEs.

There is a widespread reluctance to adopt novel, unproven technologies, with most reported innovation resulting in new to firm rather than new to market products and processes.

Reported drivers of innovation

The research findings show that innovation in the foundation industries is driven by a number of factors. The most commonly reported drivers were: Increasing sales and market share, improving quality, maintain competitive advantage, reducing costs, increasing production capacity.

There is also a strong correlation between growth ambition and innovation.

Innovation in foundation industry businesses often occurs in response to 'crises' rather than systematically or proactively.

Advice and collaboration

Innovation collaboration in foundation industry sectors is not widespread. There is some reported engagement on innovation with other businesses in the supply chain on new products and processes, but this is less common with businesses outside the supply chain and with universities and research institutions.

The use of external business advice is limited but does yield reported benefits in terms of overcoming technical issues and meeting objectives more quickly.

Energy and resource efficiency in foundation industries

Despite the energy intensive nature of foundation industry businesses, the drive to increase energy and resource efficiency is not a common motivation for innovation.

Business also report financial constraints in adopting new technologies to improve resource efficiency, with some also noting that they have achieved all the gains possible with existing technology.

Reported constraints to innovation

For non-innovating foundation industry businesses, the survey findings indicate that the most reported constraints to innovation were risk, the high costs of innovation and uncertainty around the UK's relationship with the EU. There is a widespread perception across surveyed businesses that under-developed management and leadership skills in foundation industry businesses act as a constraint on innovation activity

Impact of Covid-19

Like other sectors of the economy, foundation industry businesses have experienced a severe reduction in turnover and employment as a result of the pandemic and many have adjusted their future growth forecasts accordingly. A net balance of foundation industry businesses expects capital investment and R&D budgets to be lower even as more 'normal' trading conditions resume.

Structural barriers to innovation in the UK's foundation industries.

A key finding from the research is that that innovation in the UK's foundation industries is constrained by a number of structural factors. These barriers are important not just because they constrain innovation directly but also indirectly because they undermine the effectiveness of more focussed policy measures.

They include:

- High entry barriers and associated very low levels of churn.
- Under-developed management and leadership skills.
- Dispositions and mindsets resistant to innovation.
- Widespread reluctance to collaborate.
- Regulatory and other pressures to achieve profound reductions in carbon emissions.

The role of representative bodies and trade organisations.

The findings suggest that industry representative bodies and trade associations vary in the extent to which they actively encourage and support innovation throughout their sectors.

Rationale for policy development

This research provides an evidence based and powerful rationale for policy development in this area. Within this, there are clear market failures affecting the innovation performance of the UK's foundation industries. The very low levels of new entrants to these sectors limit churn and thereby constrain competition, dynamism, and innovation activity. Beyond this, there are also widespread information failures which result in exaggerated perceptions of the costs and risks associated with innovation.

Use of best practice

The research findings show that this is a particularly challenging area in terms of policy formation. This suggests that there would be real merit in adopting best practice in policy development such as that outlined in the HMT recommended ROAMEF model.

Segmentation

With a large number of potential recipients and limited resources, innovation policy has to be targeted. It is fundamentally important that this targeting is evidence-based. A segmentation analysis could be constructed to maximise the impacts of policy, reduce deadweight, and increase value for money.

Policy options

Our research points to a range of possible policy solutions to drive higher levels of innovation activity across foundation industry businesses. Implementation is likely to require action across a range of government departments and agencies and as well as industry stakeholders.

Recommendations can be grouped under the six broad headings:

- Funding and partnerships
- Firm-level capabilities
- Promoting more positive mindsets amongst businesses
- The role of industry representative bodies
- Market-led solutions, including lowering entry barriers
- A stronger convening role for UKRI

Conclusions

This research has shown, very clearly, that there are both structural and local, firm specific, factors that shape innovation performance in the foundation industries. Real progress in promoting higher levels of innovation depends, fundamentally, on addressing both these levels of causality.

In practice, resources are limited and there are very real pressures on policy makers to implement policies that will produce quick and tangible impacts. However, unless the structural barriers to dynamism and increased innovation are effectively addressed, progress will be, at best, limited. Amongst other things, this will require realism about what structural changes can be achieved and the timeframes necessary for such changes to be realised.

1. Background

Foundation Industries can be broadly defined as those sectors (or sub-sectors) of the economy that are principally concerned with the manufacture of core materials that supply other manufacturing and construction firms. These industries underpin vital supply chains across UK industry. Interest in ensuring that the UK has sufficient domestic capacity in these sectors has increased due to the potential for disruption to global value chains and the consequences for production across other sectors.

In recent years, the UK's foundation industries have been faced with a range of challenges, including some related to policies that have impacted on the UK cost base. As Lawrence and Stirling (2016) put it 'The foundation industries…. have had a tough post- (financial) crisis period. Despite pockets of stronger than average investment…. these industries have experienced a deeper contraction, and been in recessionary territory for longer than both the rest of manufacturing and the economy as a whole'.

These concerns have been accentuated by the Covid-19 pandemic and associated disruptions experienced across the UK and throughout the global economy. In addition, the end of the UK's transition period following the exit from the European Union is a further source of uncertainty as details around the future trading relationship were yet to be finalised, at the time of writing.

1.1 Foundation Industries in the UK

As shown in Table 1.1.1 there are approximately 7,000 businesses with employees in the six foundation industry sectors considered in this report. These businesses account for just over five per cent of businesses in the UK manufacturing sector and approximately 0.26 per cent of all UK businesses. As is the case more generally, the majority of businesses in the foundation industries are relatively small; there are just 700 medium-sized businesses (50 to 249 employees) and only 140 large businesses (250 or more employees).

In total, the six UK foundation industries sectors under consideration in the research employ 253,825 people, which amounts to approximately 10 per cent of all manufacturing sector jobs and 0.8 per cent of all jobs in the non-financial economy as a whole.

These six sectors have a combined turnover of over £67,584m, which accounts for just under 12 per cent of total manufacturing sector turnover and approximately 1.7 per cent of the turnover of all non-financial UK businesses. These data show that the mean turnover of businesses in the foundation industries is considerably higher than those in the manufacturing sector as a whole and throughout the economy.

Table 1.1.1 Foundation industry businesses in the UK

	Number of businesses						
	All businesses	Micro (1 to 9 employees)	Small (10 to 49 employees)	Medium (50 to 249 employees)	Large (=> 250 employees)	Employment	Turnover £m
Cement	1165	770	275	100	20	37450	8583
Paper	1370	790	370	175	35	58050	12188
Ceramics	545	430	70	35	10	17550	2513
Metals	2030	1315	500	180	35	69175	18642
Chemicals	1240	785	280	145	30	47830	22075
Glass	735	475	185	65	10	23770	3583
All Foundations industries	7085	4565	1680	700	140	253825	67584
All Manufacturing	137365	108300	21575	6205	1285	2521519	570095
All Economy	2718435	2431995	233960	42000	10480	31574358	4005865*
Source: Office for National Statistics							* Non-financial economy

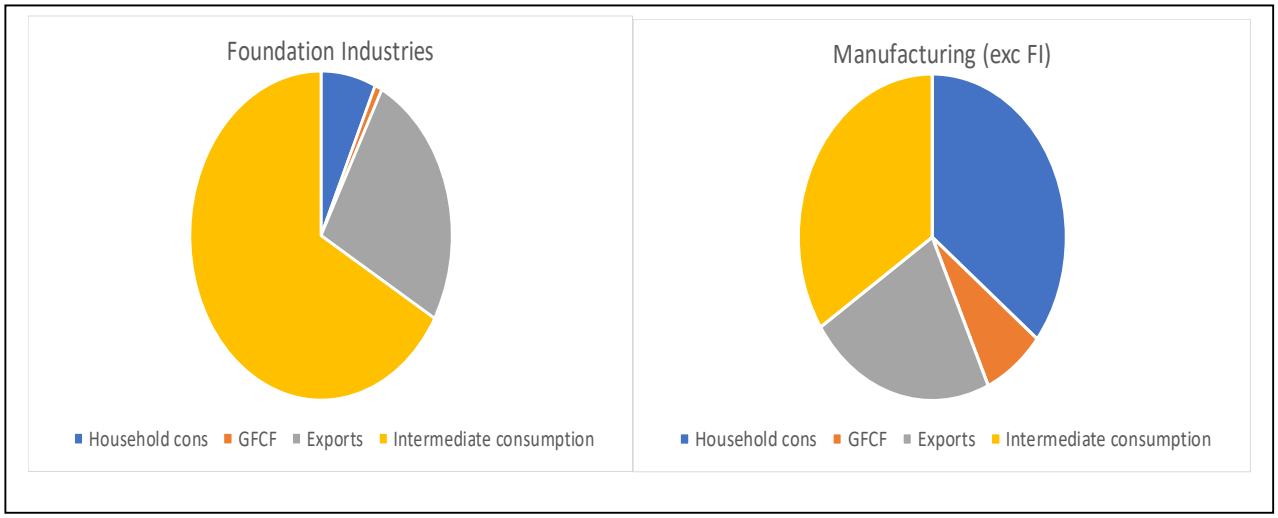
Demand profile of foundation industries

Figure 1.1.1 illustrates the large differences in the demand profile of the foundation industries compared with manufacturing as a whole (excluding foundation industry sectors). The proportion of foundation industry outputs exported (26 per cent) is similar to that of the rest of the manufacturing sector (23 per cent). In each of the sectors,[1] the European Union accounts for more than half of export values. Only 7 per cent of foundation industry output is consumed by households directly (36 per cent for the rest of manufacturing). The vast majority (two-thirds) of foundation industry output is for intermediate consumption, i.e. is consumed by other industries in the production process.

The main sectors supplied by foundation industries are construction (17 per cent), transport equipment (11 per cent), and other foundation industry sectors (20 per cent). A relatively low proportion of output from foundation industries goes directly to sectors outside of manufacturing (17 per cent) compared with non-foundation manufacturing sectors (48 per cent). This highlights the high degree of integration into narrow market segments compared with the broader manufacturing sector.

[1] Metals excluding precious metals trade

Figure 1.1.1 Final demand in manufacturing and foundation industries



Source: ONS
Note: GFCF is Gross Fixed Capital Formation

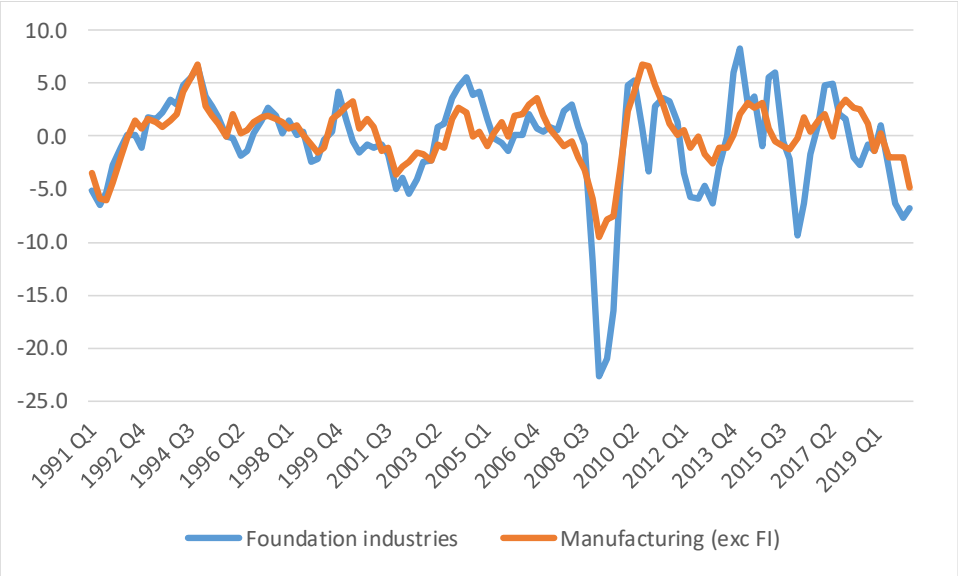
Recent trends

Since the 2008/09 financial crisis, there has been greater volatility in output across foundation industry sectors compared with the rest of manufacturing. Foundation industry sectors experienced a much larger decline in output, as measured by gross value added, during the 2008-09 crisis as a range of key customer segments, such as automotive were disproportionally affected by the withdrawal of credit and the subsequent recession (figure 1.1.2). In addition, the financial crisis brought significant disruption to global supply networks, of which UK foundation industries play a key role. There has also been a more erratic growth profile in the following decade with foundation industry sectors more often in recession compared with the rest of manufacturing.

Average annual growth across the foundation industry sub-sectors, in aggregate, has been -0.2 per cent in the past decade compared with 1.1 per cent in the rest of manufacturing (the corresponding figure for manufacturing as a whole is 0.9 per cent).

Output of the foundation industries appears to have been hit to the same degree as that seen in manufacturing and the economy as a whole by the Covid-19 pandemic and subsequent restrictions. Quarterly data from the Office for National Statistics covering the period April to September 2020 show a 15.4 per cent decline in foundation industry output compared with the same period in the previous year. This is in line with similar declines reported in manufacturing (excluding foundation industries) and the wider economy (15.6 per cent in both cases).

Figure 1.1.2 Output in the foundation industries and manufacturing, percentage change on a year ago



Source: ONS

Investment in research and development

Some internationally comparable data on research and development expenditure by businesses in foundation industry sectors is available from the OECD. Tables 1.1.2 and 1.1.3 show R&D investment expressed as a share of gross value added (GVA) in key competitor countries. The tables show total business investment across the whole economy, in manufacturing, and selected foundation industry sub-sectors. Due to data availability, these are not an exact match for the SIC codes in Annex 1, but nonetheless, provide indicative comparisons for UK industries.

Table 1.1.2 shows there are highly variable levels of R&D investment across foundation industries; this is the case in the UK and competitor countries. Overall, R&D intensity in foundation industries is lower than that of manufacturing in the selected developed economies. The chemicals sub-sector consistently invests in R&D at a higher share of GVA in the majority of countries, compared with other foundation industry sub-sectors. And in all countries, chemicals businesses invest more in R&D as a percentage of GVA than the whole economy average.

Table 1.1.2 R&D as a percentage of GVA (2017 or latest year available)

	Total	Manufacturing	Paper	Chemicals	Non-metallic minerals*	Basic metals
US	2.1	12.0	1.5	4.6	2.0	0.9
UK	**1.3**	**5.2**	**0.3**	**4.1**	**0.9**	**2.0**
Spain	0.7	2.7	0.4	2.9	0.8	1.0
Netherlands	1.3	6.0	2.8	5.2	1.0	4.0
Japan	2.5	10.6	1.5	7.1	5.3	2.4
Italy	0.9	3.9	1.2	4.0	1.5	1.4
France	1.6	7.0	0.7	5.2	2.8	2.6
Finland	2.1	7.4	2.7	5.4	2.4	1.7
Canada	1.0	-	2.3	2.6	0.7	3.0
Belgium	2.1	8.4	1.3	3.9	2.3	5.2
Germany	2.4	8.8	0.9	8.2	1.8	2.8

Source: OECD

* Non-metallic minerals include cement, concrete, and ceramics

Notably, table 1.1.3 shows that there have been declines in R&D intensity across foundation industries in the decade following the financial crisis. There are examples of some sectors in some countries that have bucked this trend, particularly the chemicals sector in the UK, basic metals in Belgium and Germany, and growth in the paper sector in the Netherlands and Canada.

Table 1.1.3 Percentage point change in R&D as a percentage of GVA 2008 - 2017 (or most recent available)

	Total	**Manufacturing**	**Paper**	**Chemicals**	**Non-metallic minerals***	**Basic metals**
US	0.0	0.7	-0.8	-2.6	-0.7	0.0
UK	**0.2**	**0.9**	**-0.4**	**1.5**	**-0.6**	**0.2**
Spain	-0.1	0.2	-0.3	-0.4	-0.1	-0.3
Netherlands	0.4	0.9	1.5	-3.2	0.1	-
Japan	-0.1	-0.1	-0.5	-1.8	0.3	-0.3
Italy	0.2	1.1	0.4	0.1	0.8	0.4
France	0.2	0.3	-0.1	-2.3	0.7	-1.3
Finland	-0.9	-2.7	-0.3	-2.8	0.3	-0.8
Canada	-0.1	-	1.3	-0.6	-0.6	0.2
Belgium	0.6	2.2	0.5	-0.4	0.3	2.4
Germany	0.3	0.8	0.3	-0.4	0.0	1.2

Source: OECD

* Non-metallic minerals include cement, concrete and ceramics

1.2 Literature Review of Foundation Industries

There is little academic literature concerned specifically with the UK's foundation industries as a distinct entity and there are only a limited number of relevant reports in the grey literature. The one exception to this is a review of these industries, undertaken by the Institute for Public Policy Research (IPPR) in 2016.

According to Lawrence and Stirling (2016), 'in the two decades up to 2016, the UK's foundation industries' share of GDP shrunk by 43 per cent, compared to an average decline across the OECD of 21 per cent …. In 2016, the foundation industries produced 10 per cent less output, in real terms, than they did in 1990…. The UK (now) has one of the smallest foundation industry sectors relative to GDP in the OECD'.

As the report makes clear, this poor performance is consequential. 'There is demand for foundation industry goods from key strategic sectors in the UK, but this demand is increasingly being met by international suppliers. For example, at the end of the 1990s imports constituted 40 per cent of domestic consumption of basic metals, but by 2016 that figure was 90 per cent. Import penetration has also risen for chemicals and fabricated metals.' These industries are also important for regional growth as most firms in these industries, which tend to provide relatively well-paid jobs, are located outside the southeast.

The IPPR report identifies some apparent causes of the poor performance of these industries in the UK. As they point out, 'firms in chemicals, fabricated metals and basic metals manufacturing have come under increasing competitive pressure as global production has increased'. This report also suggests that, in part at least, the current state of the UK's foundation industries is a consequence of failures of policy. 'Our analysis suggests that EU competitors support their industries in ways that the UK does not, which warrants investigation'.

Despite this negative assessment of recent performance, the report is relatively upbeat about the potential of these industries. 'With transitional support, the UK's foundation industry firms have the potential to supply advanced manufacturing firms, such as those in aerospace, automotive, and pharmaceuticals, to a much greater extent than they do currently. Building on our areas of existing comparative advantage would be a low-risk way to diversify our production capacity; this is, therefore, where the government should focus its efforts… (there would be) significant benefits to better embedding foundation industries in domestic supply chains. We estimate that one percentage point of demand for domestic output from fabricated metals, basic metals, and chemicals is worth an additional £2.3 billion in gross output and around 19,000 jobs in affected industries and further down the supply chain, with UK firms well placed to capitalise'.

This report also sets out a series of measures that they believe could enable the UK's foundation industries to improve their performance and better realise their potential. These include:

- ***Boost clusters*** – Foundation industries should be eligible for support from a renewed and expanded advanced manufacturing supply chain initiative, with applications from advanced manufacturers that integrate foundation industry firms considered favourably above equivalent bids that do not. Similarly, foundation industries should be better integrated into the Catapult network. Existing centres should encourage bids for co-ordinated research activities where applied science, foundation industries, and advanced manufacturing firms can align their interest and conduct joint projects.

- ***Improve access to more patient forms of finance*** - targeted explicitly at nurturing stronger manufacturing clusters, we propose restarting and repurposing the underspent regional growth fund (RGF). The government should use powers for emergency funding or delay the expiry of any existing underspend so that new or surplus budgets can be targeted specifically at supporting innovation and clustering in the supply chains of strategic industries, such as aerospace, automobiles, and pharmaceuticals.

- ***Introduce a more strategic model of public procurement*** - Stronger standards guidance for public procurement would help support a market for high-quality British foundation industry goods …. We recommend the use of more stringent standard regimes – including product quality and social and environmental impacts – in public procurement guidelines. More strategic procurement would better account for the cost of a product over a life cycle, and help the UK transition towards a low carbon economy by reducing our reliance on high carbon foundation industry imports.

- ***Spread ownership*** - Government should introduce an employee right to buy whereby employees are given the opportunity to take ownership of firms that are planning to close or are being sold off.

While there is very limited literature dealing specifically with the UK's foundation industries *per se*, there are quite numerous publications concerned with the individual sectors of which it is comprised (see Section 2). In addition to this, there are a number of publications concerned with sets of industries – notably energy-intensive industries – which in practice correspond quite closely to those sectors of the economy generally categorised as foundation industries.

Chowdhury *et al* (2019) highlight the two key challenges facing these industries. 'Currently, the UK industrial and manufacturing sectors are facing dual challenges of contributing to national 80 per cent reduction targets in CO_2 emissions by 2050 and improving economic competitiveness in the face of low-cost imports'.

The impacts of increased international competition on the UK manufacturing sector and, within this, on foundation industries are well recognised. As Lawrence and Stirling (2016) put it, 'Such has been the degree of competition from emerging markets that, even with productivity rising more quickly in the UK manufacturing sector compared with the economy as a whole, the sector has been unable to resist decline. This has hit both domestic market share – as UK

firms and consumers have looked to source goods more cheaply from outside the country – and our export volumes'. As *Jacobs et al* (2017) put it, 'One of the reasons why the UK has a low level of diversity in its exports is the offshoring of UK value chains.' Analysis of the 'import density' of UK exports – the proportion of imports in products sold abroad – shows that the UK's exporting sectors have comparatively high volumes of inputs from overseas compared with other advanced economies. Important UK export sectors such as chemicals on average contain around 40 per cent imported components in their exports.

There is also a relatively extensive literature concerned with the necessarily transformational and disruptive changes needed to meaningfully reduce the environmental impacts in the energy-intensive sectors of the economy. As Gerres *et al* (2019) put it, 'energy-intensive industry is responsible for two-thirds of carbon dioxide emissions in the EU. It has been recognised by both public and private stakeholders that a far-reaching transformation of these industries is required to comply with overall emissions reduction goals'.

Based on their study of the Dutch chemicals sector, Janipour *et al (*2019) outline some of the potential barriers to effective decarbonisation in chemical industries. These include: technological incompatibility between deep emission reduction options over time, achieving system integration in chemical clusters, increasing sunk costs as firms continue to invest in incremental improvements in incumbent installations, governmental policy inconsistency between targets for energy efficiency and deep emission reductions, existing safety routines and standards, the high operating costs of low-carbon options and low-risk acceptance by capital providers and shareholders. Similarly, Rentschler *et a*l (2018) identify a range of market frictions and barriers which can prevent firms from undertaking investments in efficiency and low-carbon. As Andersson (2020) puts it 'analysis of energy-intensive industries in the EU, decarbonizing the energy-intensive industries is possible but is likely to substantially increase production cost which, in turn, will impact downstream sectors.'

A number of authors emphasise the scale of the challenge facing these industries. According to Chowdhury *et al* (2019), 'it is possible to achieve energy consumption reduction in excess of 15 per cent from a technical point of view, however improving energy efficiency in UK industry has been hindered due to some inter-related technical, economic, regulatory and social barriers'. Griffin *et al* (2018) make a similar point, 'while the adoption of best practice technologies can secure short-term energy and CO_2 emissions savings, prospects for the effective longer-term, 'disruptive technologies are far more speculative'. In their analysis of energy-intensive industries in South Korea, Song and Oh (2015) are also sceptical of the potential to achieve transformational structural changes in these industries. Because of this, they conclude that innovation is vital to achieving increased energy efficiency and emissions reductions in a timely manner and suggest that governments should actively promote and support R&D and innovation in these industries.

Market Testing for Low-Carbon Innovation Support to Energy Intensive Industry and to Power Generation. Demand for Innovation Support (European Commission 2018)

This report was designed to provide the EC with new insights into the possible design of its Innovation Fund by assessing the needs of market participants and in particular the specific needs of the energy-intensive industry sector. Its conclusions included:

- Market failures in low-carbon innovation need to be addressed to meet climate targets;
- The Innovation Fund can play a pivotal role in promoting low-carbon innovation in the EU;
- To meet various market needs, the Innovation Fund should include both grants and other financial instruments;
- The market needs eligibility and selection criteria that effectively support different types of low-carbon innovation across different sectors;
- The market needs the right level of support at the right time while minimizing administrative costs of application.

Drivers of low carbon innovation

Several factors drive low-carbon innovation, and some are more important in different stages of technology maturity. The EC identified five key innovation drivers in companies:

- Cost savings and competitiveness;
- Carbon price;
- Developing robust inter-industrial collaboration models;
- Reduced environmental externalities resulting in improved corporate sustainability reputation;
- International competition for low-carbon products.

The EC found that when deciding on investments in innovative projects, strategic reasons (such as developing a competitive advantage or meeting future market needs) are key for less mature technologies, whereas the business case is leading for more mature technologies.

Technological, institutional, economic, financial, political, and transformation barriers hinder low-carbon innovation, most of which translate into a lack of financing

- Technological barriers include technological risks and complexity and missing stakeholder involvement (Polzin, 2016), disconnected supply chains and implementation risk for end-users (ICF, 2016);
- Institutional barriers include infrastructure problems (including physical and scientific infrastructure), and a lack of skilled staff and capabilities (Polzin, 2016);
- Economic barriers include high discount rates, artificially low energy prices due to fossil fuel subsidies (Polzin, 2016);
- Financial barriers include capital market imperfections and the lack of political and technical know-how (Polzin, 2016), but also risk aversion as a result of stricter financial regulation((ICF, 2016);
- Political barriers include the lack of multi-level policy coordination across different levels (Polzin, 2016);
- Transformation barriers include various lock-ins, including among financial market actors (Polzin, 2016).

The barriers differ for different sectors, as the risks are different (e.g. political risk is more important in sectors such as CCS where the business case is driven by policies) (ICF, 2016). However, most of the barriers translate into a lack of financing for innovative projects (Polzin, 2016).

2. Key sectors in the UK Foundation industries

This research has been concerned with foundation industries in six sectors: cement, paper, ceramics, metals, chemicals and glass. Key features of each of these sectors are described below.

2.1 Cement

Key features of this sector

The UK cement sector includes the production of cement, lime, plaster, concrete, mortars, concrete, and plaster products used in construction. The vast majority of output from the sector (97 per cent) is for intermediate consumption, of which more than four-fifths (82 per cent) goes to the construction sector (analysis of ONS data). Unlike other manufacturing sectors, there are limited export sales, with only around two per cent of outputs destined for markets outside the UK.

The modern production process for cement is relatively standardised with limestone as the key input into the manufacturing process together with smaller quantities of sand and clay. Given the bulk nature of these inputs, manufacturing sites are often located near to quarries. The manufacturing process, like those in other foundation industries, is an energy intensive one, with high temperatures required to generate the chemical reaction necessary to produce clinker – the base component of cement. The industry can also use by-products from other industries, such as secondary raw materials (for example blast furnace slag), which can further reduce environmental impacts of production.

Today's industry in the UK is characterised by a high degree of foreign ownership. The past decade has seen significant merger and acquisition activity across these major producers and the sector now has a small number of large, dominant players. This should provide access to international best practice and technology (European Commission).

Importance to the UK economy

Cement is an essential ingredient of concrete – the most consumed man-made substance on the planet. The cement industry, covered by the SIC codes under investigation in this research, accounted for just over £8.5 billion of turnover in 2018. The 1,165 firms in the sector employ nearly 37,500 people. The size breakdown of firms within the sector is similar to that across the foundation industries as a whole, with approximately 90 per cent of businesses being classified as micro or small.

The performance of the sector has been volatile over the past decade, as measured by annual changes in GVA. The sector experienced sharp contractions in output in 2012/2013 and 2018/19. Overall, the industry has seen an average annual fall in output of 0.2 per cent in the past decade – underperforming the wider manufacturing sector. According to the Mineral Products Association (MPA), members produced just over 9 million tonnes of cement in 2019 - the lowest level of output since 2014.

Table 2.1.1 UK Cement sector							
	Number of businesses						
	All businesses	Micro (1 to 9 employees)	Small (10 to 49 employees)	Medium (50 to 249 employees)	Large (=> 250 employees)	Employment	Turnover £m
Cement	1165	770	275	100	20	37450	8583
All Foundation industries	7085	4565	1680	700	140	253825	67584
All Manufacturing	137365	108300	21575	6205	1285	2521519	570095
All Economy	2718435	2431995	233960	42000	10480	31574358	4005865*
Source: ONS							*Non-financial economy

Innovation

While the statistics do not point to the cement industry as being particularly R&D intensive, there are a number of key motivations for businesses in the sector to develop new and improved products and production processes. The energy-intensive nature of the sector, as is the case in other foundation industries, has been a spur to process improvements across the industry globally. According to the MPA, (2020) the cement and concrete industry took early action to reduce carbon emissions and has achieved a more than 50 per cent cut in absolute carbon emissions since 1990. The MPA is also fostering industry-government collaboration by trialling innovative fuel mixes involving biomass, hydrogen and plasma technology to demonstrate that a 'net zero' fuel mix, with no reliance on fossil fuels, is possible.

In addition, the demand for high performance materials in the construction sector, which can contribute to a reduction in emissions from lower energy requirements for heating and cooling buildings, is another driver of innovation in the sector. Again, the MPA is playing a role in the development of new cement formulations.

Potential for growth

Growth potential is largely dependent on demand from the domestic construction market. Plans for significant increases in infrastructure investment offer growth opportunities in the sector. The requirement for non-fossil fuel energy sources will be positive for the carbon impact of the industry and provide opportunities to supply into the construction of these projects. Given the planned expansion of infrastructure investment in the UK, maintaining a strong and sustainable supply base in the concrete and cement industry will be an important underpinning for this ambition.

Challenges

As we will see with other foundation industries a competitive cost base, particularly energy costs, are seen as important in anchoring businesses in the UK. Progress towards developing low carbon energy sources, alternative fuels and carbon capture and storage are also regarded as important developments that can secure the future of the sector. The MPA (2013) notes "Because it costs in the region of £250 million to build a modern-day cement plant any capacity lost due to falling demand is unlikely to come back. That would place the security of supply of an essential building material in the hands of the volatile and unpredictable international trading markets. It also risks a decline in inward investment into the UK. The majority of the country's cement manufacturers are parts of global companies that can choose to invest elsewhere if they can achieve better returns."

The successful development commercialisation of new products also requires customers in the construction sector to adopt these. There are risks that in a low margin sector, there may be a conservative attitude to the adoption of new materials, which could slow down innovation efforts and progress on meeting net-zero carbon targets.

2.2 Paper

Table 2.2.1 UK Paper sector

	Number of businesses						
	All businesses	Micro (1 to 9 employees)	Small (10 to 49 employees)	Medium (50 to 249 employees)	Large (=> 250 employees)	Employment	Turnover £m
Paper	1370	790	370	175	35	58050	12188
All Foundation industries	7085	4565	1680	700	140	253825	67584
All Manufacturing	137365	108300	21575	6205	1285	2521519	570095
All Economy	2718435	2431995	233960	42000	10480	31574358	4005865*
Source: ONS							* Non-financial economy

Economic Importance

The UK paper industry plays an important role in the UK economy. There are 47 paper mills spread across the UK. In 2019, the turnover in the industry sector was £12.2bn, accounting for £4.2 billion of the Gross Value Added (GVA) to the UK economy compared with £4.3 billion in 2010 (ONS). The paper sector holds a significant position as a key foundation industry in the UK economy with a GVA per employee of £73,000 in 2015 (CPI 2018). In 2016, UK paper production amounted to 3.7 million tonnes. In 2017, the UK consumed 8.5 million tonnes of paper and paperboard, ranking as the 10th largest consumer below China (113 million tonnes),

USA (70 million tonnes), Germany (20 million tonnes), Italy (10 million tonnes) and France (8.9 million tonnes) on the global chart (Statista 2019).

Structure of the Paper Industry

Characterised as a heterogeneous industry with a wide range of product outputs including banknotes, books, magazines, newspapers, and packaging fabricated from corrugated paper and board (Griffin et al. 2018}. Paper is predominantly manufactured from cellulose fibres. As part of a circular economy, papermaking is characterised by recovered paper being manufactured into new paper alongside virgin fibre (BEIS 2017). Recycling is an intrinsic part of the papermaking loop and as such, 70 per cent of recovered or recycled fibre is employed to make paper products in the UK (Griffin *et al*. 2018). Statista data for 2019 identifies four main products from the sector: packaging, tissue, graphics, and specialty products.

Number of Enterprises

In 2019, there were1370 enterprises in the paper and paper products manufacturing sector (see table 2.2.1). Indicating a 2.1 per cent decrease from 2018 when there were 1395 enterprises (Statista 2019). 2019 ONS data shows that, similar to many other sectors in the UK, the paper industry is dominated by small and medium enterprises (SMEs) with a reported number of 1335 SMEs (97 per cent of total enterprises in the sector). There are just 40 large enterprises (250+ employees), which make up 3 per cent of the total business population (see Table 2.2.1). Multinational enterprises make up more than 75 per cent of capacity in the sector (BEIS 2017). Of the UK's major papermakers, only one is headquartered in the UK, and most are pan-European businesses where decisions are taken outside the UK (CPI 2018).

Employment

The UK paper-based industries employ 58,050 direct employees (see table 2.2.1). Employment in the UK paper sector is situated across various locations including counties and regions where productivity and GVA per capita lag the UK average (CPI 2019).

Exports

In 2017, a total of £5.3 billion worth of papers and boards was exported from the UK (Statista 2019). Due to increasing recyclate rates and a dwindling number of paper mills in the UK, there has been an increase in exported recyclates. Thus, more than half of UK paper recyclates are reprocessed abroad. Of the nearly four million tonnes of products from the 47 paper mills across the UK, close to a million tonnes of this was exported outside the UK in 2017 (CPI 2019). Since 2015, there has been a steady annual increase in the exported value of pulp, paper, and paperboard and this amounted to £2.4 billion in 2018. Similarly, from 2015, importation of wood pulp, paper, and paperboard increased annually to approximately £5.9billion in 2018 (Statista 2019).

Performance

The UK paper sector continues to grow with increasing demand for both packaging and tissue products. This growth is driven by changing consumption patterns, which has led to innovation in shelf-ready packaging and hygiene products, and increasing demand from

e-commerce for delivery packaging (CPI 2019). This growth has however not been the same for printing and writing products which have experienced declining markets in recent times (BEIS 2017).
The paper sector contributes to UK resource efficiency via the recovery and recycling of used paper to make new ones. Despite being an energy-intensive sector, the industry has contributed to carbon emissions reductions and is committed to achieving its quota of the UK climate change targets.

Innovation
The paper sector continues to improve existing products and adding on new functions to improve product quality (BEIS 2017). However, 2019 ONS data on UK businesses by sector shows a £0.1 billion R&D expenditure in the pulp and paper sector. Compared to other industry sectors analysed (31 sectors), the paper sector ranked 28th and was only ahead of the textile sector and iron and steel casting sector– both sectors had no R&D expenditure (ONS 2020).

Challenges
The paper sector faces strong competition especially in high-volume paper grades, which is characterized by low-profit margins (BEIS 2017). In addition, global competition and international ownership mean that UK paper mills are not only competing locally but also on product marketing and strategic investment in the international market (BEIS 2017). The sector also faces competition from other substitute products, such as plastics.

Paper production is both capital and energy-intensive, requiring significant investment to remain innovative and competitive. This coupled with long investment cycles, which can be up to 30 years, makes it more challenging to secure investment (CPI 2019).

High energy consumption in the industry sector means that the UK paper sector ranks as the sixth highest industrial energy consumption industry in the UK (Griffin et al. 2018). However, a 2017 review shows that the UK paper-based industries have the highest industrial electricity cost in Europe (Helm 2017). Furthermore, energy policies have made the UK less cost-competitive as a location for papermaking and the focus of investment in new capacity has shifted to other countries.

Opportunities
Competitive pressures and long investment cycles reinforce the pressing need for UK paper firms to continue to win and assess investment to remain sustainable ((CPI 2019). The growing trend towards the replacement of non-renewable resources with renewable represents an opportunity area for the paper sector. These lie in the development of a new range of renewable bio-based products for sustainable manufacturing (BEIS 2017). Also, re-shoring the reprocessing of some currently exported recycled paper in the UK can help increase the proportion of forest fibre produced in the UK. This can be a way of boosting virgin paper production in the UK and increasing the UK share of the evolving bio-economy to build a stronger paper manufacturing sector. As a solution to further reducing carbon emissions, the UK paper-based industries are collaborating with the UK government to develop a 2050 roadmap to enable the sector to realise its share of the UK's goal of 80 per cent emission reduction whilst maintaining its energy performance (CPI 2018).

2.3 Ceramics

Key features of this sector

The UK ceramics manufacturing industry produces a diverse range of products including bricks, roof tiles, drainage pipes, wall tiles, tableware, giftware, sanitary ware, technical components and refractories and provides inputs to a wide set of end markets including the automotive, aerospace, housing/construction, energy, electronics and computing, defence and healthcare sectors (BEIS and the British Ceramic Confederation 2017, 2019) .

The ceramics industry is a long-established sector of the UK economy with origins dating back to the industrial revolution. In the 19th century, the ceramics industry in Stoke on Trent employed more than 100,000 people and as late as 1979 around 52,700 people still worked in the city's ceramics sector. Subsequently, however, the UK industry has experienced a period of significant decline in part, at least, as a result of the recession and increased international competition. Several high-profile factories closed in Stoke and in the 1990s some manufacturers' outsourced production to South-East Asia, as firms sought to take advantage of lower labour costs (Tomlinson 2015; Ewins N 2017). According to the HoC (2016), the number of businesses in the sector fell significantly between 2009 and 2016. In 2016 there were just 350 ceramic manufacturing businesses in the UK, down from 470 in 2009.

Table 2.3.1 UK Ceramics sector

	Number of businesses						
	All businesses	Micro (1 to 9 employees)	Small (10 to 49 employees)	Medium (50 to 249 employees)	Large (=> 250 employees)	Employment	Turnover £m
Ceramics	545	430	70	35	10	17550	2513
All Foundation industries	7085	4565	1680	700	140	253825	67584
All Manufacturing	137365	108300	21575	6205	1285	2521519	570095
All Economy	2718435	2431995	233960	42000	10480	31574358	4005865*
Source: ONS							* Non-financial economy

Importance to the UK economy

In recent years, the UK ceramics sector has experienced a revival with turnover and job growth both reaching 50 per cent growth since 2010. As UK Manufacturing ((2019)) puts it "the industry slumped spectacularly in the global recession of the late 1990s as major names fell by the wayside and Stoke-on-Trent's economy fell on hard times but it's now staging a strong fightback" (see also Tomlinson and Branston 2014).

According to the HoC (2016} the UK ceramics industry employed approximately 8,000 people in 2016 down from 9,000 in 2009. Data published by the British Ceramics Confederation (BCC) (2019) show that the sector had annual sales of £2 billion, 22,200 employees and generated £720m in GVA and £550 million in export sales. UK-based ceramics manufacturers' exports have grown six per cent since 2011 to around £410 million in 2016.

Agglomeration

Although not exclusive to this region, ceramics manufacturing remains highly concentrated in Staffordshire. Approximately 8,700 people work in the ceramics sector in Stoke-on-Trent. These jobs pay well compared to other local jobs and the spending power of the sector's employees is significant in local communities. Overall, ceramics manufacturing contributed around £285 million of GVA to Stoke-on-Trent and Staffordshire's economy in 2014 (BCC 2019).

Supply Chains

Ceramics manufacturing is a core part of the supply chain for a number of strategically important markets for the UK economy (BCC 2019). Approximately half of UK ceramic sector exports are to the European Union and ongoing Brexit related disruptions and uncertainties are also a cause for concern. As Dunin-Wasowicz (2018) puts it "some sectors, especially those where a reintegration of supply chains is difficult, may go to the wall as the inevitable consequence of a hard Brexit: It is hard to imagine ceramics will survive a tariff wall".

Innovation

According to BCC (2019) the ceramics sector needs to drive up levels of innovation to maintain and strengthen its competitive position globally. BCC also argue that UK has unrealised potential stemming from the sector's R&D and technical expertise "Our design and product development expertise is recognised worldwide but we have yet to fully capture the advantage that this gives us internationally….The sector is determined to invest in innovation to improve its know-how in the design, manufacture, performance, functionality and cost effectiveness of existing and new products / processes". They identify a number of innovation priorities. The sector needs to work more closely with the research base to secure early mover advantage over international competitors in the research, development, demonstration, deployment and exploitation of innovative ceramic-based materials.

Potential for growth

Industry bodies are upbeat about the potential for growth in the UK ceramics sector. In part, this reflects anticipated expansion in global demand. According to BCC (2019) the global ceramics market is expected to reach US$286 billion by 2022, up from $158 billion in 2014.

According to Research and Markets (2017) The UK ceramics industry may benefit from advantageous conditions "the Increase in construction output, favourable economy and stable electricity prices in the future will provide impetus to the overall sales of ceramic products in the UK. Additionally, other factors such as improved trading conditions and growing export market for tableware, bricks and roof tiles are anticipated to guide the development of the UK ceramic industry".

Challenges

The European Commission (2017) identified the main challenges to the European Union's ceramic industries. These challenges remain important to the UK industry in 2020. They include:

- competition in mass volumes of low-cost products (tableware) from emerging economies
- high energy prices and reliance on raw materials from non-EU producers
- trade barriers such as tariffs or testing and certification schemes
- life style changes and substitution by other products
- attracting and keeping a skilled workforce

Other challenges include the need to reduce environmental impacts in an energy intensive industry (see, for example, Ceramie Unie 2012 and Freiman 2017).

Access to capital to fund development is also identified as a potential obstacle to future growth. As BCC (2019) put it "Ceramics and the application of ceramic technology are industries that require long term capital investment to remain competitive in world markets. Ewins (2017) points out that a dynamic ceramics sector is likely to be underpinned by churn and a process of creative destruction.

2.4 Metals

Economic Importance

The UK metals sector plays a prominent role in UK manufacturing and global supply chains, providing high quality basic and fabricated metals to the nuclear, automotive, aerospace, food, and various other manufacturing industry sectors. The UK metal industry accounts for an £18.6 billion annual turnover and just under £4 billion GVA (ONS 2020). The UK was the seventh biggest European producer of steel in 2016, contributing 0.1 per cent of the UK economy (£1.6 billion) and 0.7 per cent of manufacturing sector output (Rhodes 2018).

Structure of the Industry

The UK metal sector is characterised by a wide range of sub-sectors manufacturing both finished and intermediate products. These include basic metal production, precious metals production, metal forming, metal casting, manufacture of non-metallic products, and the manufacture of non-ferrous alloys. The metal sector produces structural parts and components, which make up a substantial part of the automotive, construction, infrastructure, engineering, nuclear, and practically all other manufacturing sectors.

Number of Enterprises

In 2019, there were 2,030 businesses operating in the UK metals sector (see table 2.4.1). Similar to many other foundation industries, the metal sector is an SME dominated industry sector. Of the total number of firms in these metal sectors, more than 98 per cent are SMEs.

Employment

This sector directly employs approximately 69000 employees in the UK (ONS 2019). The sector is SME dominated with an average of 21 employees per enterprise (Metals Council 2015).

Table 2.4.1 UK metals sector							
	Number of businesses						
	All businesses	Micro (1 to 9 employees)	Small (10 to 49 employees)	Medium (50 to 249 employees)	Large (=> 250 employees)	Employment	Turnover £m
Metals	2030	1315	500	180	35	69175	18642
All Foundation industries	7085	4565	1680	700	140	253825	67584
All Manufacturing	137365	108300	21575	6205	1285	2521519	570095
All Economy	2718435	2431995	233960	42000	10480	31574358	4005865*
Source: ONS						* Non-financial economy	

Agglomeration

The UK metal sector is geographically strongest in the Midlands, North of England, and Wales. Production capacity has declined in Scotland and Northern Ireland, even though some metal firms continue to have a presence there. Some firms in the sector are part of foreign-owned companies with representation in the UK.

Supply Chains

Many firms in the sector operate globally importing raw materials such as ores, coal, and unprocessed metals as well as exporting products to overseas markets. Thus, many UK businesses compete with international suppliers from across the globe who are also selling into the UK local metal market. Furthermore, many UK firms that are part of multinational foreign-owned enterprises also have to compete for internal investments.

Performance

The UK metal sector has been through some difficult times in recent years. The sector was one of the five major negative contributors to the manufacturing sector between 2008 and 2018. The manufacture of basic metals contributed a negative 1.6 per cent to growth in the manufacturing sector in 2018 (ONS 2019).

Challenges

UK fabricated metals and basic metals manufacturing has come under increasing competitive pressure as global production has increased resulting in the closure or threatened closure of

several large UK plants. Comparatively higher energy costs are seen as contributing to the loss of competitiveness of the UK industry. For example in the UK steel subsector, where energy cost alone accounts for more than 20 per cent of production cost, the disparity in electricity prices resulted in the UK steel producers paying 62 per cent and 80 per cent more than their competitors in Germany and France respectively (UK Steel 2019).
At the end of the 1990s, imports constituted 40 per cent of domestic consumption of basic metals, but that figure is now 90 per cent (IPPR 2016). Troubles within British Steel has led to reports of difficulties in both domestic and international markets (Make UK 2019) making the basic metals sub-sector of the industry one of the worst performers in the UK manufacturing sector with knock-on effects for the performance of metal products as well (Make UK 2019). Furthermore, Brexit uncertainties have also contributed to the industry challenges with more firms experiencing a drop in export orders as many foreign customers are sourcing products they would normally buy from the UK elsewhere.

Opportunities

Growth is anticipated in the UK metal sector as demand from infrastructure projects is expected to create a performance boost in the industry. Further support to the metals is expected to come from the development of new generations of vehicles, aircraft, and other products. However, the effects of the Covid-19 pandemic now bring the timing of these developments into question. A continuing focus and upgrade of energy and transport infrastructure in the UK is expected to create extra demand for metals (Metals Forum 2015). Furthermore, technological advancement in the sector means that metal production is less labour-intensive but rather geared towards further automation, higher efficiency, and sustainability.
The sector's move towards a more circular economy poses a great opportunity as metals are reusable and recyclable. This makes the use of metals from a lifecycle perspective more attractive and environmentally friendly.

2.5 Chemicals

Importance to the UK economy

In 2016, the UK chemicals sector had sales of £21 billion and accounted for £12.1 billion of the UK economy's Gross Value Added (See Table 2.5.1). According to the Chemical Industries Association (CIA), "the UK is one of the world's top global producers of chemicals and pharmaceuticals". CIA data for 2014 shows the UK as the 12th largest producer globally with sales of €54 billion (less than China €1,291 billion, US €652 billion, Japan €208 billion, Germany €196 billion, South Korea €144 billion, France €114 billion, India €100 billion, Brazil €83 billion, Italy €80 billion, Switzerland €66 billion, Taiwan €65 billion, Netherland €57 billion (CIA 2015).

Structure of the sector

According to the HoC (2018), the UK chemicals sector is highly diverse, including the manufacture of commodity and bulk chemicals, speciality chemicals, polymers (plastics) and consumer chemicals (e.g. personal care and cleaning products). Within this, there are sub-sectors of strategic significance, sitting at the top of UK chemicals supply chains, and which have a large UK employment and investment footprints. These include: petrochemicals and basic inorganics which make up large-scale bulk commodities used in chemical sub-sectors

further downstream and polymers and consumer chemicals supplying high-value downstream sectors including aerospace, automotive, pharmaceuticals. The sector inputs to a range of sectors such as aerospace and automotive as well as providing intermediary ingredients to the pharmaceutical, cosmetics, agrochemical, personal care, paint and home care sectors.

Number of enterprises

In 2019, there were a total 2955 enterprises in the UK chemicals and chemical products manufacturing sectors (see Table 2.5.1). As is the norm throughout the economy, the overwhelming majority of these enterprises were SMEs (with less than 250 employees); there were just 30 large businesses (with more than 250 employees). As the HoC (2018) put it, the sector is principally comprised of small and medium enterprises and microbusinesses; these make up 97 per cent of the sector with a handful of large, generally multinational, companies comprising the other three per cent. However, it is important to recognise that the small number of large businesses involved account for a disproportionally large fraction of overall employment and turnover (see Statista 2019).

Table 2.5.1 UK Chemicals sector

		Number of businesses					
	All businesses	Micro (1 to 9 employees)	Small (10 to 49 employees)	Medium (50 to 249 employees)	Large (=> 250 employees)	Employment	Turnover £m
Chemicals	1240	785	280	145	30	47830	22075
All Foundation industries	7085	4565	1680	700	140	253825	67584
All Manufacturing	137365	108300	21575	6205	1285	2521519	570095
All Economy	2718435	2431995	233960	42000	10480	31574358	4005865*
Source: ONS							* Non-financial economy

Employment

According to ONS (2019), overall employment in chemicals in September 2019 was 104,000 up from 96,000 in 2014. CIA data, which includes sector dependent downstream jobs, shows somewhat higher employment "in Q3 2014 there were 105,000 jobs in the chemical industry and 53,000 in the pharmaceutical industry. Jobs increased by 11 per cent in the chemical industry and 10 per cent in the pharmaceutical industry when comparing this quarter with the same quarter the previous year".

Agglomeration

Geographical clustering is important as companies can benefit from being located close to both suppliers of their feedstocks and end-users of their outputs as well as the large number of support services required. Approximately half of UK production is concentrated in four main

geographical clusters in England and Scotland (Yorkshire & Humberside 12 per cent of sector employment, North East 11 per cent, North West 21 per cent and Scotland five per cent (HoC 2018).

Supply chains

The sector is trade intensive and with 70 per cent of operations headquartered from overseas, it competes with global production locations for mobile investment capital. It has complex supply chain flows with often multiple border crossings of intermediate products in the supply chain. For example, companies, which are active in the specialty chemicals sector often source the raw materials they require from EU, based companies, using them to make a further product, which is then exported.

Exports

According to the Chemistry Council (2019), the wider chemical and pharmaceutical sector (manufacturing plus distribution) is the largest exporter of manufactured goods in the UK with annual exports of over £50 billion (the export of motor vehicle, trailers and semi-trailers is the sector with next highest exports of £35 billion while aerospace achieves £32 billion). Sixty-three per cent of companies in the sector export, the highest proportion of any manufacturing sector in the UK economy. Sixty per cent of chemical sector exports go to the European Union and 75 per cent of the sector's imports and raw materials come from the European Union.

Performance

The UK chemicals sector grew markedly for most of the last 20 years with output increasing by 27 per cent between 1990 and 2016; a growth rate surpassed only by the pharmaceuticals, motor vehicles and other transport sectors. While the sector was hit hard, like most, by the financial crash, its output has bounced back and is now broadly back to its pre-crisis level. Furthermore, it has continued to negotiate challenges related to exogenous factors such as fluctuating oil and commodity prices. This relatively stable performance has contributed to significant productivity improvements in the sector. The chemical industry improved its labour productivity by around 25 per cent between 2008 and 2016 and pays its workers on average 30 per cent more than the average manufacturing worker (Make UK 2017).

Innovation

The UK has a competitive advantage in innovative and high-value products due to its strong R&D base (HoC 2018). The industry spends £4 billion each year on investment in buildings, vehicles and machinery and invests over £5 billion each year on research and development. The sector's impressive slice of R&D expenditure, given its size, has also contributed to gains in productivity growth over the last 20 years (Make UK 2017).

Challenges

The chemicals sector is highly competitive and UK businesses face a number of challenges. These include increasing global competition (particularly from the United States and China), very high operating costs (as an energy intensive industry), and difficulty in attracting investment from global parent companies and skills shortages (HoC 2018). The sector is also highly regulated and faces pressures to reduce its environmental impacts (see also Knowledge Transfer Network 2017).

According to Make UK (2018), high and volatile energy costs are a concern for many sectors, but they hold particular significance for the chemicals industry. Energy forms a substantial cost for many chemical companies, due to the nature of their production processes, particularly those at the source end of the value chain. Any increase in energy prices hit the cost base of chemicals manufacturers, squeezing profitability in the process. This has been a continuous concern for chemicals manufacturers in the UK, with numerous sources demonstrating that UK industrial electricity prices are amongst the highest against our international competitors, including Germany, France and the Netherlands, and have been rising significantly since 2013.

However, despite retaining its position as one of the most highly energy intensive sectors, the chemicals sector's energy consumption has actually fallen by around 40 per cent since 2007, while production has remained broadly stable, illustrating a more efficient use of resources (Make UK 2017).

Shortages of workforce skills and management and leadership skills are well-recognised problems throughout the UK manufacturing sector (see, for example, Cranfield University 2017, DfE 2017). According to the HoC (2018), the chemicals sector requires a highly dynamic workforce which can keep up with new technological innovations, in order to keep best manufacturing practices and drive growth…. the sector can struggle to retain its skilled labour, losing out for example to the higher paying finance sector. There is a range of activity underway to address the sector's skills needs, including through the SIP Skills Strategy.

The chemicals industry in the UK is regulated through a framework that is largely based on EU legislation. The European Chemicals Agency (ECHA) implements the EU's chemicals legislation. One of the main pieces of EU chemicals legislation is REACH 1907/2006/EC - Registration, Evaluation, Authorisation and Restriction of Chemicals. This primarily affects manufacturers and importers of chemicals and other substances with a focus on identifying risk. Applying appropriate risk management measures is a duty on manufacturers (HoC 2018). Uncertainties concerning the nature of the future regulatory regime following Brexit are a further source of concern for this sector in the UK (see, for example, BEIS 2019).

Opportunities

According to Make UK (2018), the UK chemicals sector is in some respects, at least, well placed to achieve future growth and performance gains. "Despite the risks highlighted, the chemicals sector's importance, not just to the final consumer but also to a host of other manufacturing sectors, protects it from significant demand fluctuations and ultimate decline. Consequentially manufacturers in the sector are well positioned to take advantage of a number of opportunities on the horizon, in order to grow their output, as well as crucially improve their production processes". Make UK cite three areas of potential opportunity. Digitalisation in the industry has the scope to reduce costs by up to 3.9 per cent within five years, with further improvements beyond. The development of shale gas in the UK can reduce the dependence on imports. Increased demand for low-impact products and production processes and opportunities also lie in the development of new bio products.

2.6 Glass.

Economic Importance

The UK glass industry accounts for £1.3bn in GVA, which equates to less than one per cent of total manufacturing sector GVA. The sector manufactures a broad range of products mostly supplied to other industries, but it also supplies some products directly to consumers. The main outputs from the sector include flat glass for construction and vehicles; container glass such as a bottles and jars; glass fibre for insulation; scientific hollow glass such as tubing and vials; photonic components, which includes optical technology for navigation systems; and domestic glassware. In addition, high-performance coatings are increasingly used to improve the thermal efficiency of glass. There has also been a continuous focus on toughening and laminating in order to manufacture lighter-weight products for the transport sector, for example (British Glass).

Much of modern glass manufacturing has its roots in the UK. For example, the first commercial application for flat glass production – the Pilkington process – was developed in the UK in the 1950s in the North West of England. The industry is considered a mature market, with demand forecast to be stable in developed markets, such as the UK and Europe, but with greater future growth potential in China and other emerging markets.

The emergence of low cost imports, especially for consumer products, saw a decline in production at the lower value-added end of the market. In addition, glass manufacturing activity has relocated from countries such as the UK and Italy to Central and Eastern Europe in the 2000's to take advantage of lower production costs and also following the offshoring of customers in, for example, the automotive sector (European Commission).

Table 2.6.1 UK Glass sector

	Number of businesses						
	All businesses	Micro (1 to 9 employees)	Small (10 to 49 employees)	Medium (50 to 249 employees)	Large (=> 250 employees)	Employment	Turnover £m
Glass	735	475	185	65	10	23770	3583
All Foundation industries	7085	4565	1680	700	140	253825	67584
All Manufacturing	137365	108300	21575	6205	1285	2521519	570095
All Economy	2718435	2431995	233960	42000	10480	31574358	4005865*
Source: ONS							* Non-financial economy

Structure of the Glass Industry

All glass production requires the melting, at high temperatures, of raw materials or recycled material (cullet) and glass is therefore an energy-intensive sector. As a consequence, the industry has been subject to increasing regulatory requirements on its environmental performance.

Two-thirds of value added in the UK glass sector comes from the manufacture of hollow glass and the processing of flat glass (ONS). Firms in the hollow glass industry manufacture hollow or container glass products by melting silica sand or cullet and fabricating it into finished products. These can include drinking glasses, glass bottles and jars used to package beverages and foodstuffs. Flat glass manufacture is a continuous process of producing large sheets of glass, at high temperatures, primarily for glazing and vehicles. Flat glass production processes are highly capital intensive, with plant designed to operate 24-7 for around 15 years. This production is therefore associated with large manufacturers, rather than SMEs, which dominate the sector (British Glass).

The past decade has seen a significant increase in the use of cullet, which can contribute to lower energy consumption and carbon emissions from the manufacturing process. However, potential for further gains is limited and there are challenges with the quality of available cullet, as this requires colour separation and contaminations removal.

Number of Enterprises

In 2018, there were 735 businesses operating in the glass manufacturing sector, and in line with the rest of the economy, the vast majority are small and medium sized enterprises with less than 250 employees. Of these SMEs, almost two-thirds are classified as micro-businesses with less than 10 employees. However, a small number of large internationally owned companies dominates the industry output.

Employment

In 2019 there were 23,770 people employed in the UK glass sector, this represents less than one per cent of employment across the wider manufacturing sector. The sector has experienced some modest job growth in recent years as it recovered from a low point of under 20,000 during the financial crisis.

Agglomeration

Businesses in the glass manufacturing sector are concentrated in three geographic regions – the North West, East of England and the South East. Together these regions account for a third of businesses in the sector. However, employment is clustered in the North West and East of England, reflecting the location of the small number of large employers in the sector.

Supply Chains

The main inputs into the glass sector are soda ash, which is one of the most expensive raw materials used and accounts for around 60 per cent of batch costs sand and energy from natural gas. Cullet glass is also used in the production process can contribute to lower CO2 emissions, both because of reduced process emissions (due to lower use of raw materials), and from less energy consumption in the melting process.

Exports

In 2019, direct exports from the glass sector amounted to just under £1 billion, with two-thirds of export sales to the European Union – this proportion has been steadily declining since 2007. There has been modest growth in export values in the previous five years, however, these figures do not capture indirect exports – that is the exports of other industries the sector supplies to such as automotive or beverages.

The industry has a persistent and widening trade deficit, with imports mainly coming from the European Union. That said, imports from outside the EU have been rising, year-on-year, over the past two decades.

Innovation

Innovation efforts in the UK, and across Europe, have been focused on improvements in production processes aimed at improved productivity and cost reduction, and new product innovation. Regulation has played a role in promoting innovation and new product development. New building requirements, which specify the use of low-emissivity glazing and associated performance requirements for new houses and refurbishments have encouraged flat glass producers to instigate changes to operational processes and continuous innovation in production techniques. Similarly, emission reductions from vehicle requires an on-going focus of lightweight inputs in the automotive supply chain – including glass.

Significant pressures to reduce energy consumption have been a major innovation driver. In the UK, Glass Futures has been established to provide a funding vehicle for the bridge in technology between glass manufacturing now and in the low carbon future. Over £7 million of funding has been secured for research to demonstrate a range of alternative, low-carbon, fuel technologies for glass manufacturing, including biofuels, hydrogen, electric and hybrid scenarios. The outcome of this will contribute to the sector's long-term decarbonisation plan.

Challenges

The main challenges for the sector are cost-related. These include the high upfront capital cost and long payback periods of investment in innovation and associated issues with access to finance.

There is a requirement for higher quality recycling infrastructure to improve the supply of high-quality cullet. Additionally, high and fluctuating energy prices in the UK add to the competitive challenge of companies (British Glass).

The UK's exit from the European Union presents further industry challenges from changes to the regulatory framework and trade policy. Non-EU countries have, for example, been active in establishing non-tariff barriers. This could impede future export growth and will require the UK to develop necessary trade defence measures (European Commission). The glass sector's interconnectedness with the automotive sector is a further area of risk, which could materialise if future investment decisions by OEMs do not favour the UK.

Opportunities

The UK's transition to a net zero economy creates significant potential opportunities for the UK glass sector – particularly around the development of and demand for high-performance products supplied to the construction sector. Commitments from the UK government on future house building could provide additional upside to the outlook for the sector.

European collaboration will be important in developing new technologies that can reduce energy inputs. For example, The 'Furnace of the Future' is a fundamental milestone in the industry's decarbonisation journey towards climate-neutral glass packaging. Located in Germany, it will be the first large-scale hybrid oxy-fuel furnace to run on 80 per cent renewable electricity in the world.

Covid-19 has also presented some potential opportunities as retail spaces and offices invest in protective screening in response to social distancing requirements.

3. Methodology

3.1 Aims and scope of this research

This research is designed to quantify and provide a comprehensive understanding of innovation readiness in six foundation industry sectors: cement, paper, ceramics, metals, chemicals, and glass.

The principal research questions we identified and explored through this research were:

- How ready and capable are these six foundation sectors to adopt new or tried and tested innovations including those related to products, processes, and services?
- What are the key barriers and market failures constraining innovation performance in these sectors?
- What are the drivers of innovation, and what measures encourage and enable innovation in these sectors?

3.2 Methodology

This research was undertaken by the Enterprise Research Centre on behalf of UKRI between March 2020 and November 2020. In order to improve our understanding of innovation readiness in foundation industries, our data and methods were targeted at developing new quantitative and qualitative insights into the UK foundation industry sectors. The research sought to understand the factors that shape innovation and business performance in individual sub-sectors and their influence downstream in the supply chain. It explored the business objectives of UK foundation industry businesses, their ambition, barriers to success, and changes to their business strategy due to the Covid-19 pandemic and any issues that need to be addressed as a consequence of the UK leaving the European Union. The research examined the role of innovation in achieving set business objectives, including past innovation experiences and future plans. We collected qualitative and quantitative data via interviews and surveys of foundation industry trade associations and businesses. Foundation industry businesses are defined as those with SIC codes shown in Annex 1.

The project involved five principal stages:

Stage 1. Review of existing literature

A review of academic and grey literature was undertaken to document established thinking around the performance and innovation activities of the UK's foundation industries and to contextualise these findings. Within this, the review provided an understanding of the operational and innovation related opportunities and challenges faced by businesses operating in these sectors and the concerns of policy makers.

Stage 2. Analysis of available data

This stage of the project involved a review of the available quantitative data describing output, productivity, employment, and key indicators of investment (capital goods, R&D) and innovation in the individual sub-sectors comprising the foundation industries. Data was analysed from the BEIS Longitudinal Small Business Survey and available data from the Office for National Statistics. The research also considered the international context in which these sectors operate in with comparisons drawn with relevant competitor nations using data from Eurostat and the OECD.

Stage 3. In-depth interviews with representative bodies

Qualitative data was collected in two phases using a purposive sampling approach. The first phase of qualitative data collection was aimed at exploring the foundation industries through a sectoral lens. This was to provide a comprehensive overview of historical and recent sectoral growth, market segmentation, innovation adoption, barriers to innovation, and future outlook of the sectors. To achieve this, industry bodies representing the industry sectors were interviewed using a semi-structured questionnaire.

A total of 12 in-depth qualitative interviews were conducted with a range of industry bodies in March 2020. Respondents included industry representative bodies, BEIS sector leads, and other organisations with an interest in and knowledge of these industry sectors. The roles of the interview respondents contributing to this stage of the research are summarised in table 3.2.1.

Table 3.2.1 Description of Phase I (Trade Association) Interviewees

Interviewees	Position	Sector
Participant A	Director	Ceramics
Participant B	Senior Adviser	All Sectors
Participant C	Senior Lead	Chemical
Participant D	Chief Executive Officer	Chemical
Participant E	Director	Paper
Participant F	Senior Executive	Metals
Participant G	Senior Executive	Metals
Participant H	Manager	Ceramics
Participant I	Chief Executive Officer	Metals
Participant J	Chief Executive Officer	Cement
Participant K	Director	Materials
Participant L	Director	Metals

The discussion guide for Phase-I interviews drew on an extensive review of the literature on the case-study sectors, input and clarification from government research agency (UKRI) as well as expert advice from academics, consultants, and case-study industry executives. The final draft thus evolved through a detailed iteration process to eliminate ambiguities, as well as to guarantee that the interview questions aligned to the project aim and objectives.
The interviews were designed to provide a better understanding of themes and trends in the foundation industry sector regarding sectoral characteristics, market segmentation, business challenges, innovation efforts, obstacles to innovation adoption, and untapped opportunities. The questions focused on five key themes:

- Sectoral characteristics and concerns
- Approach to innovation and barriers
- Supply chain integration and collaboration
- Business management practices; and
- Government support and policy

The interviews were recorded, with the permission of the participants. All recorded interviews were transcribed before analysis. Interview responses were analysed using the NVivo software. Codes were generated and these were added to a codebook as the text was examined in detail. Analysis of these interviews was used to inform the development of the questionnaire to be used in the telephone-based survey of businesses operating in these sectors in the next phase of the research.

A number of these organisations were re-contacted towards the end of the project for a high-level discussion on survey findings and to obtain insight into how these might translate into potential policy options for UKRI and government.

Stage 4. Telephone survey of businesses

A telephone-based survey was undertaken by a specialist market research company on behalf of ERC in May through to September 2020. A total of 249 interviews were completed (see Table 3.2.2). Respondent businesses were recruited from sectors with SIC codes agreed with UKRI (see Annex 1).

Table 3.2.2 Achieved CATI survey responses by size and sector

Foundation industry sub-sector	0-9	10 – 49	50 - 249	250+	Total
Chemical	3	35	7	5	50
Cement	5	24	4	2	35
Ceramics	9	16	5	1	31
Glass	14	18	2	1	35
Metal	5	30	13	4	52
Paper	3	25	16	2	46
Total Surveyed Firms					**249**

This survey was designed to provide data relating to:

- Key characteristics of the business
- The business' fit as part of a foundation industry
- Performance in terms of employment and turnover
- Exports and imports
- Ambition
- Obstacles to business performance
- Access to finance
- Innovation
- Use of business support
- Management capabilities

The questionnaire for the survey was designed based on the emergent themes from Phase-I interviews, research objectives, and an expansive literature search. Additional questions from earlier industry surveys and external benchmarks, particularly the LSBS (Longitudinal Small Business Survey) and the Microbusiness Survey were added to the questionnaire to maintain some comparability.

Similar to the interview questions, the questionnaire was also reviewed by academics and subject experts from UKRI and the ERC to ascertain its content validity and appropriateness for the study. Feedback from this exercise was adopted and the questionnaire was piloted in the first week of May 2020. The pilot informed some more changes in the question structure, added clarity in the contents, and a reduction in the duration of the survey per respondent.

The survey across foundation industry businesses was conducted between May and September 2020 via Computer-Assisted Telephone Interviews (CATI). This followed a short interview format that lasted between 18 to 20 minutes. A total of 249 usable responses was obtained across the six foundation industry sectors. The backdrop of the pandemic and

lockdown restrictions added to the challenge of data collection and required the survey period to be extended from initial plans.
The survey outputs were analysed using SPSS software considering trends at the aggregate level across all industries and analysis by industry sub-sector and turnover bracket.

Stage 5 In-depth interviews with businesses

The final stage of the fieldwork involved in-depth interviews with 16 businesses operating in these sectors. The majority of these interviews were with businesses that provided data in the preceding extensive survey. The key objective of these interviews was to provide a greater depth of understanding of the issues affecting innovation performance identified during the previous stages of this research. To achieve this, businesses across the foundation industries were interviewed using semi-structured questions between July and October 2020.

The interviewees were business owners, senior business executives, and high-level managers involved in shaping strategy and investment decisions in foundation industry businesses. See table 3.2.3 for the characteristics of respondents.

Table 3.2.2 Description of Phase II (Business) Interviewees

Interviewee	Position	Sector	Size of Firm
Participant A1	CEO	Chemical	Small
Participant B2	Commercial Manager	Chemical	Small
Participant C3	Director	Ceramics	Small
Participant D4	Managing Director	Ceramics	Small
Participant E5	General Manager	Chemical	Medium
Participant F6	Marketing Manager	Ceramics	Large
Participant G7	Innovation Coordinator	Chemical	Large
Participant H8	Director	Metal	Large
Participant I9	General Manager	Metal	Small
Participant J10	Managing Director	Metal	Small
Participant K11	Director	Metal	Small
Participant L12	Managing Director	Paper	Small
Participant M13	Managing Director	Chemical	Large
Participant N14	Operations Manager	Glass	Small
Participant O15	Managing Director	Glass	Small
Participant P16	Managing Director	Glass	Medium

The discussion guide for phase-II interviews was based on findings from the phase-I interviews and analysed survey responses. Similar to Phase-I, the discussion guide followed an iterative process that involved input from UKRI as well as expert advice from academics and consultants based at the ERC as well as other external research agencies. Hence the phase-II interview questions were designed to capture foundation industry businesses' strategies pre-pandemic, business ambition, innovation adoption, innovation motivation and barriers, engagement with external funding and support, future business plans, and the influence of government support and policy on innovation adoption. The questions focused on five key themes;

- Business strategy
- Innovation adoption; drivers and management influence
- Innovation experience and challenges
- Future innovation plans
- Government support and policy

Also, similar to Phase-I, interviews were recorded, transcribed, and analysed using the NVivo software to generate emergent themes and trends across foundation industry businesses.

4. Findings from the in-depth interviews

Two sets of in-depth interviews were conducted. The first with representatives of industry bodies, stakeholders, and sector experts at an early stage of the research. The second set comprised interviews with respondents to the CATI survey who had agreed to be recontacted for a more in-depth discussion using a semi-structured interview questionnaire.

This section outlines the main findings from these interviews with industry experts and representatives and businesses in the foundation industries.

One point worthy of note is that, in general, responses to the in-depth interviews tended to be more positive than the findings from the CATI survey of businesses. For example, the quantitative data from the extensive survey shows that collaboration is less common than the in-depth interview responses would suggest. Similarly, while a clear majority of CATI respondents agreed that under-developed management and leadership skills act as a constraint to innovation, respondents to the in-depth interviews, particularly the representative bodies, generally suggested that this was not the case.

4.1 Findings from the in-depth interviews with representative bodies

A total of 12 in-depth interviews were conducted with representative bodies, trade associations, BEIS sector teams, and other organisations with a strategic interest in the six foundation industries covered by this research. These interviews were conducted during March and April 2020.

It is important to note that the primary purpose of these interviews was to inform questionnaire design for the next stage of the research. Given the relatively low number of interviews conducted, it would not be appropriate to generalise directly from these findings. The larger sample achieved through the survey of businesses provides a sounder basis for generalisation.

The findings from these interviews are summarised in table 4.1.1. Interview responses confirmed findings in the literature that the two most significant challenges facing these industries are (a) increased international competition and (b) the high energy costs and associated regulatory pressures to reduce carbon emissions and associated environmental impacts.

Table 4.1.1 Innovation drivers and challenges reported by industry bodies		
	Drivers of Innovation	**Innovation Challenges**
Ceramics	Regulatory compliance. Improving energy efficiency, cost reduction, moving towards net-zero obligations. Competitiveness. Trade associations' actively encouraging and enabling innovation.	Responsive innovation. Loss of expertise and capacity. Skills shortages. 'Conservative' industry. Commercial sensitivities inhibiting collaboration. Access to funds within the parent company. Competition from low-cost imports. Issues with uninterruptable processes. Growth rather than innovation is often a key aim. Cultural resistance to change.
Chemicals	Increasing demand for sustainable products. Profitability and business success, meeting customer requirements. Environmental regulations especially European legislation. Supportive trade associations. Need for competitive advantage.	Access to technology for innovation. The regulatory framework, management and leadership skills. Government prioritising other sectors. Regulatory drivers are sometimes overstated. Competition from places like China and the US, which have access to cheap energy.
Paper	Supply chain factors (customers), Regulations & environmental issues. No domestic source of raw inputs (only recycling).	The lack of scale in the UK paper market. Minimal collaboration and concerns about breaching competition rules by collaborating. Long investment cycles, and branch management system (i.e. decisions made at the parent company often not in the UK)
Metal	Regulatory compliance, supply chain led innovation. Sustainability agenda. Costs reduction. Innovation tends to be in response to crises rather than normalised.	Underdeveloped management and leadership skills. A lack of strategic planning. Structural approaches to innovation and forward planning are lacking. Research is not strongly supported. Lack of financial resources, bureaucracy and frustration with support processes. Effect of Brexit, foreign ownership. Responsive innovation.
Cement	Sustainability agenda. High level of expertise in the sector.	Justifying capital investment. Frustration with the support process, Lack of collaboration. Process-focussed innovation. Lack of innovation pull from customers.

Glass	New technologies. Net-zero obligations. Changing attitudes to collaboration. Establishment of Glass Futures by British Glass - to promote innovation and R&D. Role of trade associations in fostering cooperation and collaboration.	Lack of capital including internal funding within parent companies. Continuous/uninterruptable production processes. Skills shortages. Often the motivation is to get grant funding rather than to reap the benefits of being more efficient and competitive. Perception of high levels of activity, but some lack of coordination...

4.2 Reported drivers of innovation

The most widely cited driver of innovation was regulatory and other pressures to reduce carbon emissions and associated environmental impacts. Whilst businesses are aware that innovations that increase energy efficiency can reduce their cost base, it is also the case regulatory compliance is seen as imposing costs.

As one respondent put it:

> *'nearly all the innovations are driven by cost but this also means that where innovations themselves cost money they are discarded'.*

High levels of international competition were mentioned by respondents in several of the sectors being considered. Competition from low-cost producers increases pressure to reduce costs, which can act as a driver of innovation. Competition from substitute products manufactured outside the sector was also noted as a challenge, for example paper manufacturers saw competitive challenges coming from within the sector and from plastic packing solutions.

Some respondents suggested that although historically businesses in these industries had been very resistant to collaboration with other firms, attitudes are, at least beginning, to change.

Several respondents mentioned the potentially very positive role of trade associations and industry representative bodies in promoting and enabling innovation. However, the evidence from these interviews (and the findings from the extensive survey) suggest that industry representative bodies vary in the extent to which they actively encourage and support innovation throughout their sectors. There are examples of good practice where representative bodies function as collaboration champions, facilitating cooperative ventures and programmes involving member firms, government agencies, research centres, and academia. Representative bodies are generally well-positioned to boost networking within and across sectors as well as proactively lobbying on behalf of sector firms for resources and sector-enhancing policies.

Respondents also suggested that, in practice, innovation often occurs in response to 'crises' rather than systematically. An important corollary of this is that it is clear that whilst innovation does occur proactively in some sectors, it is often only undertaken in response to pressures

for product innovation from customers. However, in industries where most sales are business to business, these customers are often unwilling to accept higher costs. Actively seeking and responding to opportunities to innovate is not a normalised strategy throughout the foundation industries.

4.3 Reported barriers to innovation

Several respondents cited access to capital as a barrier to innovation. The requirement for patient capital in industries where investment cycles are often long was seen as a key part of this issue. Within this, a number of interviewees suggested that securing funding for innovation within what are commonly large multinational firms can be problematic. This last point relates to a more general problem related to the branch plant structures prevalent in several of these sectors, which results in strategic decision-making being remote from production facilities.

An underlying theme in several responses was that major reductions in carbon emissions, for example through a shift to hydrogen as an energy source, will require transformational, highly disruptive, and very expensive changes that are likely to be beyond the means of individual businesses.

Management and leadership skills were generally seen as being variable throughout these sectors. Some respondents reported a more general issue with skills shortages.

Concerns about commercial sensitivities which serve to discourage collaborative ventures were cited by a number of respondents. According to one respondent:

> *'there is a need to work hard on collaboration and partnerships and few individuals put in sufficient time and effort'.*

A number of respondents cited continuous production processes as a practical barrier to innovation.

Some respondents also suggested that there is often 'a race to be second' as businesses resist the adoption of novel innovations, preferring to wait until new technologies are proven. Respondents in several of these sectors suggested that these are generally 'mature' industries where there is little potential for product innovation.

Respondents' own words

"One of the challenges the industry has is that it can be energy-intensive, so that's an area where they need to make themselves competitive".
"Energy and CO_2 are the main drivers, then pollution control. Don't underestimate how big these are".
"Businesses are extremely innovative in a crisis. Nothing better than when something goes wrong. However, structural approaches to innovation and forward planning are lacking. Research is not strongly supported. This is in part due to cost but also because of the time taken to realise benefits".
"Challenges include competition from places like China and the US because they have access to cheap energy".
"In the UK they operate a branch management system, they don't make the long-term strategic investment decisions…. We push as hard as we can, but decisions are not made in the UK……..The first question is what country do we invest in rather than what do we do."
"There can be novel product innovation but it is more around the process and use innovation".
"[Innovation] is not the first thing sales people think about when they get out of bed in the morning".
"Companies getting together is unusual because they are concerned about competition and so forth if they have an innovative process, they don't really want to share that".
"We need a careful understanding of what the costs would be and clearly some of this is estimated and then you have to evaluate what the payback is for any given innovation …."
"….there are people with the scientific ability, but do they always have the business abilities to take an idea to market?"
"If you look at government policy over recent years there are what might be called 'darling sectors' – aerospace, automotive, pharma …. chemicals isn't seen in this way".
"…regulation is part of it but it has been a boardroom issue for many years. The biggest driver is keeping your cost base low and keeping your company competitive".
"…we have lost a lot of the capacity we used to have. Stoke used to have a ceramics undergraduate course, so a lot of people in the industry now are graduates of that course. But that course finished 20 years ago and now it is much broader in terms of people's backgrounds".
"They are challenged by making that investment case, it makes it difficult, but it doesn't mean that the technical competency isn't there".
"They understand what's going on but the big bottleneck is cash constraints".

4.4 Findings from Follow-up Interviews

Follow-up interviews were conducted across the six industry sectors being examined to provide a deeper understanding of the motivations for and barriers to innovation and businesses' capability to engage in innovation across the foundation industries. Businesses within the foundation industry sectors were interviewed using a semi-structured questionnaire. The questions asked related to current business strategy, the impact of the Covid-19 pandemic, innovation efforts, past innovation experiences, and the future innovation outlook of the industry sectors. A total of 16 telephone interviews were conducted across five out of the six foundation industry sectors in August and September 2020

4.5 Business Strategy

Respondents tended to agree with the findings from the CATI survey that a minority of foundation industry businesses lack meaningful growth ambition. However, respondents were also clear that in those businesses with ambition before the Covid-19 pandemic this was typically centred on growth rather than innovation *per se*. Many of the respondents indicated that they had plans to increase sales and profit margins. A few of them also emphasised their commitment to reducing carbon emissions in the long-term.

Some of the businesses indicated that they had set growth targets and strategically positioned themselves prior to the pandemic to grow over a specific period (usually two to three years) and move towards more sustainable processes. Investment in workforce skills, plant expansion, as well as product and process development were being prioritised by many of the foundation industry businesses resulting in expectations of growth and improved profitability.

> "*We had a very positive growth forecast; we were looking to not quite double but to go from three million to five million within three years. Which for a very specialist niche business is quite a big jump"*

Respondents indicated that business challenges at this time revolved around process optimisation, long lead times, competitive markets, and declining customer base for some products (for example, in the automotive sector).

Despite the impact of the pandemic, which many businesses confirmed has had significant negative effects (including supply chain disruptions, loss of sales and reduced cash-flow) there was nevertheless a sense of optimism across interviewed businesses. Respondents tended to claim that the overall ambition of the business from before the crisis has not changed. However, they also tended to recognise that it would take some time for a full recovery to be made and that it was not going to be 'business as usual' for some time.

> *"Our ambition hasn't changed; to be a sustainable supplier of innovative ingredients and to be climate, land, and people positive by 2030"*

4.6 Innovation: Motivation, Barriers, and Experience

Interview responses suggest that many foundation industry businesses have a clear understanding of the benefits of innovating. However, whilst some businesses indicated that they were innovation-active and some were open to opportunities to innovate, a significant minority did not perceive innovation as a necessary element that fitted well to their business strategy. Amongst the self-identified innovators, there seems to be a clear distinction between those businesses that innovate only in a responsive way; for example, when asked for a new product by a customer, and those that actively seek out opportunities to innovate.

4.6.1 Types of Innovation

While some respondents indicated that they were actively involved in both product and process innovation, many indicated that they were *either* process or product innovators.

On many occasions, especially with product innovation or enhancement, innovation was customer-driven. This is sometimes achieved via supply chain collaboration. However, in-house innovation was a characteristic feature of many foundation industry innovators with some businesses having modest R&D units tasked with developing innovative solutions. Some respondents also engaged the services of research institutes, universities, and consultants to access new knowledge.

> *"We have done both [in-house and outsourced] in the past and we've done things that are new to the industry. So we are the system we manufacture"*

Many foundation industry businesses prefer not to be 'first mover' innovators but would rather adopt "tried and tested" innovations.

> *"…We are more reactive [when] someone else has blazed the trail. We probably like to be a close second rather than a leader"*

4.6.2 Innovation Motivations

As noted previously, although respondents stated that their businesses are motivated to achieve growth, they do not necessarily expect to achieve this through innovation. In practice, many businesses remain ambivalent about innovation.

> *"I do not think businesses are innovative. I think they are being led by outside forces. We are almost having to move with the times. Otherwise, businesses would just carry on regardless"*

Many businesses remain non-innovators. Some respondents argued that the nature of some foundation industry sectors means that they tend to be regarded as basic industries (for example, in the metal sector) with traditional production processes and thus with limited scope for innovation.

The most mentioned innovation drivers in the foundation industries are:

Competition in the market: Increasing competition both domestically and internationally means that many businesses are simply striving to improve on existing products and processes. For some businesses, keeping abreast of new developments in the marketplace was described as a means of survival.

> "*Yes, I think everybody does keep one eye on what their competitors are up to..*"

Profitability: Increasing profit margins evidenced by increased turnover and cost reductions are key innovation drivers in the foundation industries. Many businesses concentrated on improving their product and process performance with the ultimate goal of increasing business profitability.

Business diversification: Development of new product streams with the view of venturing into new market segments and diversifying the business for growth and sustainability purposes due to rising increasing global competition is increasingly important in some foundation industry sectors (for example, in the metal sector). Some respondents suggested that this is occurring in response to Covid-19 restrictions (for example, in the glass sector).

Changing regulations: Meeting new regulatory requirements and changing industry standards, not least those associated with carbon emissions reductions, require some foundation industry businesses to adopt new processes and products. However, respondents were clear that the challenges involved are often profound and that responses are often focussed on compliance rather than anything more strategic.

Customer demand/sectoral influences: Innovation in the foundation industries is often influenced by customer requirements. Many businesses innovate simply to meet emergent customer requirements. For example, customer preferences for more sustainable products have led to the increasing development of recyclable and compostable packaging products in the paper sector.

> *"Every new product that we have, aside from the things we bring in from our alliance partners, is through speaking with customers and finding out what they need"*

Management culture: Some foundation industry businesses regarded innovation as an important part of the business, which has been ingrained in the management culture. Many of these businesses are characterised by well-defined management ethos and well-structured work practices. However, most respondents agreed with the CATI findings which show that management and leadership skills are underdeveloped in many foundation industries and that this acts to constrain innovation.

Supply chain: Supplier influence also plays an integral part in innovation adoption. The availability of new technology or the improvement of existing technology through equipment suppliers or supply chain tiers has made it necessary to change or upgrade existing processes or in some cases, products.

4.6.3 Innovation Barriers

Across foundation industry businesses, there is a clear set of challenges to innovation adoption. The barriers to innovation reported in our survey included:

Risk aversion: There is widespread risk aversion particularly in relation to being confident that a new product can be commercialised and will provide a return. The uncertainty associated with investing in an unproven or new technology and the cost of not getting it right is a deterrent to innovation in many businesses. Some respondents noted that new product development only provides a short term competitive advantage as there are many industry 'copycats' waiting to adopt the innovation and limiting potential profit gains to the innovator.

Disengagement from innovation: Interview responses suggest that some businesses are disengaged from the idea of innovation. For some, this is a considered position – "if it's not broken, why mend it". Others appear to have mindsets that are simply antithetic to innovation.

Niche products: Some respondents suggested that innovation has little relevance to them because they produce niche products. Such businesses are characterised by a loyal customer base and tend to innovate only when the customer requests improvements or when it suited the business case.

No supply chain collaboration for innovation: There is limited evidence of meaningful cooperation within supply chains to facilitate innovation. Similarly, few respondents noted a recent engagement with the research base.

Limited exposure to good practice: While respondents were almost all aware of the importance, indeed the necessity of collaboration, collaborative innovation is not a common feature in the foundation industries. Respondents indicated that concerns about commercial sensitivities and the cost of facilitating partnerships were the key reasons for the apparent lack of inter-firm collaboration in foundation industries. Associated with this, there appears to be very limited networking within these sectors. More networking could expose respondents to new ideas and promote more collaborative ventures. However, there appears to be an appetite for peer-to-peer learning – especially around technology adoption.

> *"I think too many businesses are overprotective. You won't get collaboration. Again, unless it's a legal requirement. It won't happen. Everyone is protective of their own little world".*

Time constraints: The challenge of allocating time either in form of labour or the time to manage an innovation project and prioritising the cost and time involved in doing this whilst still keeping up with a normal business schedule is sometimes not possible for some businesses. Thus, businesses end up looking for the next best, and often cheaper solution to save time. In addition, the challenge of keeping the project on schedule for on-time delivery sometimes makes the use of existing solutions or upgrades more appropriate.

> *"…the challenges are always people's time and attention and how you prioritize the costs and the time involved."*

Standards and regulations: Meeting frequently changing industry standards and certification requirements for new innovations can be challenging and costly. This, alongside the sometimes bureaucratic process for certifications and the time it takes, can be discouraging for businesses planning to innovate.

Financial constraints: Many foundation industry businesses operate within slim profit margins and therefore lack the financial capability to take on, particularly large scale, innovation projects on their own. However, as our survey result confirm, the demand for finance has declined in the foundation industries in recent years as it has throughout the economy more generally.

> *"… if you are small and you are looking at your balance sheet and your Profit & Loss and you are looking to survive, so ploughing a significant amount of your turnover into R&D which may or may not payback later on is always quite a risk. You can argue that doing nothing is just as risky"*

Lack of engagement with the research base: Responses suggest that there is quite a general disconnect between universities, other support providers, and foundation industry businesses. This is apparent in the perceived lack of applicability of innovation emerging from universities/research institutes for industry adoption.

4.6.4 Representative Bodies and Innovation

Evidence from the interviews suggests that foundation businesses have a mixed perception of industry representative bodies as innovation enablers. A minority of the businesses were not members of any industry representative body. Businesses that were members of trade associations argued that their primary function is to act as lobby groups promoting the sectors' concerns and needs to government.

However, their role as innovation enablers was seen as being variable, with some firms stating that they were not necessarily functioning in that role, while others stated that they have been instrumental in their innovation adoption through the provision of networks and necessary support where required. Respondents were, however, of the opinion that the role of industry representative bodies could be extended to accommodate more innovation facilitation if equipped with the necessary resources.

> *"Now I don't think we have had a single conversation with a rep body about innovation in the XX sector. Don't get me wrong, we know that there are regional advisory boards. They do a good job in many areas and they have helped us in many areas but not in anything to do with innovation"*

4.6.5 Innovation Experience and Future Plans

Innovation support: There is a general awareness of the availability of external support for innovation through grants and innovation tax credits across the foundation industries. However, while some businesses are engaged with this support, the majority of foundation industry businesses are not. One of the reasons given for this a lack of clarity around what are perceived to be complex application processes. Respondents also suggested that innovation support through the tax system did little to help with capital investment requirements, which are often an important component of adopting new process innovations.

> "*Funding is the other big issue, always, and trying to access funding for these things is so complicated and it spreads so thinly across so many different things. But it's a nightmare"*

In addition, some businesses indicated that the decision to abstain from the use of external support and funding was a matter of business policy.

> *"I am sure that grants would be available if we could be bothered to look for them.* We were aware that these grants have been available but we took a strategic decision that we did not need them"

Some respondents stated that being able to interact and acquire knowledge on innovation and advice from the government through agencies such as InnovateUK, KTNs, and the research council, for example, was an important boost to the innovation process. However, long-term engagement with these agencies was seen as challenging not least because of a lack of continuity and frequent changes of personnel and contacts.

Lessons from failed innovation: Some foundation industry respondents indicated that they had experience of a number of failed innovation attempts and that lessons have been learned in the process. These failures tend to act as a barrier to further innovation attempts. Success depends on appropriate planning including the identification of clear objectives and proper recognition of the practical challenges.

> *"If you are not confident of success, don't do it"*

Impact of Covid-19 pandemic: Foundation industry businesses indicated that the Covid-19 pandemic and associated lockdown measures introduced to combat the spread of the virus led to supply chain disruptions and logistics issues, furloughed staff, and loss of profit margins due to a loss of export markets and order cancellations. Businesses reported a drastic drop in profits, which were considerably greater than they anticipated before the lockdown measures came into place. However, a small number of respondents noted new opportunities that they

were able to respond to during the crisis. These did not, however, tend to compensate for other lost orders and production.

> "… ninety-two per cent of our products go outside the UK for export so it was more the global impact on the car industry that affected us. But it has also had some effects on our other ranges – the food, pharma, and beverage markets"

The Covid-19 pandemic has slowed down innovation plans. Despite this, many firms reported that they remain committed to innovation both in the short- and long-term.

> *"There has to be a stabilisation period and whether that's six months or 12 months or 18 months. We don't know but definitely, we will be innovating going forward as that's how we protect our market position"*

> *"We are always looking to do more process enhancement as much as we can"*

Current Business Concerns: Current business concerns in foundation industry businesses revolve around regulatory requirements, the impact of Brexit, high energy costs, increasing cost of production, and difficulty in obtaining grants. Continuous increases in energy costs over the years mean production costs continue to rise in the sector. The growing requirement for UK businesses to reduce their carbon footprint as the UK moves towards a 2050 net-zero target means that many foundation industry businesses are thinking about measures to reduce their emissions alongside other business challenges.

There is a high level of anxiety over the impact of Brexit on foundation industry businesses. Concerns about restricted access to the European market, the need for re-registration of some UK businesses in Europe, loss of exports, payment of duties, and the relocation of UK-based suppliers and customers after Brexit, were some of the lingering issues in the sector.

> *"…at the moment if we lose access to European markets it doesn't matter how big or small you are in the chemicals industry it is going to be a meteoric problem that will not be solved by money grants or assistance or whatever... So that is our biggest concern – what happens with the European Chemicals agency that is based in Helsinki"*

> *"…. we sometimes move material around two or three assets in Europe before it becomes a saleable product to a customer and we are in a situation where we will have to pay import and export duty every time we cross the UK border. And that may significantly affect our manufacturing processes"*

4.6.6 Policy measures and recommendations

Evidence from interviews suggests a mixed perception of the benefit of current policies governing foundation industry businesses. Whilst some businesses were comfortable with the level of engagement, support, and regulatory requirements, many others were of the opinion that 'more should be done' to support foundation industries.

> *"I think that as an industry we are pretty well regulated, pretty well supported and the big companies seem willing to help the smaller ones"*

Foundation industry businesses suggested policy improvements on grant allocation, facilitation of industry-academia collaboration, better-defined industry standards, encouraging process digitalisation, and assisting energy efficiency attainment in the sector. Respondents

emphasised that businesses will benefit more from the grant process if it is more transparent and easier to access.

Encouraging and facilitating digitisation of manufacturing assets in the foundation industries through the development of mechanisms to support and implement new digital technology in the sector is necessary and this was cited as an area where foundation industry businesses are still lagging compared to other manufacturing sectors.

> *"what the foundation industries and the chemicals sector need is a translation of those digital technologies at a much earlier stage …. We need real support to implement digitalisation ….things that are common elsewhere…. Application of these into processes is much more difficult"*

In addition, respondents indicated that the sector would benefit from the development of policies to encourage and facilitate innovation diffusion and collaboration between businesses and academia or research institutes. This is necessary to assist businesses to actualise new ideas that can be pivotal to building a global competitive advantage for foundation industry businesses in the UK.

> *"They could make R&D tax breaks a bit better and easier to understand. They could do more to help businesses put good ideas from university spinoffs into practice"*

5. Survey findings

This section outlines the key findings from a survey of 249 foundation industry businesses.

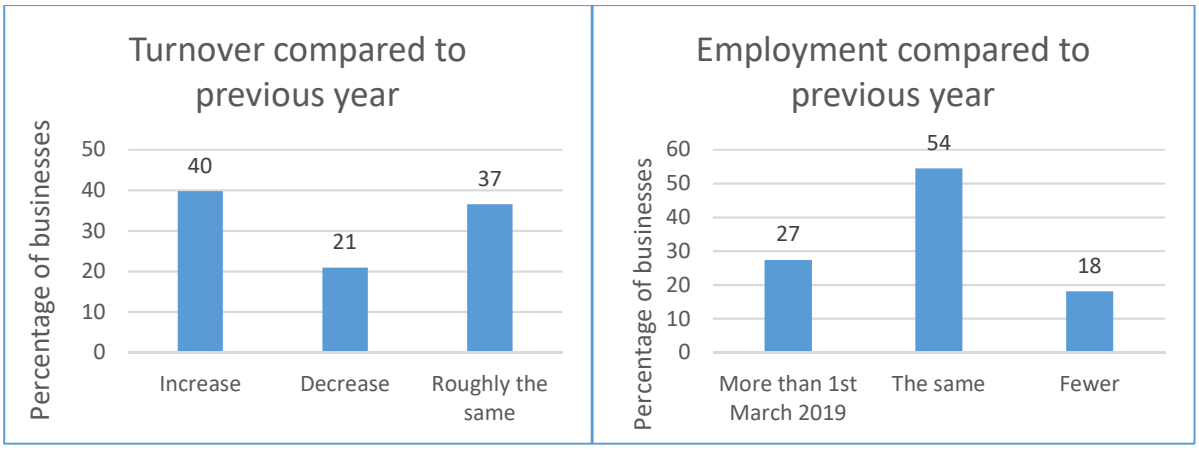
5.1 Characteristics of foundation industry businesses

Performance metrics

Our survey indicates generally solid performance amongst foundation industry businesses in the year to March 2020 (figures 5.1.1 and 5.1.2) . Overall four in ten businesses reported an increase in turnover compared with just over a fifth (21 per cent) seeing a fall. The remaining 37 per cent reported broadly stable turnover relative to the previous 12 months. However, in terms of changes to employment across the sector (figure 5.1.2), a majority (54 per cent) said employment was largely the same in the year to March 2020 compared with the previous 12 months, 27 per cent reported employment growth and 18 per cent saw a reduction in the numbers employed.

Turnover growth was more likely across larger foundation industry businesses (50 per cent of businesses with a turnover of more than £15m reported growth, compared with 36 per cent with turnover less than £5m). There was some sectoral variation in reported turnover growth, with around half of businesses in chemicals, cement and glass experiencing growth. Businesses in the glass sector were least likely to report growth (26 per cent).

Figures 5.1.1 and 5.1.2 Change in turnover and employment in the 12 months to March 2020 percentage of respondents

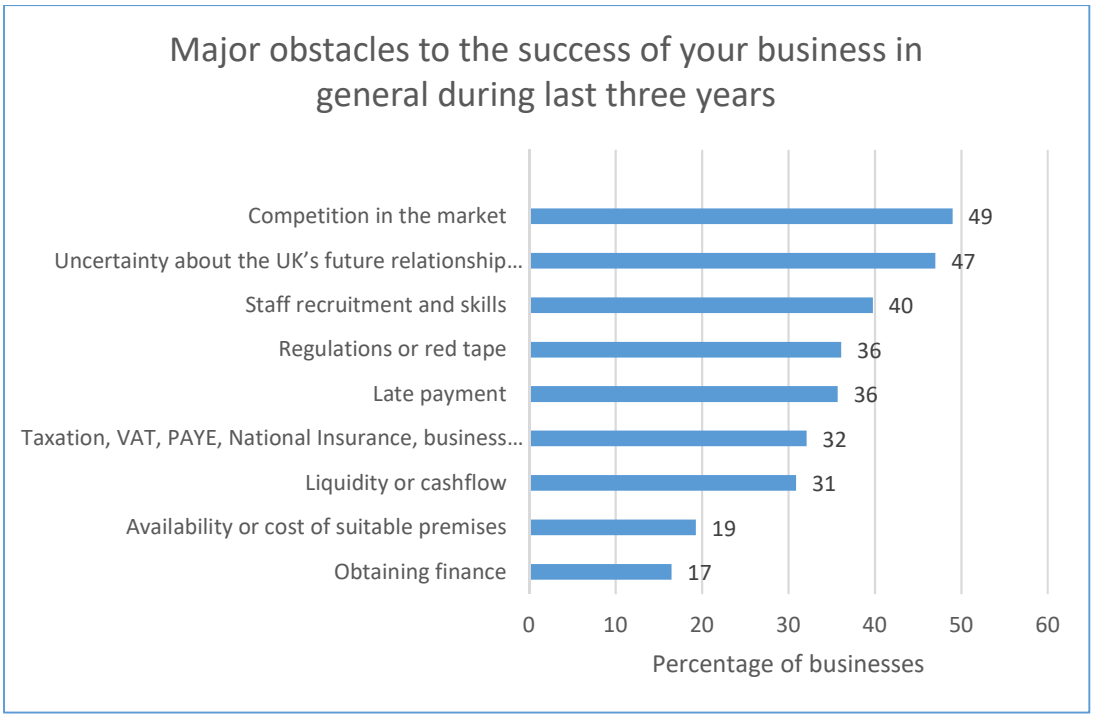


Obstacles to business success

Foundation industry businesses reported experiencing a range of obstacles to business success (figure 5.1.3). On the whole, these are not substantially different from business obstacles reported by the wider business population in LSBS 2019. The most commonly reported were competition in the market and Brexit related uncertainties (as shown in figure 5.1.3). Concerns about Brexit uncertainly are somewhat higher than in other business sectors. Furthermore, concern about Brexit implications increases with company size.

Taxes, such as VAT and business rates, were more likely cited as an obstacle to growth by smaller companies, whereas the availability of skills was most cited by businesses with a turnover between £1m and £15m. The chemicals sector stands out with more businesses (44 per cent) concerned with regulations as an obstacle to growth, and a higher proportion of businesses in the cement sector reported the availability of suitable premises as an obstacle (34 per cent).

Figure 5.1.3 Reported barriers to success in the past three years percentage of respondents



Trade performance

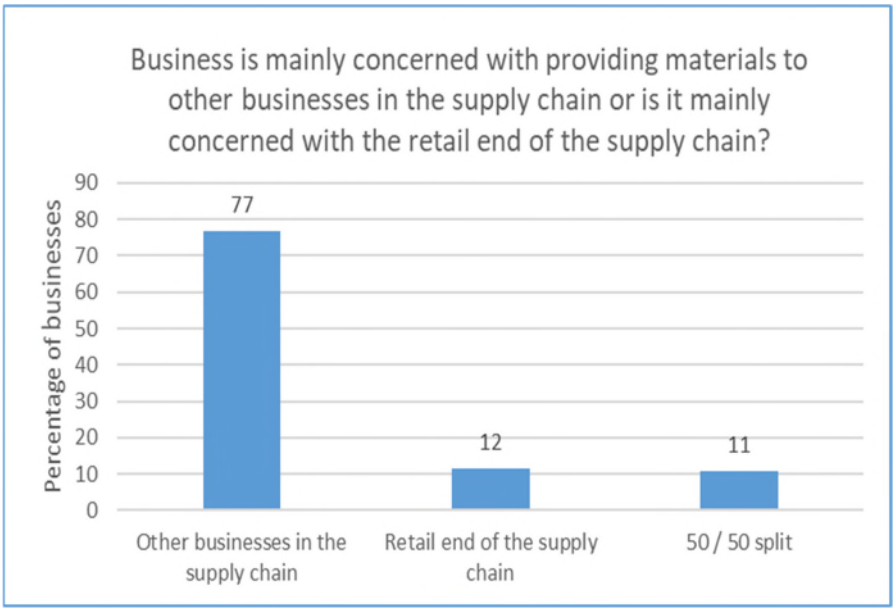
More than half (59 per cent) of foundation industry businesses exported goods or services in the year to March 2020. Of these, 22 per cent traded with just the EU, six per cent with just markets outside the EU while the majority (71 per cent) traded with both. However, for the majority (61 per cent) only a relatively small proportion of turnover (up to 25 per cent) is accounted for by exports. Chemicals businesses in our survey were more export intensive with 28 per cent exporting over three-quarters of their turnover. This sector picture is consistent with official statistics.

Half of the UK's foundation industry businesses imported inputs in the year to March 2020. Almost one in three businesses (30 per cent) imported from just the EU, while 61 per cent imported goods or services from both inside and outside the EU. The chemicals and paper sector were most likely to import inputs (74 per cent and 57 per cent respectively).

Customer profile

More than three quarters of foundation industry businesses (77 per cent) sell mainly to other businesses in the supply chain. This is one of the key characteristics of businesses in these sectors. Indeed, a clear majority across all sub-sectors supply to other businesses in the supply chain, although just over a quarter (26 per cent) of ceramics businesses sell to the retail end of the supply chain (see figure 5.1.4).

Figure 5.1.4 Foundation industry businesses selling to the supply chain and retail customers percentage of respondents

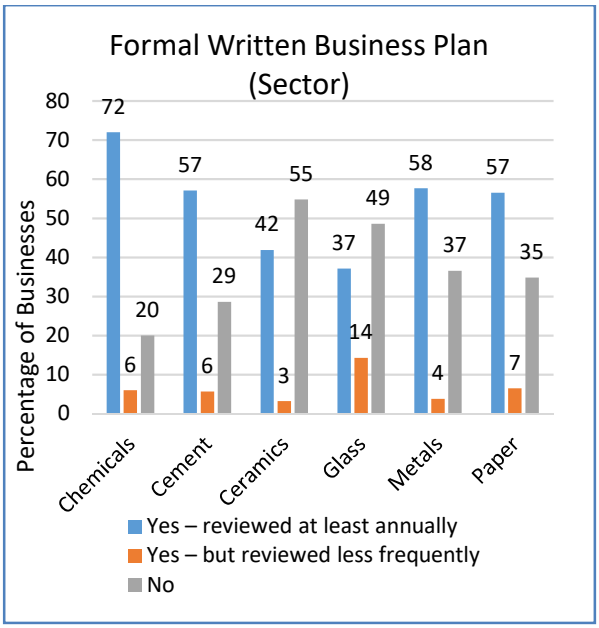


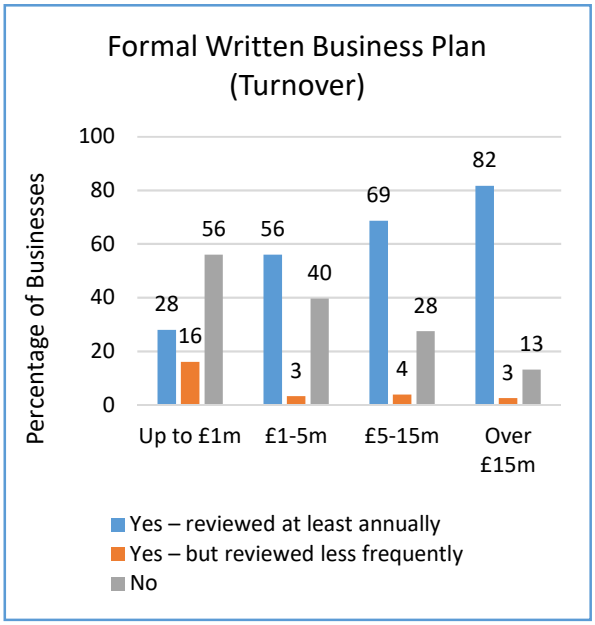
5.2 How foundation industry businesses are run

Business planning

Approximately half of foundation industry businesses (54 per cent) had a written business plan which was reviewed annually while more than one-third (37 per cent) did not have a written business plan. Large businesses were most likely to have written business plans, with more respondents in the over £5m turnover size category reporting a written business plan which was reviewed annually; 69 per cent of businesses with turnover of £5m to 15m and 82 per cent of those with turnover over £15m with (see figure 5.2.2). The use of written business plans was somewhat less common amongst small businesses (businesses with a turnover of up to £1m) - more than half of these businesses did not have a written business plan and less than one-third of those with a written business plan reviewed such plans annually (see figure 5.2.2). This relationship with size is consistent when considering the number of people employed as well as turnover. Businesses in the chemical sector (72 per cent) were most likely to have a written, annually reviewed, business plan. More than half of businesses in the cement (57 per cent), metals (58 per cent), and paper (57 per cent) sector indicated doing the same (see figure 5.2.1)

Figures 5.2.1 and 5.2.2 Businesses with a formal business plan percentage of respondents





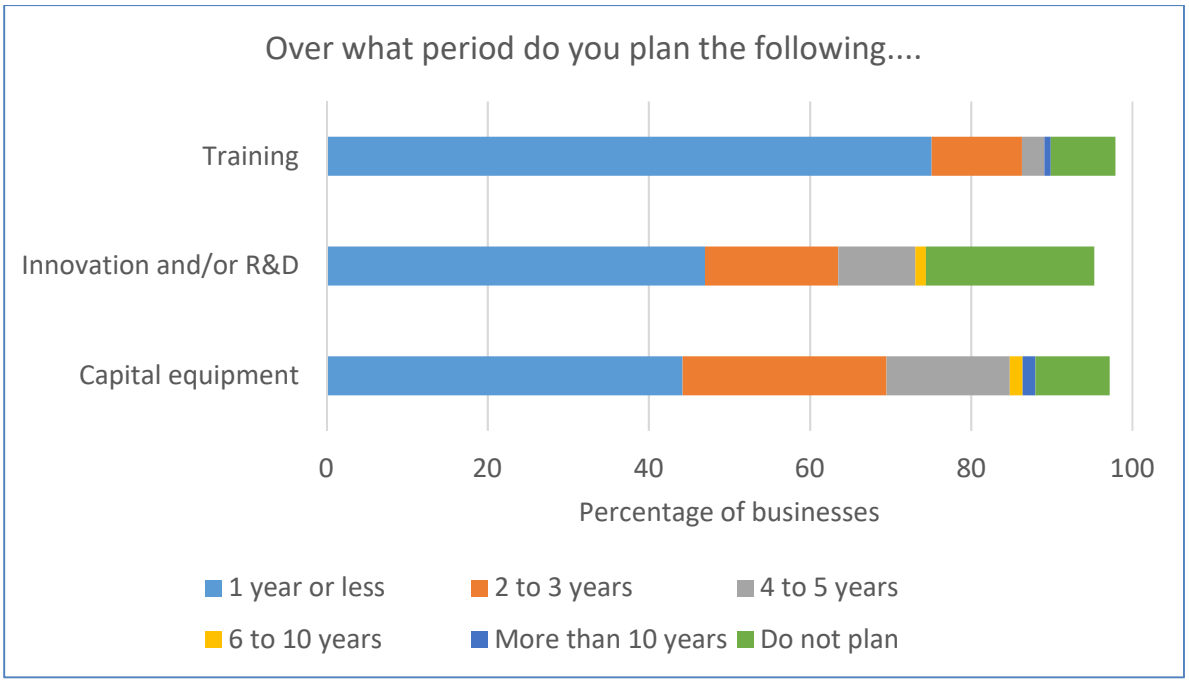
Business planning horizons

Survey findings suggest that long-term planning horizons in the foundation industry sector (6 years or more) are rare, with the majority of businesses across the sectors engaging in short-term investment planning (≤1 year to 5 years).

Foundation industry businesses engaged in investment planning for innovation, training, and capital equipment over varying time scales (typically between one to 10 years). An average of 90 per cent of surveyed businesses planned investment for training while 88 per cent and 75 per cent planned investment for capital equipment and innovation/R&D respectively.

Businesses were more likely to plan investment for training within a short-term planning period (one year or less) than planning investment for innovation or capital equipment. An average of three-quarters of businesses (75 per cent) planned for a one year or less training investment while less than half planned for investment for innovation (47 per cent) or capital equipment (44 per cent) for the same period (see figure 5.2.3).

Figure 5.2.3 Planning horizons for investment in foundation industry businesses
percentage of respondents



Analysis by turnover suggests that planning for training and capital equipment were popular features with more than four-fifths (80 per cent) of businesses indicating that they planned for training and capital equipment over varying time scales (between one to ten years). Of this percentage of businesses that planned for training, more than three-quarters indicated a short-term planning horizon (≤ 1 year to 5 years). Investment planning for capital equipment and innovation was highest in businesses with £5 to £10m turnover with 90 per cent and 80 per cent respectively.

A comparison of foundation industry sectors suggests that the majority of businesses in the glass and ceramics sector (more than four-fifths) were planning for investment in innovation/R&D. Many of the other sectors also showed high percentages of investment planning. An average of three-quarters of businesses in the chemical, cement, and paper sectors planned for innovation investment. The metal sector emerged as the sector with the lowest percentage of businesses planning for innovation across all surveyed foundation industry sectors with over one-third of businesses (35 per cent of businesses in the metal sector) not planning for innovation at all.

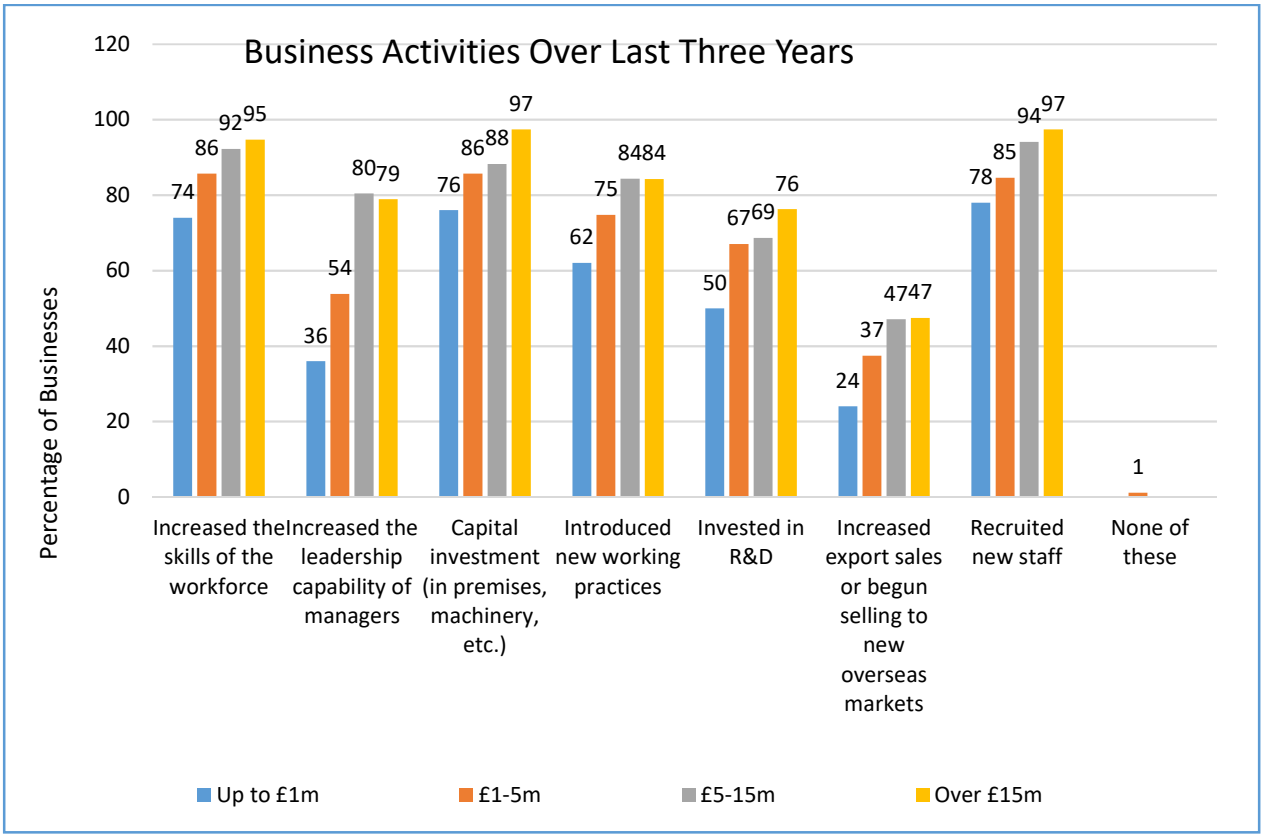
Business improvement activities

Over the last three years, foundation industry businesses engaged in various business improvement activities. Survey findings indicate that businesses invested in premises and machinery, introduced new working practices, invested in R&D, increased export sales, recruited new staff as well as increased management and leadership and workforce skill.

More than 90 per cent of businesses in the over £15m turnover classification increased workforce skill while about 74 per cent of businesses with up to £1m turnover did the same in

the last three years (see figure 5.2.4). Increasing managerial leadership capability was a popular business improvement activity in the larger firms (with turnover over £5m) with over three-quarters of businesses indicating that they engaged in leadership capability improvements in the last three years. The percentage was much lower in small businesses where only 36 per cent and 54 per cent of businesses in the up to £1m and £1m to £5m turnover category respectively invested in managerial capability improvements.

Figure 5.2.4 Actions undertaken to achieve business objectives in the past three years
percentage of respondents



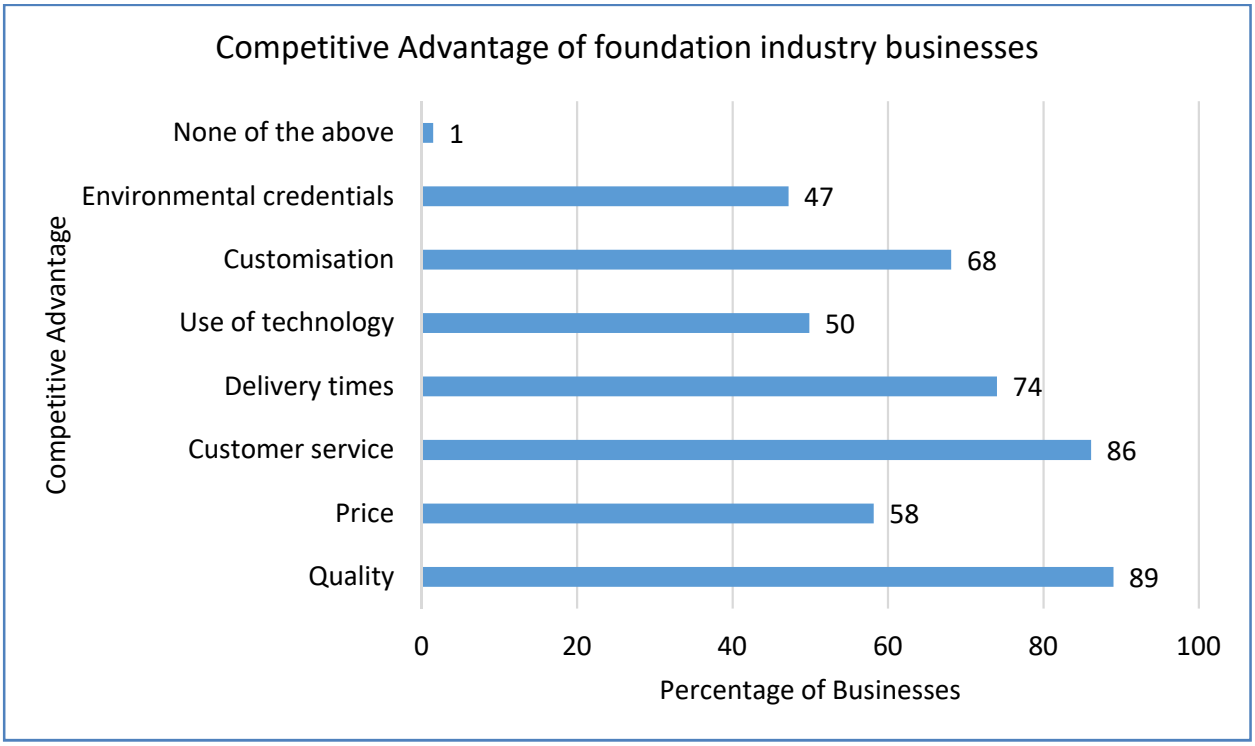
Across the foundation industry sectors, more than two-thirds (70 per cent) of businesses in the paper sector invested in management leadership and capability development while the majority of businesses in the metal sector (90 per cent) invested in workforce skills development and new staff recruitment (90 per cent). The cement sector had the lowest percentage of businesses (20 per cent) which increased export sales/selling to new overseas markets. Two-thirds (66 per cent) of businesses in the chemical sector increased their export sales over this period. These proportions reflect the export intensity of the different sub-sectors. The chemical sector reported the highest percentage of businesses (80 per cent) investing in R&D over the last three years, whereas 71 per cent of businesses in the ceramic and glass sector indicated that they invested in R&D over the same period. The cement sector recorded the lowest share of businesses making an investment in R&D over the last three years.

Competitive advantage in foundation industry businesses

Businesses reported a wide range of factors contributing to their competitiveness in the market place. The most-reported factors were quality, customer service, and delivery times. More than four-fifths of respondents compete based on quality (89 per cent) and customer service (86 per cent). Less than half (47 per cent) of businesses regard their environmental performance as a competitive advantage. Nearly three-fifths (58 per cent) of businesses regard price as a competitive strength while only half (50 per cent) consider technology use as giving them a competitive advantage (see figure 5.2.5).

The survey data showed little variation in the factors contributing to competitive advantage by the size of business. However, factors contributing to competitive advantage do vary somewhat more by sector. For example, apart from quality, customer service and, delivery times, which were the most frequently identified factors for business competitiveness across all sectors, customisation was a more frequently cited factor in the paper sector (80 per cent). In the chemicals and ceramics sectors, environmental credentials emerged as the least important contributor to competitiveness (38 per cent and 39 per cent respectively).

Figure 5.2.5 Factors considered areas of competitive advantage percentage of respondents



5.3 Innovation activity across foundation industry businesses

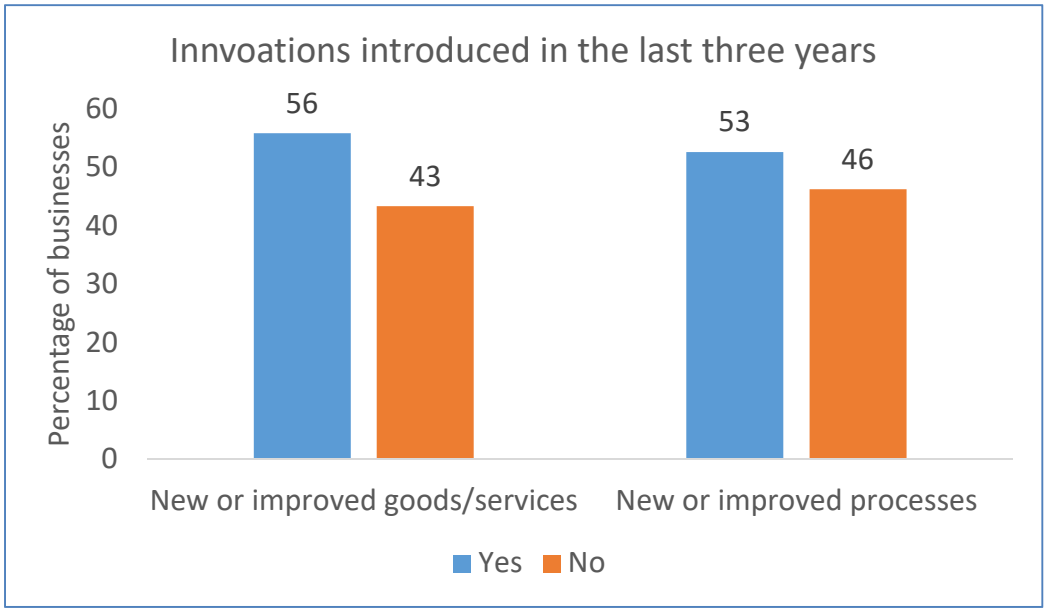
In the previous three-year period, 56 per cent of foundation industry businesses had innovated to develop new or improved products or services and 53 per cent had engaged in innovation activity for the purpose of developing new or improved processes (see figure 5.3.1). This compares favourably to the wider business population and, to a less extent, manufacturing as a whole. LSBS (2019) reports that 25 per cent of medium-sized and 19 per cent of small businesses introduced new/improved goods or services, and 35 per cent of medium-sized and 36 per cent of small businesses introduced process innovations during the previous three years. Just over two-fifths of manufacturers (41 per cent) in LSBS 2019 introduced new/improved product innovations over the same period.

In line with the findings from LSBS 2019, our survey shows that innovation activity in the foundation industries tends to increase with business size. Under two fifths (38 per cent) of businesses with a turnover of less than £1m reported product or service innovation in the past three years compared with 71 per cent of businesses with a turnover of over £15m.

There were also differences across foundation industry sub-sectors. Businesses in the chemicals sector were most likely to report new or improved product or service innovation (68 per cent), followed by the paper sector (61 per cent). Whereas just under than half of cement and ceramics businesses introduced new product/service innovations (49 per cent and 48 per cent respectively).

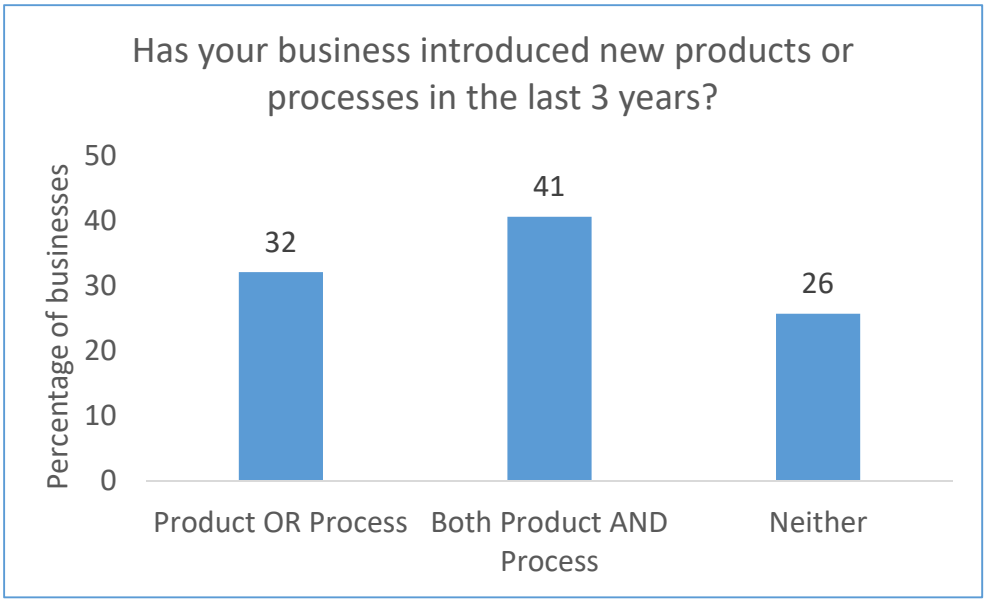
Size and sector differences were less apparent for process innovators. Just under a half (48 per cent) of business with less than £1m turnover reported new process innovations compared with 59 per cent of businesses with a turnover between £5m and £15m. Glass and paper sub-sectors were the most likely to be process innovators (57 per cent), chemicals and metals were least likely in the previous three years (48 per cent and 50 per cent respectively).

Figure 5.3.1 Foundation industry businesses introducing new innovations in the past three years percentage of respondents



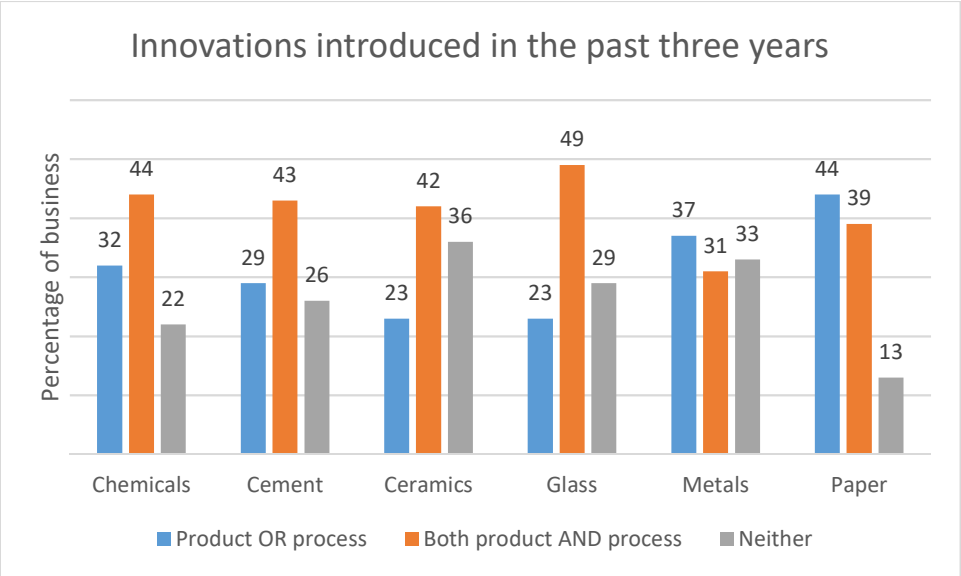
Our survey shows that foundation industries businesses are more likely to engage in both product/service and process innovation than just one form of innovation – two fifths (41 per cent) of businesses compared with just under a third (32 per cent) of businesses (see figure 5.3.2). Over a quarter (26 per cent) of businesses in our samples reported no innovation activity in the previous three years (we will return to the non-innovators later in this section).

Figure 5.3.2 New innovations introduced in the past three years percentage of respondents



Across all turnover categories except the smallest businesses, a higher proportion of respondents reported innovating across both new products and processes compared with those innovating across just one of those areas. For businesses with a turnover less than £1m, the proportion was evenly split (32 per cent). The extent of product and process innovations also varied by sector with metals and paper businesses more likely to engage in either product or process innovation, rather than both, as was the case in the other foundation industry sectors (as shown in figure 5.3.3).

Figure 5.3.3 New innovations introduced in the past three years by sector percentage of respondents



New to market or new to firm innovation?

Figure 5.3.4 shows that just over half (52 per cent) of new or improved product innovations were new to the market compared to those that were simply new to the firm. The proportion of foundation industry businesses reporting new to the market product innovations is somewhat higher than that reported by manufacturers and the wider business population in LSBS 2019 (41 per cent and 31 per cent respectively). There were differences by both sector and business size when looking at new to market versus new to firm product innovations. While the smallest firms were most likely to say their product/service innovations were new to the market (74 per cent) there is no clear trend amongst larger businesses (57 per cent of business with a turnover of £1m to £5m, 32 per cent of £5m to £15m and 56 per cent of business with a turnover more than £15m). The chemicals and glass sectors were the most likely to report new to market product innovations (71 per cent and 68 per cent respectively) compared with 31 per cent of metals and 40 per cent of ceramics businesses.

More than two-thirds of businesses (69 per cent) engaging in process innovation said this was new to their business but not new to the market (see figure 5.3.4). This was true of a majority of businesses in all turnover bands up to £15m, where approximately 70 per cent said their process innovations were all new to the business. For the largest businesses (over £15m turnover) new to the market and new to firm process innovations were equally split. Across all sub-sectors a trend towards more businesses engaged with new to business process innovation was also evident. A slightly higher proportion of chemicals and glass businesses reported new to market process innovations (42 per cent and 40 per cent).

Figure 5.3.4 New to market and new to firm innovations introduced in the past three years percentage of innovating businesses

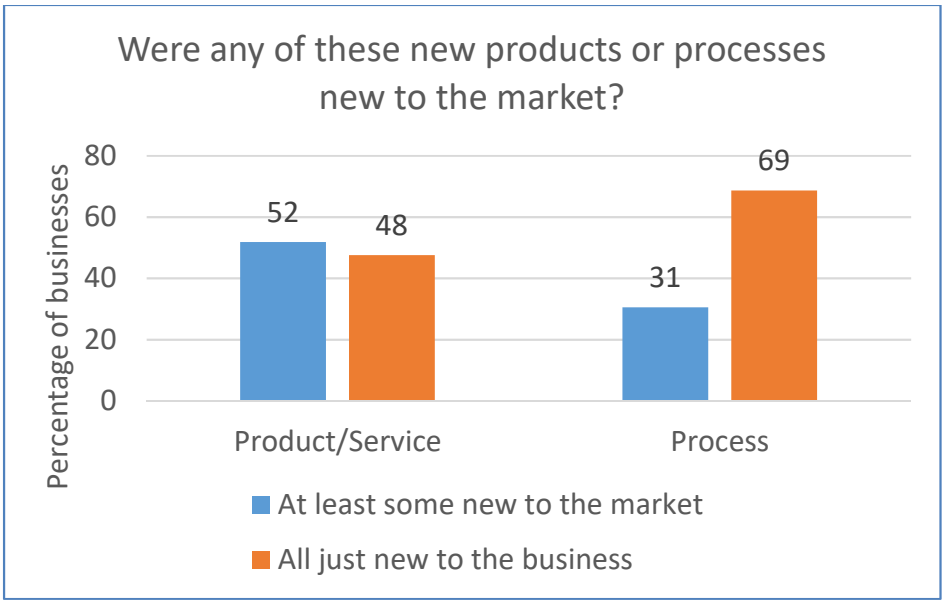
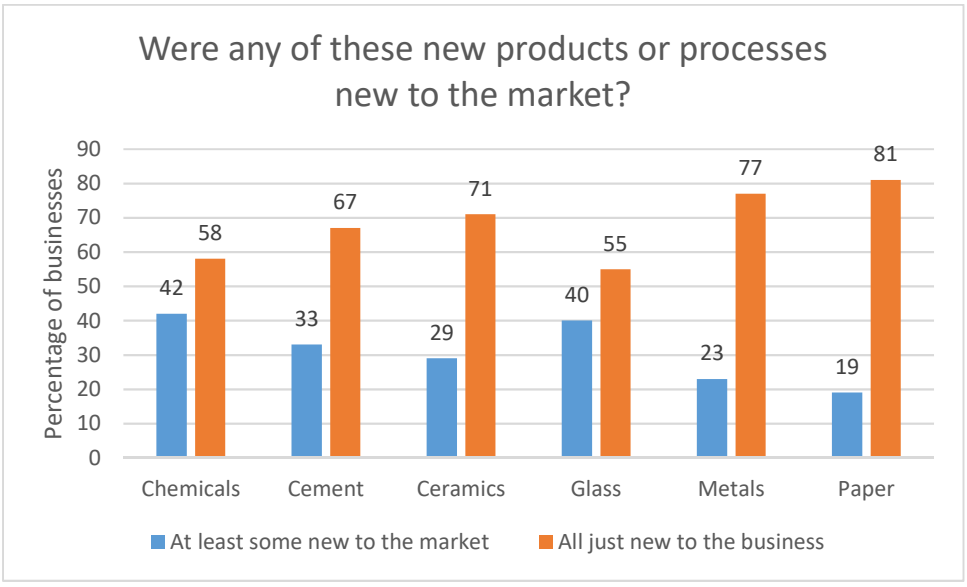


Figure 5.3.5 New to market and new to firm innovations introduced in the past three years by sector percentage of innovating businesses



Innovation drivers

Respondent businesses reported a wide range of factors as being important in influencing decisions to innovate (see figure 5.3.6). The most reported drivers amongst innovating businesses were increasing market share (29 per cent), improving quality (19 per cent), and maintaining or increasing competitive advantage (17 per cent). At the other end of the list, just six per cent of respondent businesses cited survival as the most important factor and five per cent cited reducing energy use as a driver of innovation.

There were some minor differences in the motivations to innovate across different business size bands. For example, foundation industry businesses with a turnover of more than £15m were less likely (16 per cent) to cite increasing sales/market share as a major driver of their innovation efforts compared with their smaller counterparts (31 per cent of businesses with a turnover of £1m to £5m and 38 per cent of £5m to £15m turnover businesses). The smallest businesses (up to £1m turnover) were more likely to innovate to improve the quality of their products or services (29 per cent). This group was also more likely to cite survival reasons as a motivation to innovate (14 per cent compared with seven per cent of the largest businesses in the sample). In contrast, large businesses were more likely to cite ambition to increase their competitive advantage as an innovation driver (36 per cent).

As shown in table 5.3.1, motivations to innovate vary somewhat by sector. For example, both increasing market share and improving the quality of goods and services were most frequently reported by innovating businesses in the glass sector. Reducing environmental impacts was cited by a relatively small proportion of innovating businesses; 13 per cent in the glass sector and below ten per cent in each of the other foundation industry sectors. NB some cell sizes in this table are very small.

Figure 5.3.6 Factors important to the decision to innovate percentage of respondents that undertook innovation

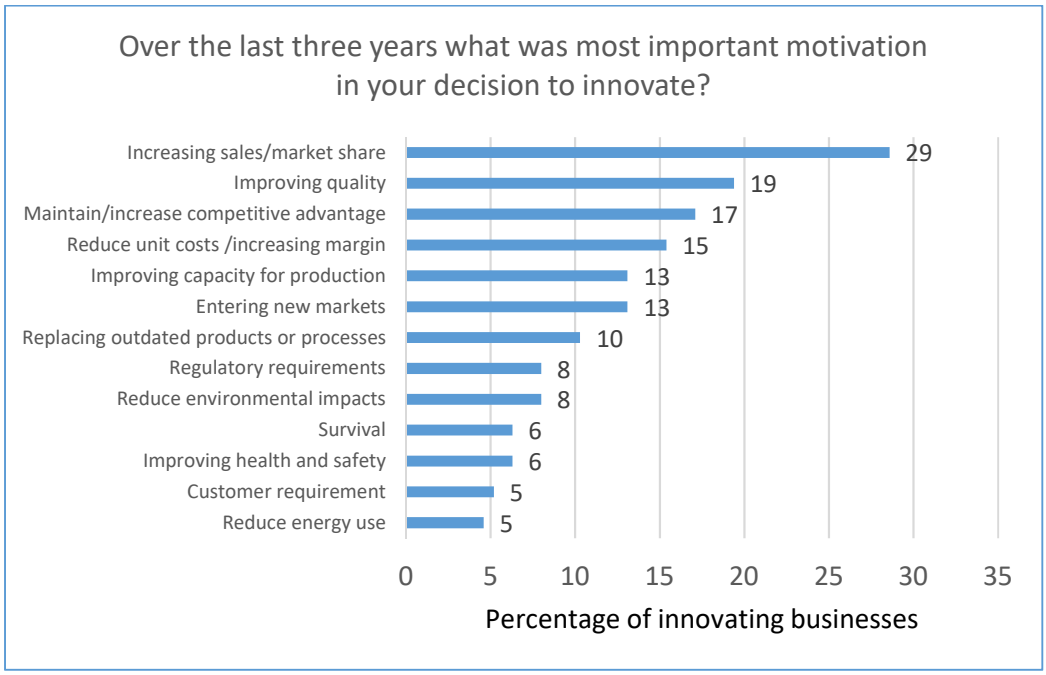


Table 5.3.1 Factors important to the decision to innovate by sector percentage of respondents that undertook innovation

	Chemicals	Cement	Ceramics	Glass	Metals	Paper
Entering new markets	11	13	25	13	14	8
Increasing sales/market share	27	22	35	44	29	22
Improving quality of goods/services	16	22	15	39	11	19
Improving production capacity	14	4	25	17	14	8
Reducing costs /increasing margin	8	13	20	22	6	27
Improving health and safety	5	4	10	13	6	3
Reducing environmental impacts	8	9	15	13	3	5
Replacing products or	11	22	10	13	6	5
Reducing energy use	5	4	5	13	0	3
Meeting regulatory	16	9	5	17	3	0
Customer requirement	8	0	5	9	9	0
Maintain/increase comp. advantage	24	17	0	13	20	19
Survival	8	0	10	4	6	8

Figure 5.3.7 Factors important to the decision to innovate percentage of respondents that undertook innovation

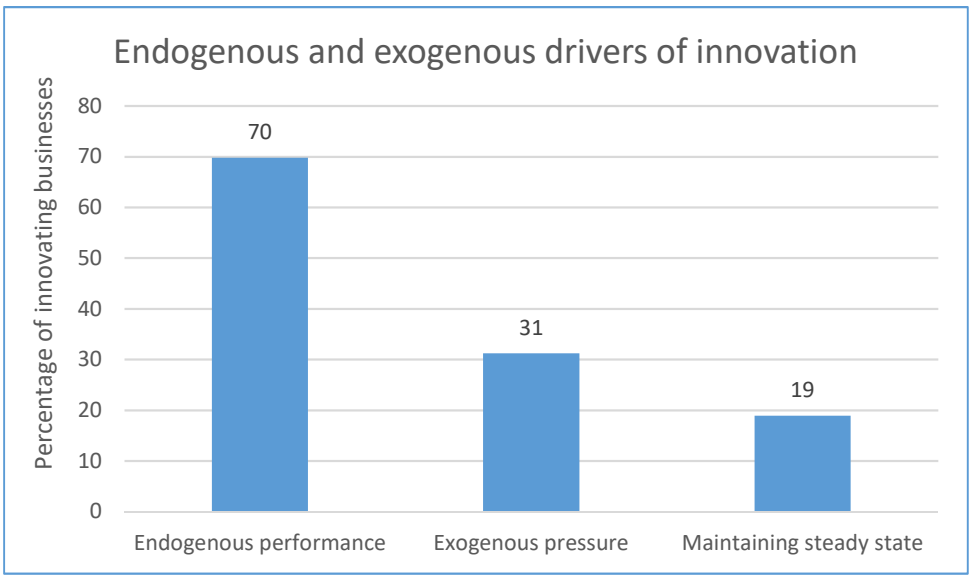


Figure 5.3.8 Factors important to the decision to innovate by firm size percentage of respondents that undertook innovation

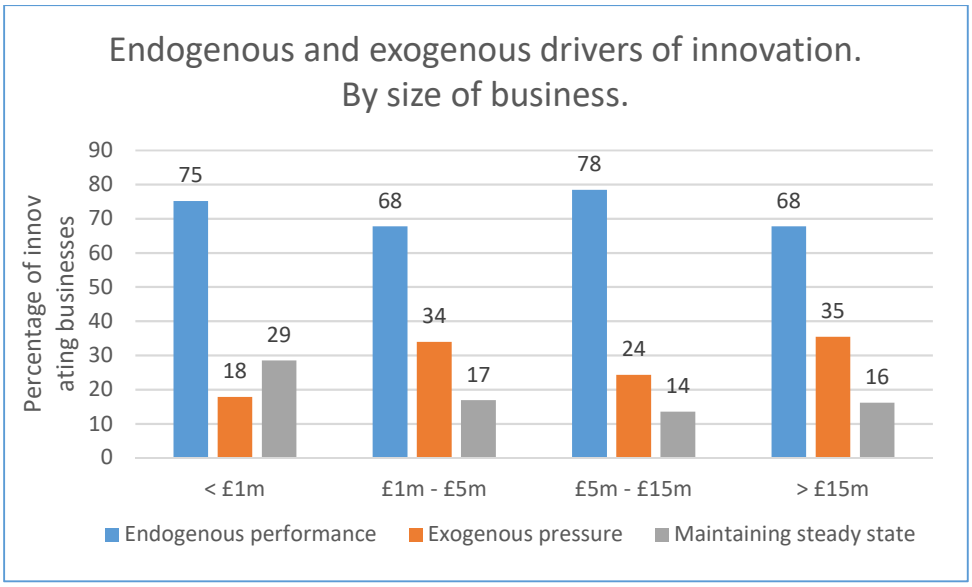
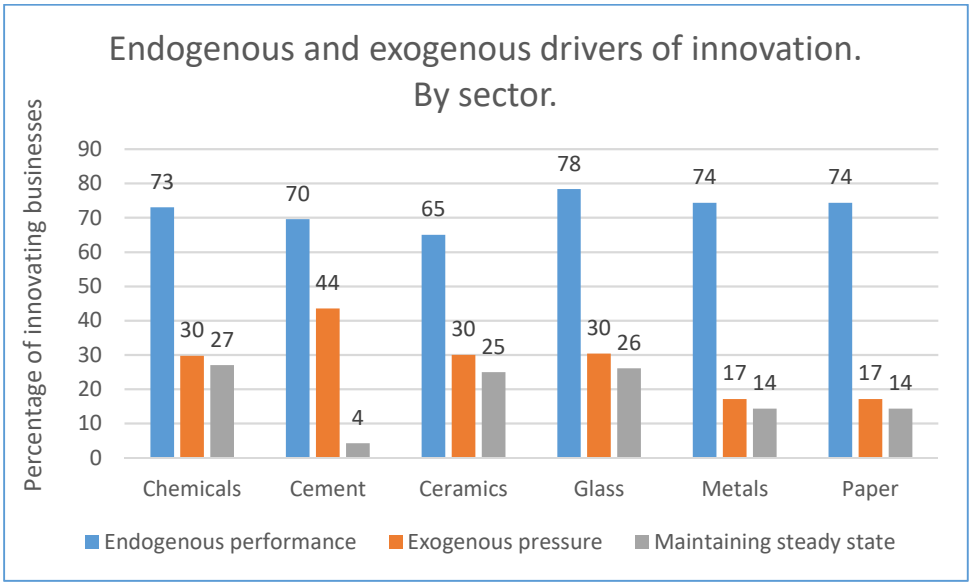


Figure 5.3.9 Factors important to the decision to innovate by sector percentage of respondents that undertook innovation



In figures 5.3.7, 5.3.8 and 5.3.9, the reported drivers of innovation are conflated into three broad categories: endogenous which includes factors internal to the business such as seeking improved performance, exogenous which encompasses pressures arising outside the business such as competition or demands from customers. The third category, termed steady state, consists of those businesses who were primarily concerned simply to maintain their current situation.

Endogenous pressures (70 per cent of innovating businesses) is clearly the most common reported set of drivers amongst foundation industry businesses. Less than a third (31 per cent of innovating businesses) report exogenous pressures as the key divers of innovation. Almost one in five foundation industry businesses (19 per cent) are primarily motivated to innovate in order to maintain their current situation.

The data described in figure 5.3.8 shows that there is little variation in these categories by business size. While there is little variation in the proportions of businesses reporting endogenous drivers of innovation by sector, exogenous pressures are most prevalent in the cement sector. Businesses in the cement, paper and metals sectors are the least likely to be innovating simply to maintain the status quo.

Energy Costs as an Innovation Driver

The UK's foundation industries are generally energy-intensive and they face regulatory, cost and other pressures to reduce carbon emissions; not the least of which is the commitment to achieving net-zero impacts by 2050.

A comparison of businesses based on size suggests that energy use/cost reduction is not generally considered to be an important driver for innovation - less than one-tenth of businesses across the size band categories indicated that they were motivated to innovate to reduce energy use/costs. For example, only seven per cent and five per cent of businesses in the up to £1m and £1m to £5m size bands were motivated to innovate for energy use/cost reduction, while only three per cent of businesses in the £5m to £15m and over £15m were motivated to do the same.

Sector differences were relatively small. Across the foundation industry sectors, the glass sector had the highest percentage of businesses motivated to innovate for energy use/cost reduction at 13 per cent while no companies in the metals sector reported this as a reason for their innovation activity.

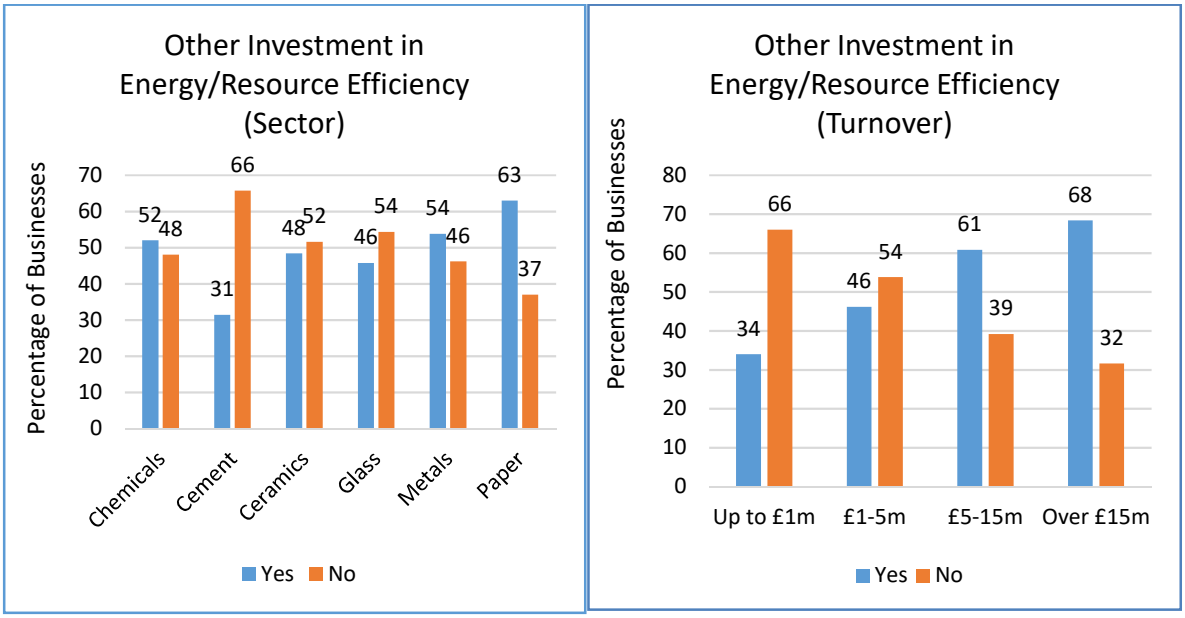
Investment in new energy efficient technologies

Across the foundation industries, half of businesses invested in new technologies to improve energy/resource efficiency over the last three years. The percentage of businesses with up to £1m, and £1m to £5m turnover that did so were 34 per cent and 46 per cent respectively. In contrast to small businesses, larger businesses (those with a turnover of over £5m) were more likely to invest in new technologies to improve energy efficiency - approximately three-fifths of such businesses did so in the last three years - more than 60 per cent of businesses in the £5m to £15m (61 per cent) and 68 per cent the over £15m size categories invested for this purpose (see figure 5.3.11).

Sectoral comparisons suggests that the paper sector had the highest percentage of businesses (more than two-fifths) investing in new technologies to improve energy/resource efficiency in the last three years (see figure 5.3.10). The cement sector was the sector with the lowest percentage of businesses (66 per cent) investing in such efficiency. In other sectors,

52 per cent, 48 per cent, 46 per cent, and 54 per cent of businesses invested in energy efficiency technologies in the chemicals, ceramics, glass, and metals sectors respectively.

Figures 5.3.10 and 5.3.11 Investment undertaken in support of energy/resource efficiency percentage of respondents



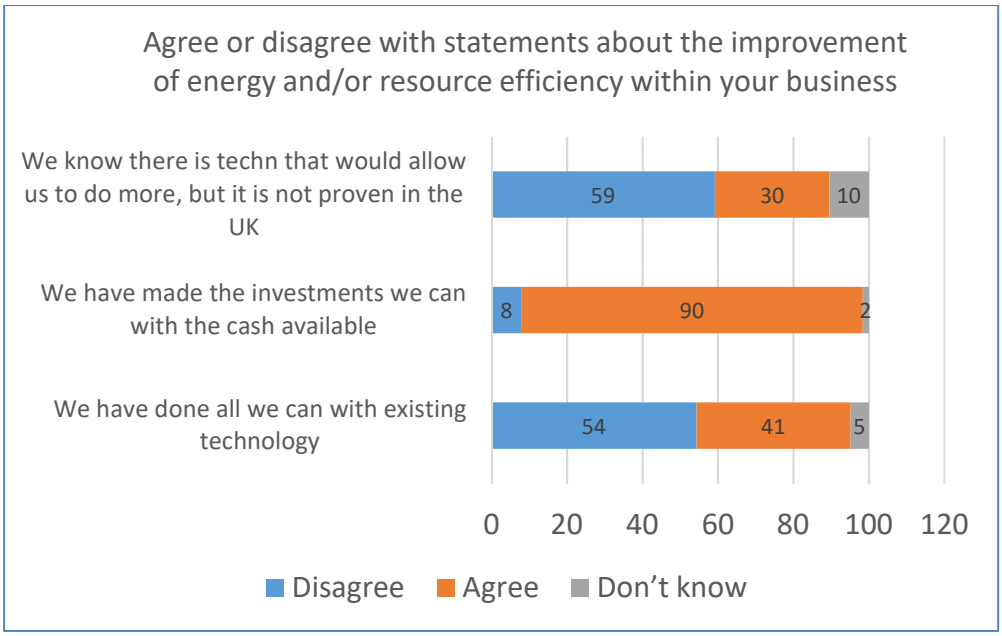
Possibilities for future energy efficient investment

Some of the investments necessary to reduce energy use and improve resource efficiency in these industries are of a scale that is beyond the resources of many businesses. Our survey sought to identify not only what investment had been undertaken in recent years, but also to understand attitudes to future investment.

Available funds as a constraint - A large majority (90 per cent of all businesses surveyed) reported that they had made all investment possible in energy/resource efficiency with the funds they had available. There was little variation in this view across different sizes.

All ceramics and cement respondents agreed that they had made all the investment they could with the cash available. The proportion of businesses in chemicals and glass businesses agreeing was slightly lower at (81 per cent in both sectors), but there was nevertheless a substantial majority indicating that cash constraints were a constraint to future energy/resource efficiency investments.

Figure 5.3.12 Businesses agreeing with statements on energy/resource efficiency
percentage of respondents

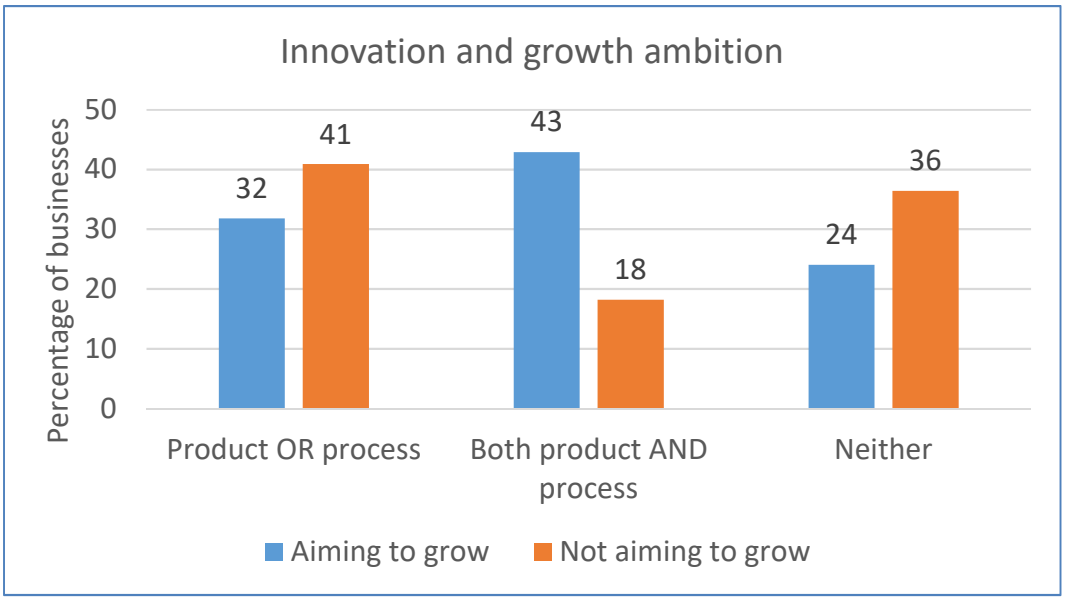


Limits of existing technologies as a constraint - Views were more mixed on whether businesses had achieved all they could with existing technology or if there were other, unproven, technologies that could help them to achieve greater energy and resource efficiency gains. Looking first at the extent to which businesses agree they have done all they can with existing technology. Across the whole sample just over two-fifths agreed with this statement (41 per cent). The smallest companies (up to £1m turnover) were most likely to agree – 53 per cent, although almost a fifth (18 per cent) of this group were unsure. A majority of businesses across all other turnover band disagreed that they had secured all the energy efficiency gains they could with existing technology. Across sectors, only a majority of businesses in ceramics agreed (52 per cent) they had achieved all they could with the technology available, but a fifth were unsure.

Limits to proven technologies as a constraint - Fewer than one in three businesses (30 per cent) agreed that there was technology that could help them improve resource efficiency, but it was unproven in the UK. Whereas one in ten did not know if this was the case or not. Therefore, a majority of foundation industry businesses see their efforts to improve energy and resource efficiency constrained by the availability of proven technologies. There was a degree of variation of views on this statement across business size and sector. Ceramics businesses were more likely to agree that there was unproven technology which may support resource efficiency efforts, in contrast businesses in the metals sector were more likely to disagree.

Innovation and ambition

Figure 5.3.13 New innovations introduced in the past three years by companies with and without ambitions to grow percentage of respondents



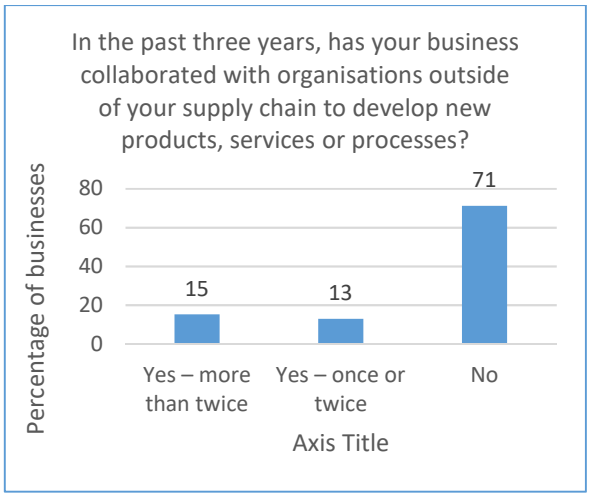
In line with evidence in the academic literature, our survey points to an association between levels of ambition in foundation industry business and innovation activity. Businesses that declared an ambition to increase future sales were more likely, by over two to one, to have engaged in a combination of product and process innovation over the previous three years. In contrast, businesses that lacked a growth ambition were more likely to have undertaken no innovation activity in the previous three-year period. While sample sizes for turnover bands and sectors are small, this relationship between ambition and innovation holds across both business size and sub-sector, but is notably weaker for businesses with turnover under £1m.

5.4 What does innovation involve?

Collaboration

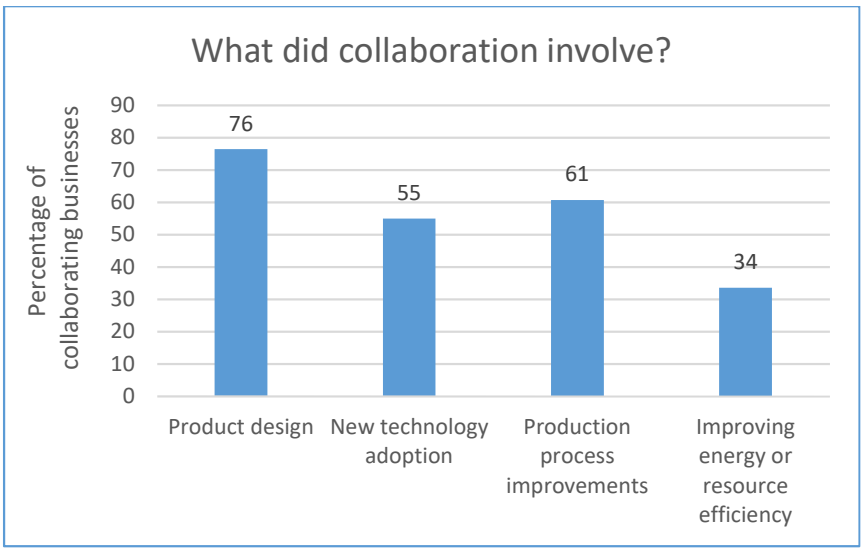
Collaboration is widely accepted to be an important driver and enabler of innovation. Over the past three years, half of foundation industry businesses (51 per cent) had collaborated on innovation with other businesses in their supply chain (see figure 5.4.1). Far fewer had collaborated with organisations outside the supply chain (see figure 5.4.2). Product design was the main reason for collaboration.

Figures 5.4.1 and 5.4.2 Innovation collaboration by foundation industry businesses per cent of respondents that undertook innovation



Larger businesses were more likely to collaborate within their supply chain than smaller ones – 40 per cent of those with turnover <£1m, 66 per cent with turnover >£15m. Businesses in the cement sector were the least likely to collaborate. As shown in figure 5.4.3, collaboration was most commonly concerned with product design, new technology and production process achievements.

Figure 5.4.3 Types of innovation collaboration per cent of respondents that undertook innovation



Access to finance

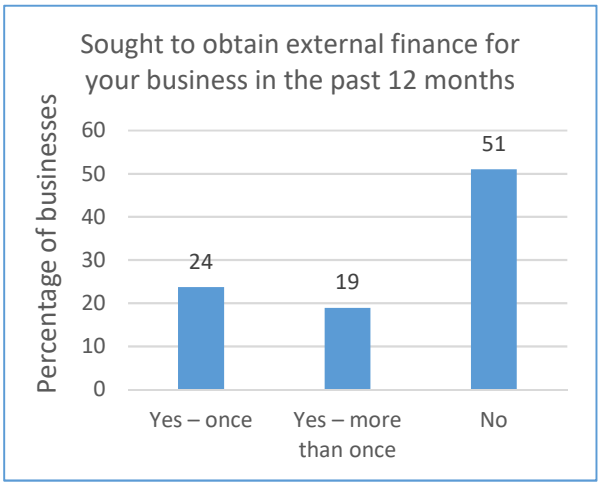
Less than a half (43 per cent) of foundation industry businesses had sought external finance during the previous year. Businesses with turnover between £1m and £5m were most likely to have sought external finance. Those with turnover between £5m and £15m were most likely to have sought funds to finance innovation. Businesses in the chemicals sector were the least likely to have sought external finance but were most likely to invest the finance received in innovation (see figures 5.4.6 and 5.4.7).

The demand for finance is markedly higher in foundation industry businesses than that in the economy as a whole. LSBS (2019) data shows that 15 per cent of all small business and 19 per cent of all medium-sized businesses had sought finance over the previous year.

Most of the foundation industry businesses that sought finance (84 per cent) were successful in securing all or at least some of the finance sought (see figure 5.4.5). This is similar to the proportion of population of SME employers (78 per cent) that were successful in securing all or some of the finance they sought in LSBS 2019.

Just over one-third (36 per cent) of foundation industry businesses used the finance they obtained to finance innovation (see figure 5.4.5). This proportion is somewhat higher than that reported for the overall population of SME employers in LSBS 2019 which showed that 17 per cent funded new or significantly improved goods or services and 11 per cent invested the funds obtained in new or significantly improved processes.

Figures 5.4.4 and 5.4.5 Foundation industry businesses seeking finance and outcome
percentage of respondents



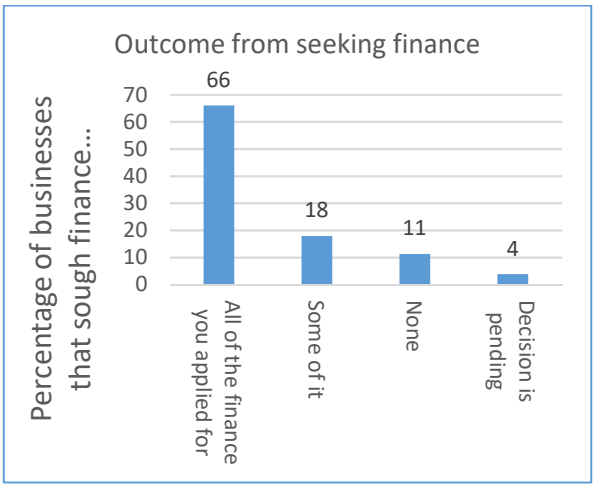


Figure 5.4.6 Foundation industry businesses seeking finance by size percentage of respondents

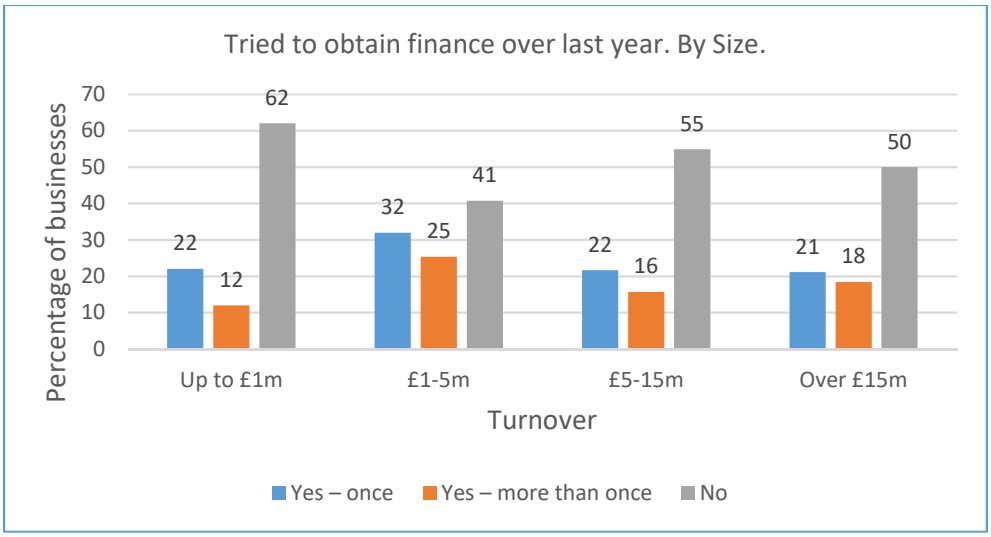
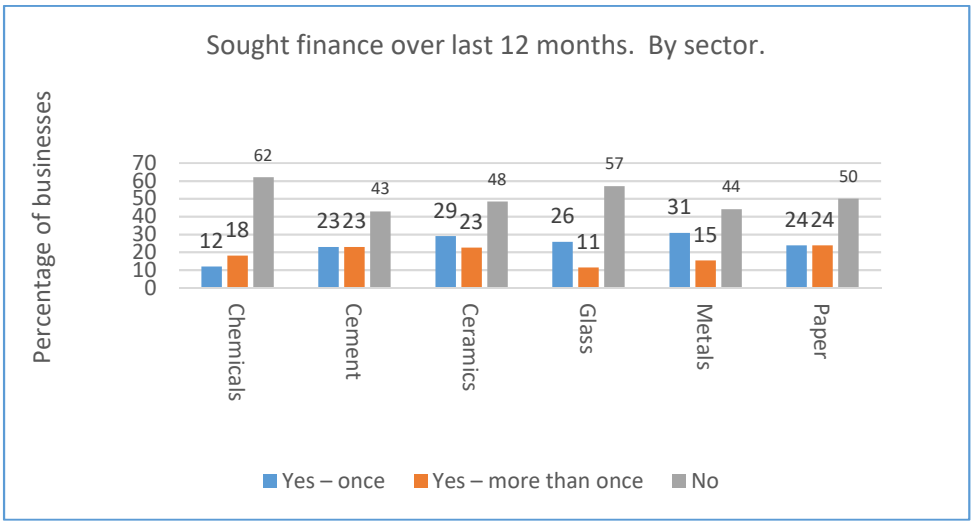


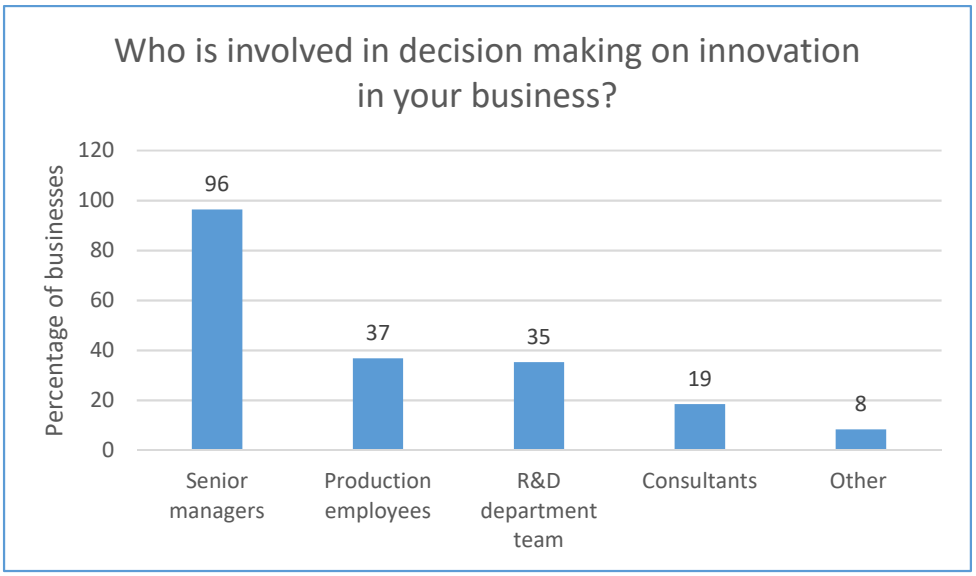
Figure 5.4.7 Foundation industry businesses seeking finance by sector percentage of respondents



Decision making

Senior managers are involved in almost all decisions about innovation in foundation industry businesses. However, production employees are involved in such decisions in only a little over one third (37 per cent) of these businesses (see figure 5.4.8).

Figure 5.4.8 Involvement in innovation decision making percentage of respondents that understood innovation



Innovation strategy

Board level discussion of innovation strategy takes place at least annually in just 56 per cent of foundation industry businesses (43 per cent quarterly and 13 annually). In over one third (35 per cent) of businesses, it occurs less frequently. There are no such discussions in one in twenty businesses (see figure 5.4.9). Businesses with turnover greater than £5m were more likely to have regular board level discussion than smaller ones (see figure 5.4.10), The proportion of businesses with less regular discussions is markedly higher in the cement sector (51 per cent) than elsewhere in the foundation industries (see figure 5.4.11).

Figure 5.4.9 Frequency of board-level discussions on innovation percentage of respondents that undertook innovation

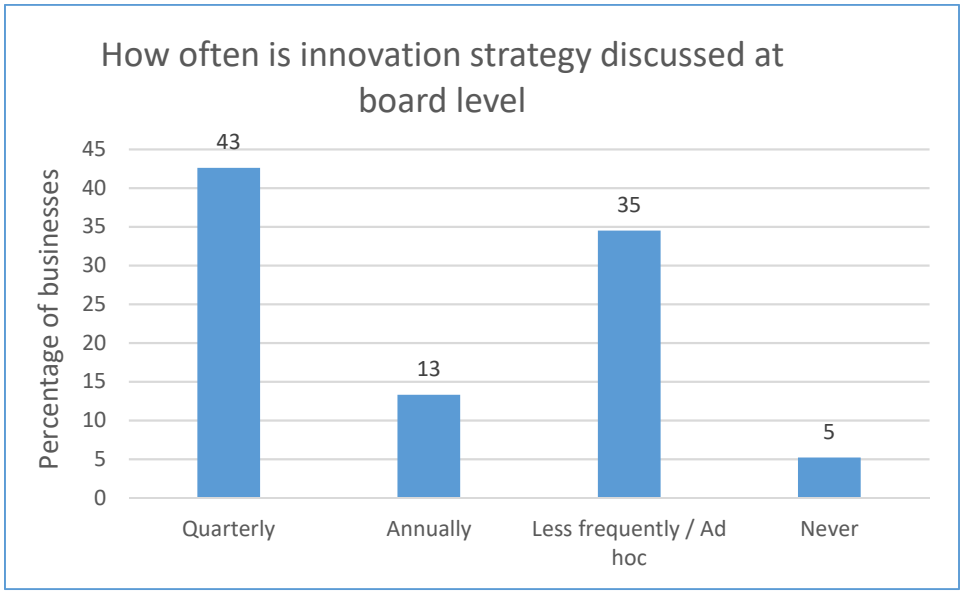


Figure 5.4.10 Frequency of board-level discussions on innovation by size percentage of respondents that undertook innovation

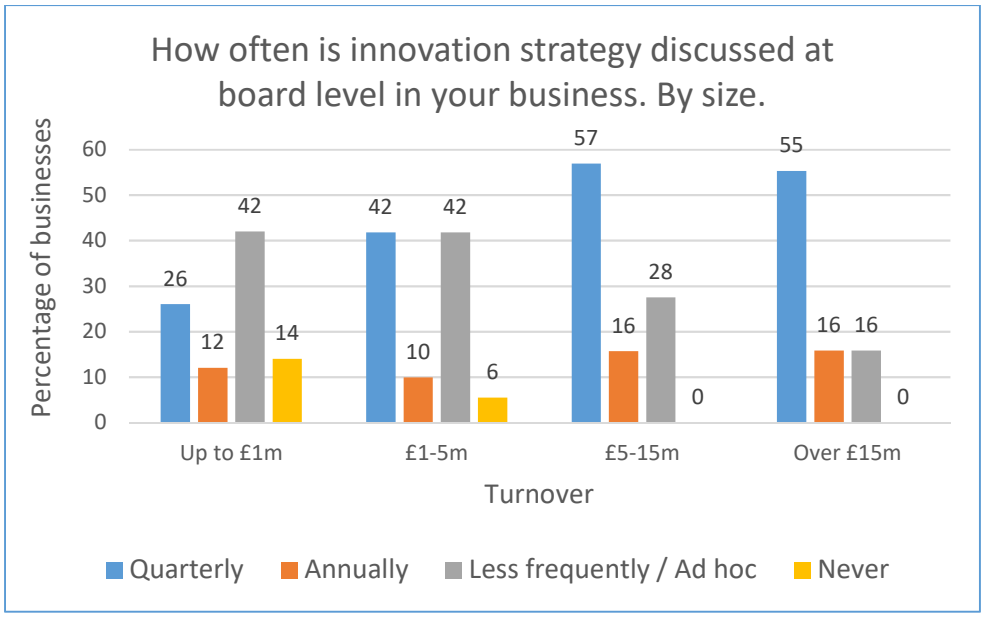
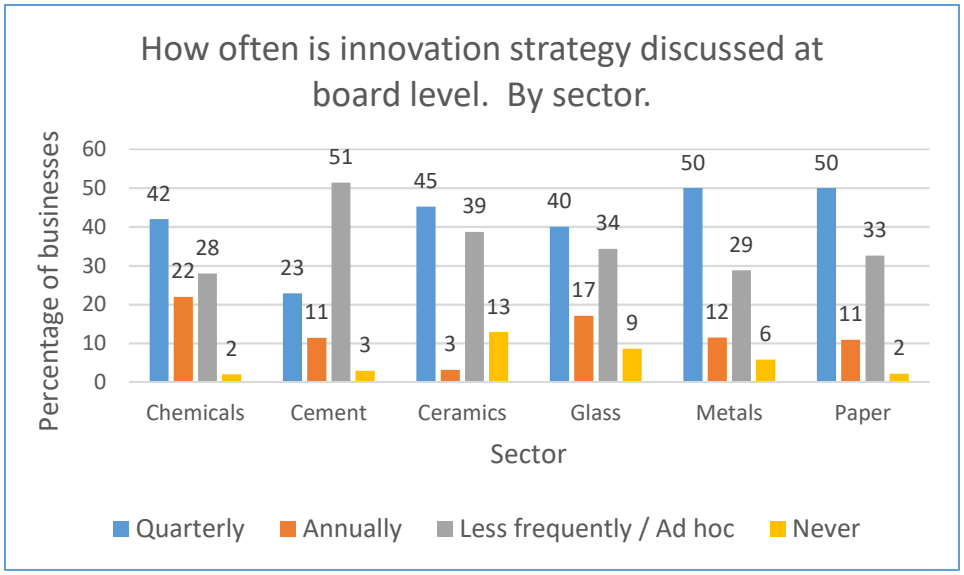


Figure 5.4.11 Frequency of board-level discussions on innovation by sector percentage of respondents that undertook innovation



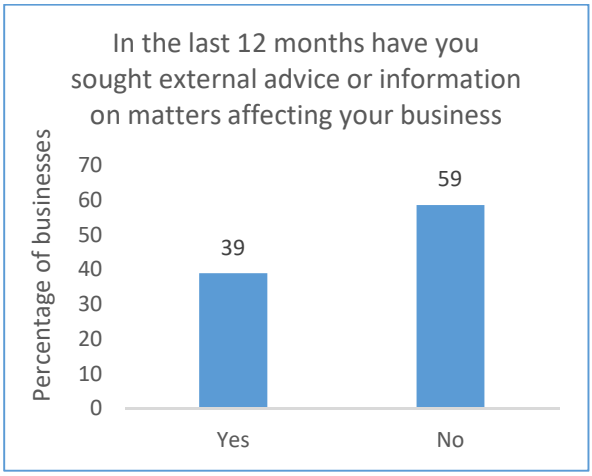
Business support

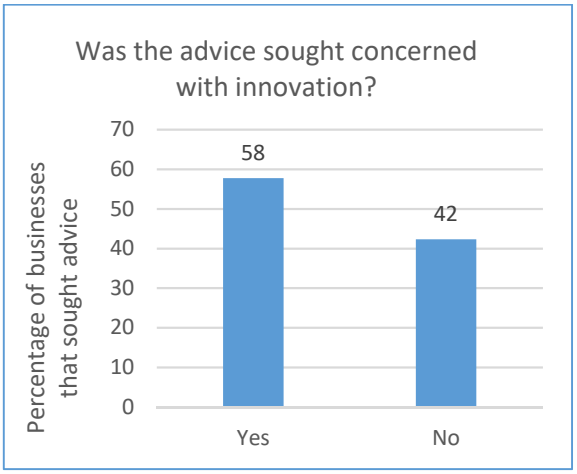
Just 39 per cent of foundation industry businesses sought external information or advice on matters affecting the business over the previous year. Larger businesses were most likely to seek advice (26 per cent with turnover up to £1m, 53 per cent of businesses with turnover over £15m) (see figures 5.4.12, 5.4.14 and 5.4.15).

These proportions are somewhat higher than those in the proportion in the UK business population as a whole. LSBS (2019) data shows that 24 per cent of SME employers reported seeking external information or advice in the preceding 12 months. Larger SMEs were more

likely to have sought external information or advice, 36 per cent of medium sized businesses sought it, compared with 29 per cent of small businesses.

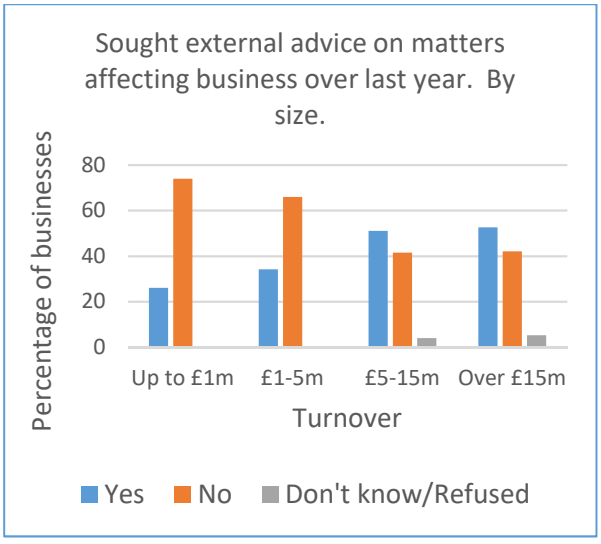
Figures 5.4.12 and 5.4.13 External advice sought and advice sought in support of innovation percentage of respondents





In just over half (58 per cent) of the foundation industry businesses that sought advice, the advice sought was concerned with innovation (see figure 5.4.15). A majority of the foundation industry businesses seeking advice on innovation reported positive outcomes (see figure 5.4.16).

Figures 5.4.14 and 5.4.15 External advice sought in the past 12 months by size and sector percentage of respondents



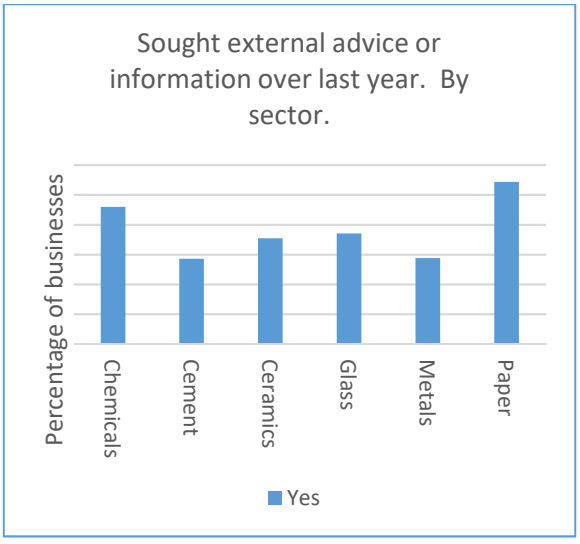
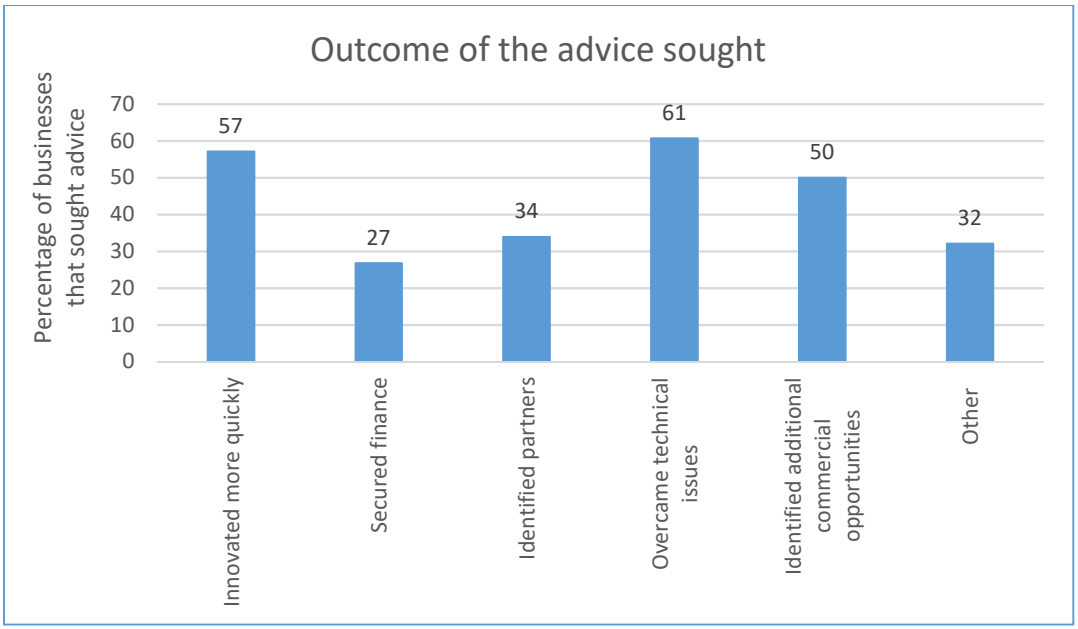


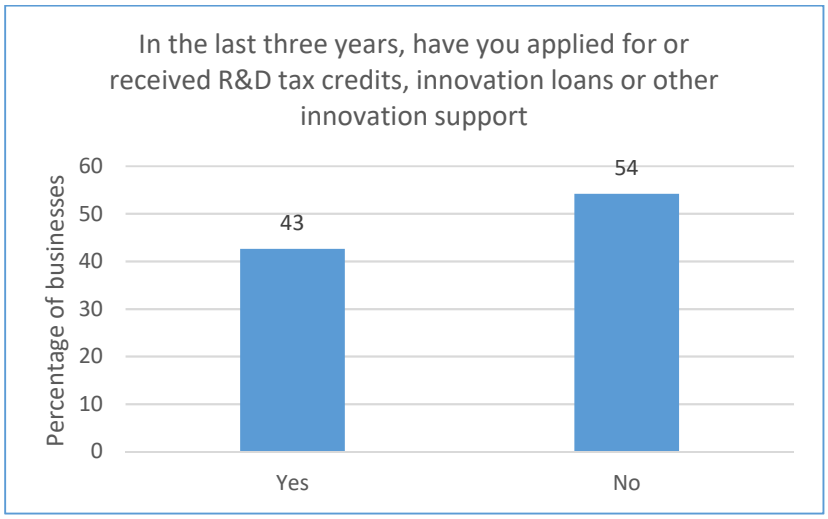
Figure 5.4.16 Outcome of advice sought relating to innovation percentage of businesses using innovation support



R&D tax credits, innovation loans or other innovation support

Over the last three years, 43 per cent of foundation industry businesses had applied for or received R&D tax credits, innovation loans or other forms of innovation support (see figure 5.4.17). This compares with just six per cent of businesses in the economy as whole (20 per cent of medium-sized businesses and 13 per cent of small businesses. One in five (20 per cent) of manufacturing sector businesses reported having sought or received such support (LSBS 2019).

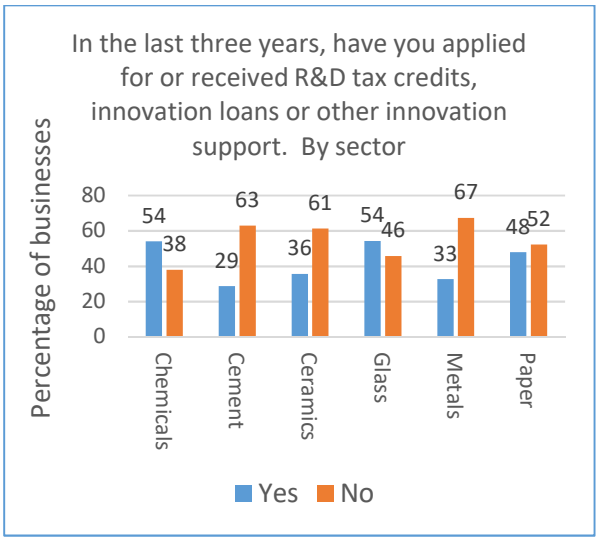
Figure 5.4.17 Use of R&D tax credit and other innovation loans percentage of respondents

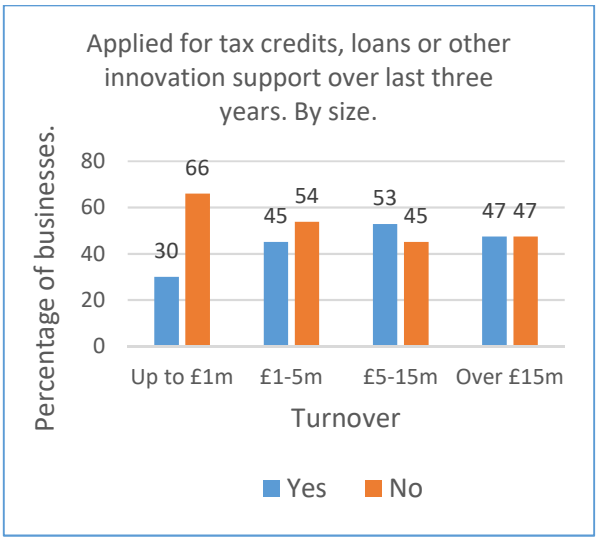


There is variation in the uptake of innovation support within the foundation industries by both size and sector. By size, 47 per cent of foundation industry businesses with a turnover >£15m had sought or accessed such support compared with just 30 per cent of businesses with a

turnover <£1m. (see figure 5.4.19). By sector chemicals (54 per cent) and glass (54 per cent) are the most to have sought or received innovation support. This compares with just 29 per cent of businesses in the cement sector (see figure 5.4.18).

Figures 5.4.18 and 5.4.19 Use of &D tax credits and other innovation loans by sector and size percentage of respondents





5.5 The role of representative bodies and trade organisations

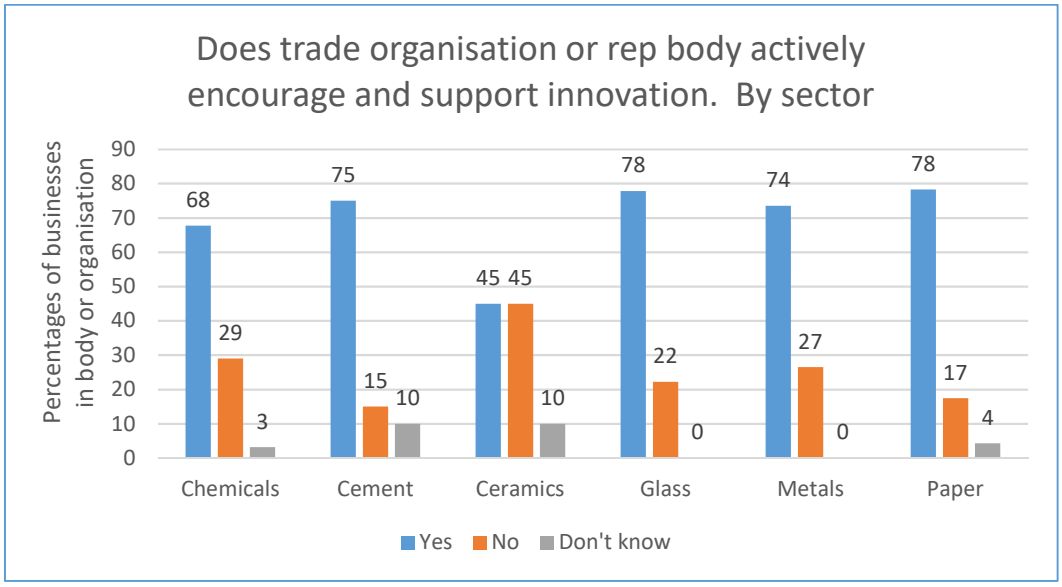
More than half (59 per cent) of the UK's foundation industry businesses are members of a representative body or trade organisation (see figure 5.5.1).

Larger businesses were most likely to be members of such bodies (76 per cent with turnover over £15m, 46 per cent with turnover less than 1m). There is little variation in membership levels between sectors.

In more than two thirds of cases (70 per cent) members report that their organisation does actively encourage and support innovation within the sector (see figure 5.5.2). However, more than a quarter (26 per cent of members) report that this does not occur. There is also variation between sectors. Businesses in the ceramics sector were markedly less likely to report active encouragement and support - 45 per cent compared with 70 per cent overall (see figure 5.5.2).

Figures 5.5.1 and 5.5.2 Membership of trade associations and perception of encouragement of innovation percentage of respondents

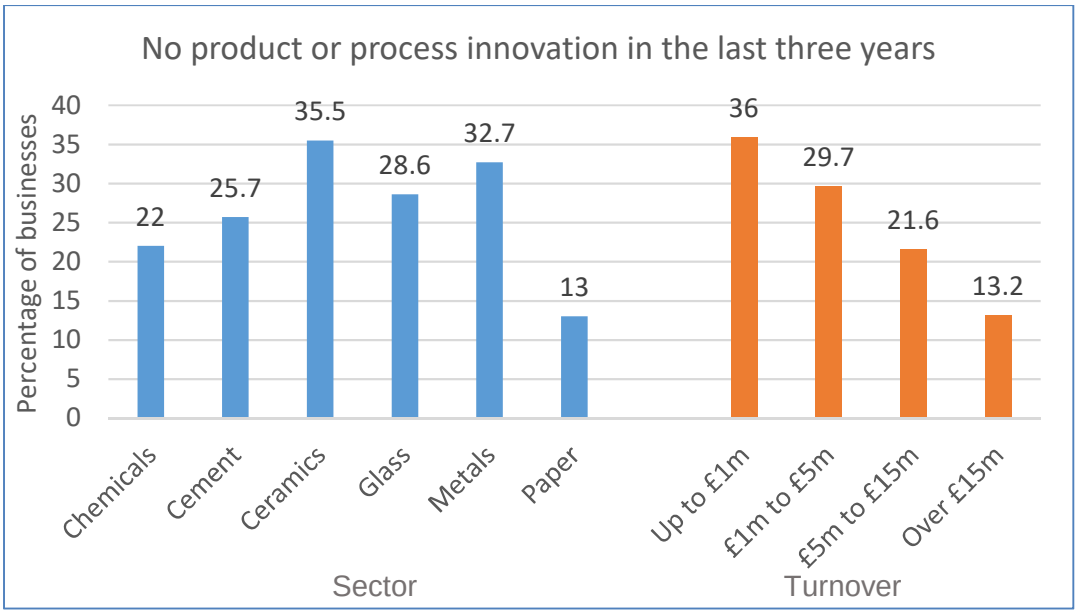
Figure 5.5.3 Perception of trade association encouragement of innovation by sector percentage of respondents that are members of a trade association



5.6 Non-Innovating foundation industries businesses

More than a quarter (26 per cent) of foundation industries businesses in our survey engaged in no innovation activity in the past three years. As discussed earlier, the proportion of innovation-inactive business declines as business size increases. There is also some sector variation. Businesses in ceramics and metals are most likely to report not undertaking any innovation in the previous three years, 36 per cent and 33 per cent respectively. However, it is worth noting that the ceramics sector has a relative high share of businesses with less than £5m turnover in our sample.

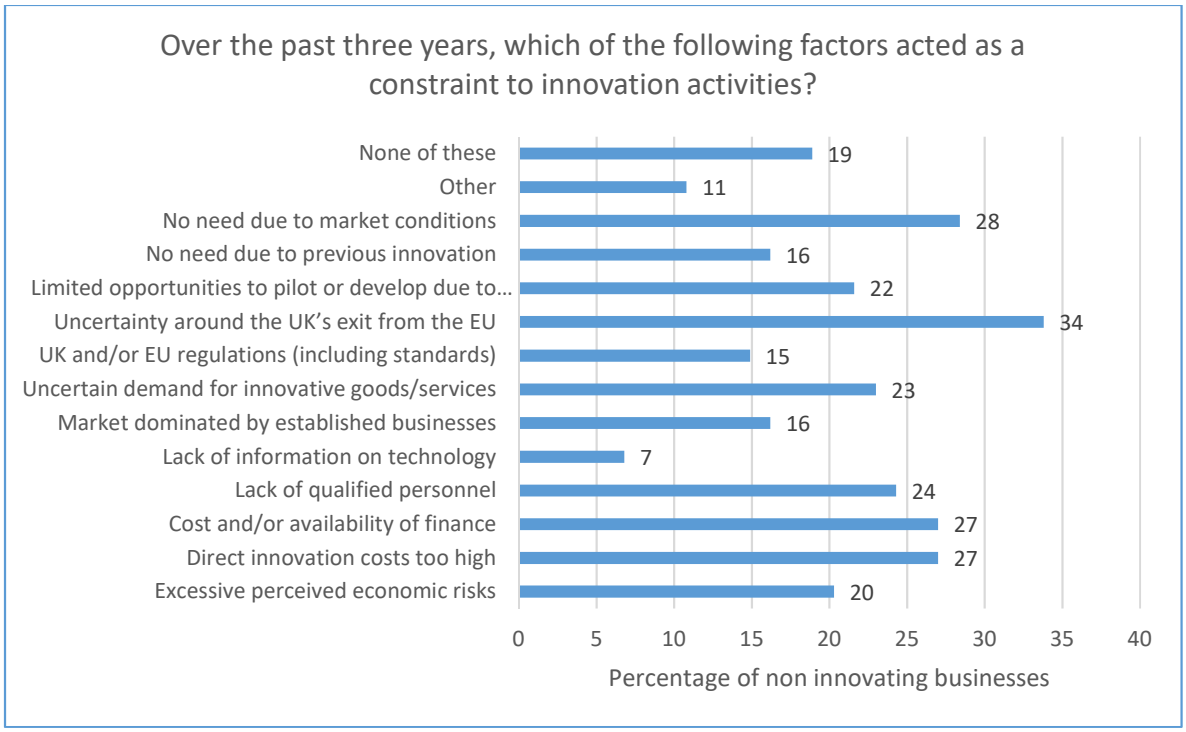
Figure 5.6.1 Foundation industry businesses engaging in no innovation in the past three years percentage of respondents by sector and size



Non-innovating foundation industry businesses reported a wide range of factors acting as constraints to innovation (see figure 5.6.1). As these data relate to just non innovating businesses, percentages reported are lowest in those sectors where innovation is most common, for example in the chemicals sector. That said, the most prevalent reported factors were: costs too high (15 per cent of non-innovating businesses) and perceived economic risks (13 per cent). By sector, innovation costs are most frequently cited by businesses in the ceramics and paper sectors, IT and technical issues with production processes are high in the glass sector which likely a function of the uninterruptible processes used in these sectors. Brexit related issues are most commonly cited in the ceramics, glass and paper industries. There are also some variations by business size. Larger firms cite the widest range of factors including Brexit, access to capital, the dominant role of established businesses and a lack of need due to previous innovation.

Figure 5.6.2 shows the factors that respondents considered to be constraining innovation efforts. Prominent innovation barriers are a lack of perceived need to innovate, risks associated with the UK's exit from the European Union and the cost of innovation. In addition, when asked which of these were the most important barriers, businesses cited innovation costs and the perceived risks of innovation (15 and 13 per cent of non-innovating businesses respectively).

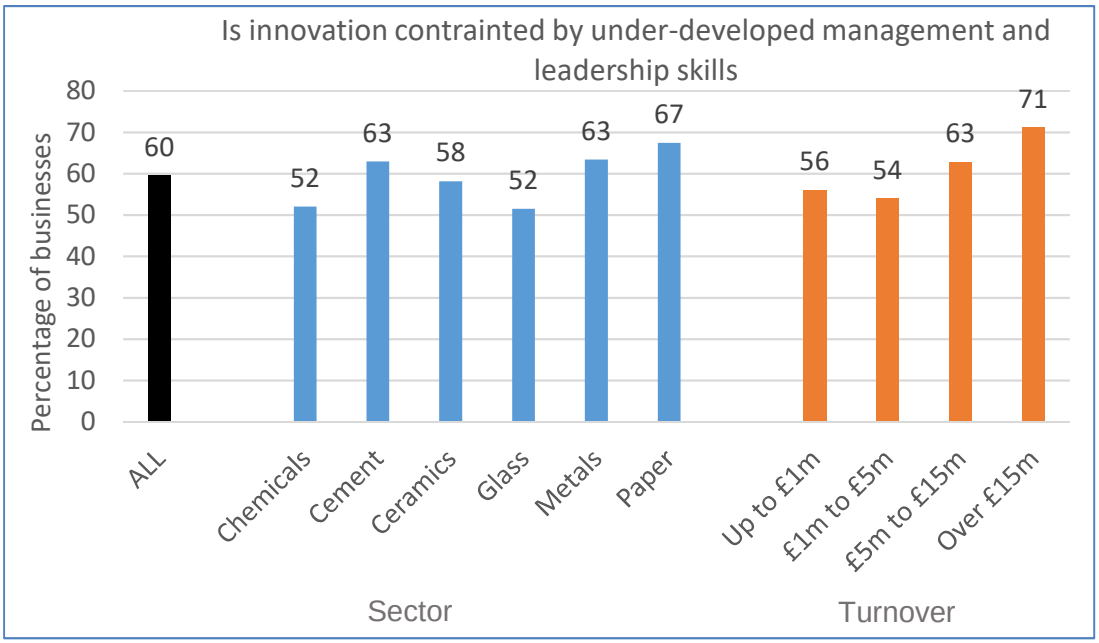
Figure 5.6.2 Identified constraints to undertaking innovation per cent of respondents undertaking no innovation



Management capability and innovation

Our survey shows a widespread perception that under-developed management and leadership skills in foundation industry businesses act as a constraint on innovation activity. Overall, three-fifths of businesses surveyed said that innovation in their industry is sometimes of frequently constrained by poorly developed management and leadership skills. This majority view is held across all foundation industry sectors and businesses size bands. Larger companies, with a turnover of more that £5m were more likely to agree with the statement, than smaller ones. And by sector, there was a large majority in agreement in the paper, metals and cement sectors.

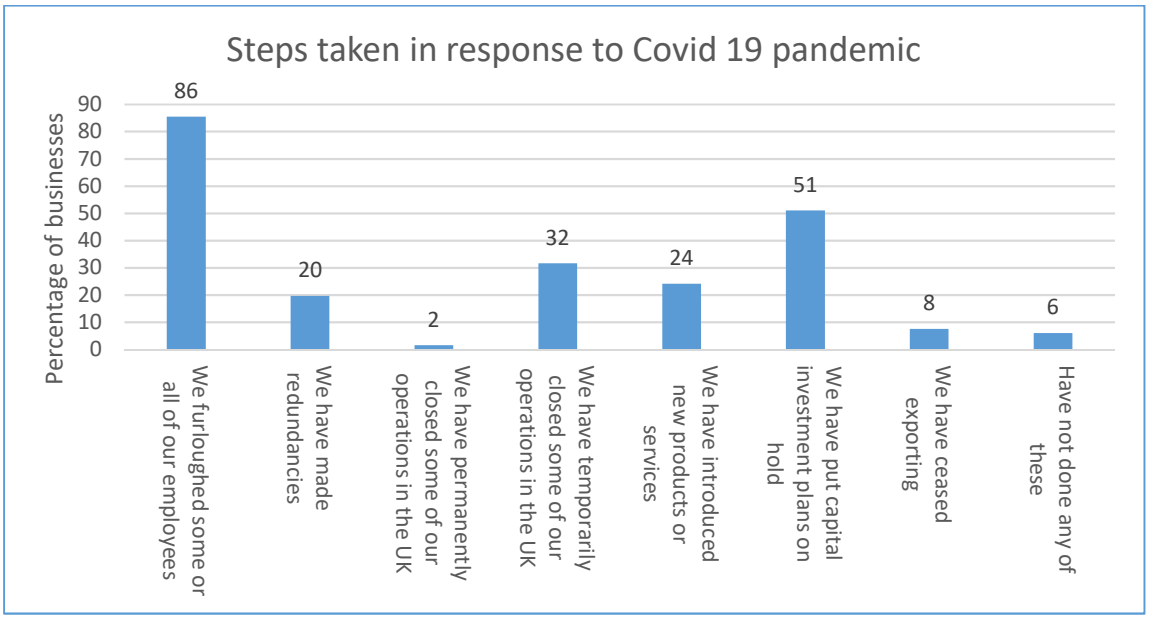
Figure 5.6.3 Perception of the contribution of under-developed management skills to innovation in foundation industry businesses percentage of respondents by sector and size



5.7 Impacts of the Covid pandemic on innovation in the foundation industries

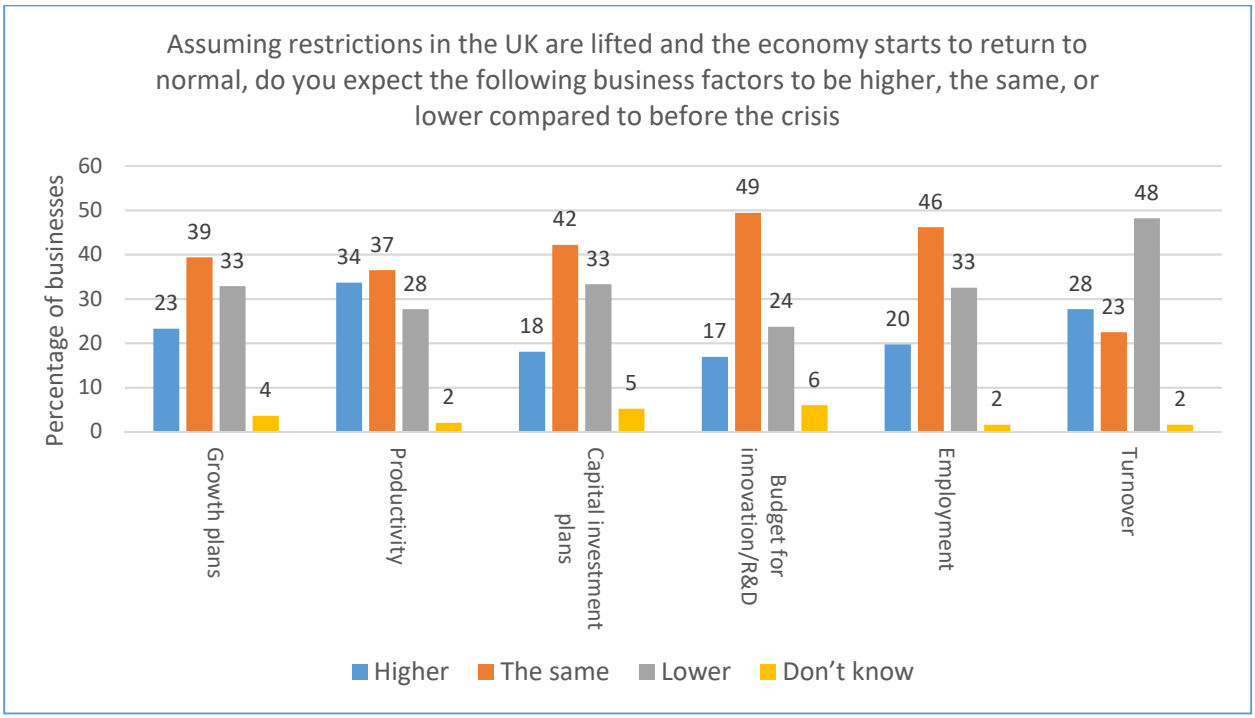
The most common responses to the pandemic have been to furlough some or all of the businesses' employees (86 per cent of businesses) and to put investment plans on hold (51 per cent of businesses). However, at the time of the survey, just two per cent of businesses had permanently closed some or all of their operations in the UK (see figure 5.7.1).

Figure 5.7.1 Actions taken in response the Covid-19 pandemic percentage of respondents



Survey respondents were asked 'assuming restrictions in the UK are lifted and the economy starts to return to normal', what changes they expect in key business metrics (see figure 5.7.2). Between a quarter and a half of foundation industry businesses across all size and sector bands expect marked reductions in turnover, employment, investment and R&D budgets post pandemic. Almost half of businesses (48 per cent) expect their turnover to be lower and a third (33 per cent) anticipate lower employment. A third of businesses (33 per cent) expect to have lowered plans for growth. One in four businesses (24 per cent) expect to have a lower innovation budget. However, a third of foundation industry businesses anticipate improvements in productivity.

Figure 5.7.2 Expectations of future performance as a result of the Covid-19 pandemic
percentage of respondents



6. Conclusions

6.1 Key findings

The evidence presented in this report describes a number of factors which shape innovation performance in the UK's foundation industries and which provide the context for future policy formation.

The foundation industries are distinctive in two principal ways; these sectors tend to be energy-intensive and they have very few new entrants due to their capital intensity, which leads to exceptionally low levels of churn. High levels of energy usage are important because they create profound challenges in terms of meeting commitments to achieving net-zero emissions in the coming decades. Many businesses lack the resources needed to address these challenges unilaterally suggesting that effective actions will require substantial collaboration between businesses and possibly with government. The foundation industries are 'mature' and have significant entry barriers. This is a major structural challenge in terms of innovation performance. In many sectors of the economy, dynamic new entrants drive innovation and improved business performance.

As this research has confirmed, there is a clear and strong association between growth ambition and innovation. Whilst foundation industry businesses are more likely to report ambition to grow than those in the overall business population, there is nevertheless a sizeable minority that lack ambition. Many foundation industry businesses are clearly resistant to innovation and change. Alongside this, there is widespread reluctance to collaborate with other businesses including both those within their supply chain and those outside it. As this research has shown, many businesses cite concerns about commercial sensitivities. And given foundation industries' position in the supply chain, this lack of collaboration means they can be perceived as manufacturers of commoditised products, competing on price, rather than offering the potential for more strategic partnerships.

These issues are consequential in a number of respects and this suggests a clear need for policy to be informed by segmentation analysis, which identifies those businesses that will and will not respond positively to policy interventions. Effective policy needs to allow evidence-based targeting of businesses with unrealised innovation potential and identification of those businesses that are unlikely to change their business behaviours.

Business owners with mindsets that are not conducive to innovation is just one of a number of factors that suggest the need for 'patient policy'. Whilst innovation support initiatives understandably tend to focus on achieving relatively quick and apparently tangible impacts, real progress depends in large part on effectively addressing structural constraints to innovation such as low levels of churn and collaboration. This also highlights the need to develop logic models that set out both output and (medium-term) outcome objectives, and which allow for informed progress towards ultimate goals.

While the foundation industries are distinctive in a number of respects, innovation policy in these sectors also faces challenges that are common throughout the economy. As is the norm

more generally, these sectors are dominated by small businesses. This creates real challenges for communication and engagement. Smaller businesses tend to be the least innovation active and the most difficult to engage, particularly in mature sectors such as the foundation industries.

There are also generally relevant constraints to innovation that occur both in the foundation industries and throughout the economy as a whole. For example, the findings from this research reflect the general view that under-developed management and leadership skills are a widespread constraint to innovation. It may well be possible to increase innovation activity in the foundation industries by promoting the development of management and leadership skills. But again, this requires a willingness for policy to address the underlying causes of low levels of innovation rather than just focussing on innovation activities *per se*.

Structural barriers to innovation in the UK's foundation industries

High entry barriers and associated very low levels of churn.
Under-developed management and leadership skills.
Dispositions and mindsets resistant to innovation.
Widespread reluctance to collaborate both within and outside their supply chains.
Regulatory and other pressures to achieve profound reductions in carbon emissions.

These barriers constrain innovation directly but also indirectly because they undermine the effectiveness of more focussed policy measures.

Conversely, this research has shown that some factors generally held to be constraints to innovation are not currently widely seen as being problematic. For example, access to finance is often cited as a barrier to innovation, but few of the respondents to this survey cited this as a major constraint and those seeking finance were generally successful in doing so. Similarly, while respondents to this survey highlighted the inherent risks of innovation as a major barrier, this is a common finding throughout the economy.

6.2 Rationale for policy development

The evidence presented in this report suggests that there is a clear and convincing rationale for policy in this area. The key arguments are:

- Effective innovation is important to the performance of the UK's foundation industries directly including their ability to compete internationally, but also because these industries provide the basis for dynamism through a wider segment of the economy – more than three quarters of their sales are to other businesses.

- Innovation rates in the UK's foundation industries are lower than those in key competitor countries. For example, in the two decades up to 2016, the UK's foundation industries' share of GDP shrunk by 43 per cent, compared with an average decline across the OECD of 21 per cent.

- Innovation is uneven throughout the UK's foundation industries: well over a third of businesses in these sectors had not introduced new products in the last three years and a similar proportion had not introduced new processes.

- Smaller businesses are markedly less likely than larger ones to be innovation active. This is important because approximately 98 per cent of businesses in these sectors are SMEs.

Within this, there are clear market failures affecting the innovation performance of the UK's foundation industries. The very low levels of new entrants to these sectors limit churn and thereby constrain competition, dynamism, and innovation activity. This is unlikely to change in the future due to the nature of the sectors and needs to be factored into any future policy designs. Beyond this, there are also widespread information failures which result in exaggerated perceptions of the costs and risks associated with innovation.

6.3 Objectives of policy

As the ROAMEF guidance (see Box 6.2.1) suggests, defining SMART objectives is a key prerequisite to identifying and assessing the merits of potential policy options. The development of SMART objectives requires that realistic and achievable metrics are determined in the light of the resources available to fund policy.

In a case such as this, it is necessary to define both output and outcome measures and ideally to situate these within a logic model that links shorter term measures and objectives to the progressive achievement of the ultimate objectives of policy. Objectives for innovation policy in the UK's foundation industries are likely to reflect the following points:

Outcome objectives (the ultimate objectives of policy)

- Increase the responsiveness, productivity and competitiveness of the UK's foundation industries.

- Increase the proportion of the UK's foundation industries that are innovation active.

- Increase energy and resource efficiency by promoting the adoption of novel and low carbon technologies.

Output objectives (key steps necessary to achieving outcome objectives)

- Remove or limit the significance of market failures, particularly the low levels of churn and dynamism that militate against sector-wide innovation.

- Improve management and leadership capabilities throughout the UK's foundation industries.

- Increase networking to expose respondents to new ideas and promote more collaborative ventures.

Box 6.2.1 The ROAMEF cycle – best practice in policy development.

ROAMEF CYCLE

HM Treasury guidance on how to develop, appraise and evaluate policies, projects and programmes is summarised in the so called 'Green Book'.[2] The guidance advocates use of the ROAMEF Cycle as a model for policy development. (See also Innovate UK 2018[3]). In the cycle, each stage follows on rationally from the previous one. These stages are:

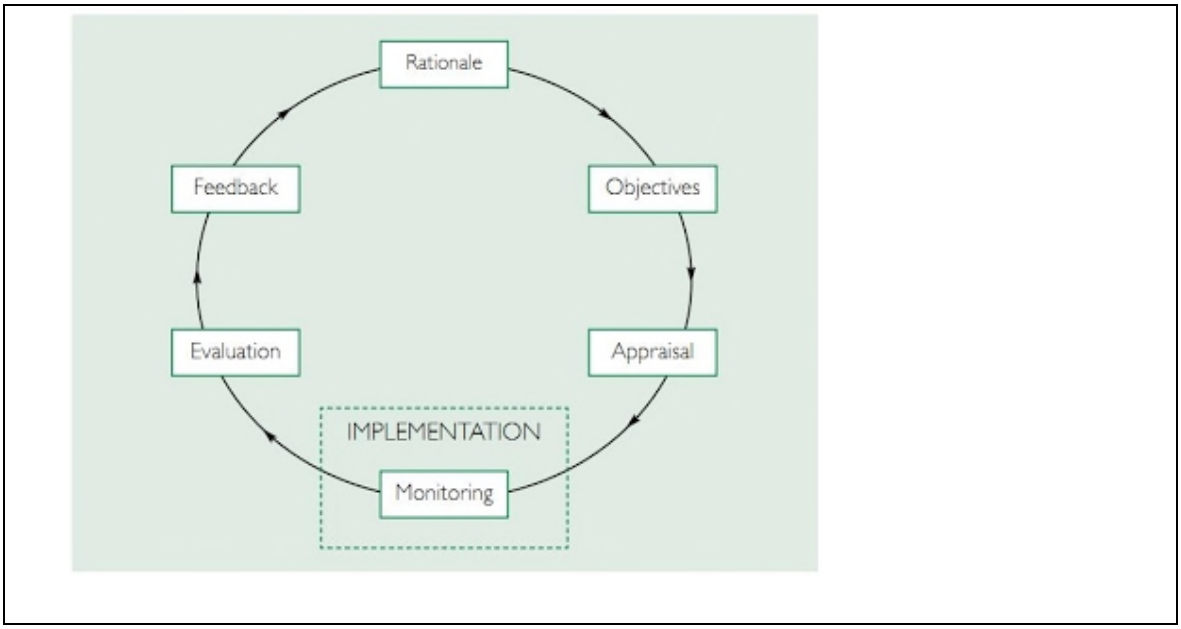
- ***Rationale*** – setting out the rationale for government action.
- ***Objectives*** – defining the objectives a policy or programme.
- ***Appraisal*** – assessing the best options for delivering a policy or programme, and estimating the costs and benefits.
- ***Monitoring*** – continuously checking progress of the policy in delivering the stated objectives.
- ***Evaluation*** – assessing the effectiveness and impact of the policy to see whether the anticipated benefits have occurred.
- ***Feedback*** – ensuring learning from the policy is fed back into its implementation and into the design of other policies or programmes.

It is important to note than in practice this is not a smooth, linear process, but rather an iterative one, with each stage potentially informing the others.

While the ROAMEF process is sometimes criticised for being too idealised, it nevertheless represents best practice in policy development.

[2] HM Treasury, The Green Book: Appraisal and Evaluation in Central Government, 2003, p. v. Green Book available at: http://www.hm-treasury.gov.uk/d/green_book_complete.pdf

[3]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/681741/17.3253_Innovate_UK_Evaluation_Framework_RatherNiceDesign_V2_FINAL_WEB.pdf



Segmentation for the effective targeting of innovation support policies.

Developing an evidence-based analysis to inform the targeting of policy is a further important step in the policy development process. Segmentation analyses are widely used by BEIS and other government departments to inform the development of policy relating to small and medium sized businesses (see, for example, HMRC 2010)[4].

With a large number of potential recipients and limited resources, innovation policy has to be targeted. It is fundamentally important that support is targeted in ways that maximise its impacts and eliminate deadweight. It is also crucial that this targeting is evidence-based. The only alternative is opinion-based policy which is clearly inappropriate, likely to be contestable and unlikely to be totally effective.

A central aim of targeting innovation support is to identify those potential recipients with unrealised potential to innovate that will respond positively to support. That is those businesses where support will encourage and enable higher levels of innovation. Equally, however, it is important that businesses that are unlikely to engage with or respond positively are also identified and not supported. Furthermore, policy should not seek to support businesses that would have been more innovative in any event, thereby reducing deadweight.

The factors that shape businesses' attitudes to and investment in innovation are complex and multi-layered. They include both tangible factors such as access to capital and skills and less concrete factors such as the dispositions and mindsets of business owners. However, these factors are, for the most part, well understood and well documented. Using the available evidence base to segment the business population in an evidence-based way can clearly provide for better-informed targeting of support, greater impacts and better value for money.

4 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/344830/report205.pdf

6.4 Policy options

Best practice in policy development requires that a range of policy options are identified, and their absolute and relative merits are considered in order to identify those options that are both realistic and most likely to be impactful. The policy options available for promoting higher levels of innovation in the UK's foundation industries are likely to include:

- ***Do nothing***. HMT guidance is clear that the first policy option considered should always be to do nothing. Innovation rates are currently sub-optimal in the UK's foundation industries. There has been a protracted period of poor performance in which the UK's foundation industries have fared worse than those in key competitor countries. These industries are currently facing major Brexit and Covid-related challenges. Beyond this, there are major challenges associated with decarbonisation in what are energy intensive sectors that are not currently being effectively addressed. There is little prospect of positive change without further intervention. Accordingly, without effective new interventions there are very real risks of detrimental effects not just on these industries but throughout the supply chains which depend on these sectors and the economy more generally.

- ***Expand current approaches to promoting innovation through grants and demonstration projects and other established forms of innovation support***. There are well-established innovation support mechanisms available to businesses in the foundation industry sectors. Evidence from this research suggests that the key issues here are not with the mechanisms in place *per se*, but rather limited engagement with non-innovating businesses and deadweight where innovation would have occurred without support. To some extent current initiatives do attempt to support non-innovators, for example by requiring consortia to include smaller businesses. However, our findings suggest that more effective segmentation and targeting of support would be appropriate. Consideration could usefully also be given to considering how communication with and engagement of smaller businesses might be improved. One approach to avoiding deadweight in large businesses would be to increase the proportion of matched funding required from these businesses in order to qualify for support.

- ***Pilot approaches for RTOs to engage with foundation industry sectors.*** As the relative importance of foundation industries has declined in recent decades so too has the breadth of academic and research expertise that relates to these sectors. As already discussed, the large number of SMEs in these sectors also makes it challenging for the research base to build partnerships across these industries. Additionally, while the foundation industries can be important components of high-value supply networks, there is a perception that they fall outside the scope of high-value manufacturing innovation activity. Piloting new models of systematic engagement, specific to these sectors, would offer opportunities to introduce foundation industry SMEs to the existing innovation infrastructure. This approach could also foster greater engagement with end-users to increase demand for new product and process innovations. A formal evaluation and feedback process, as outlined in the ROAMEF cycle in box 6.2.1, is important in sustaining long-term engagement with the sector.

- ***A stronger convening role for UKRI.*** UKRI could adopt a convening role, engaging businesses, sectors, end-users and the science base to inform innovation and technology priorities, identify barriers and tailor funding solutions accordingly. This approach could overcome the challenge faced by individual businesses, particularly small ones in developing appropriate innovation strategies and reduce perceived risks in new to market innovation activity.

- ***Improve management and leadership skills.*** The findings from this research reflect those from other studies of the economy as a whole that suggest business performance, and within this innovation, is often constrained by poorly developed management and leadership skills. More than half the respondents to this survey reported believing that management skills are deficient throughout the foundation industry sectors and that this acts as a constraint to innovation. This contention is clearly supported by other findings from this research including those relating to business planning and strategy development. There are numerous management development initiatives in the UK. Consideration should be given to which approaches are most suitable for the foundation industry sectors. This approach could be extended to those with decision-making responsibility, but are not Directors within the business. The relatively small number of businesses in these industries suggest that an initiative of this sort may well be realistic and effective.

- ***De-risk innovation.*** The most commonly cited barrier to innovation raised in our discussions with foundation industry businesses is risk. The actual and perceived risks of innovation are widespread and have clear consequences. For example, perceived risk is the key driver of the widespread reluctance to reject new to the market innovations in favour of tried and tested new processes or products. In some sectors, where there is a higher degree of regulatory oversight, this exacerbates a conservative approach to new to market innovations. There would be clear merit in initiatives that allowed foundation industry businesses to share risks with other businesses through collaboration and possibly with government through measures such as innovation loans which are repayable only where projects are successful.

- ***Government procurement.*** The government is a major customer in some foundation industry sectors. This creates an opportunity to promote the use of innovative products and processes by mandating their use in procurement specifications. For example, government is a major customer of construction products and could look to require the use of novel low carbon cement products. This would allow government to share the risks involved in the adoption of novel products and provide the best possible means of demonstrating their viability and benefits. Although this option would require buy in from a range of government departments and possibly local authorities, it should be essentially costless to implement.

- ***Focus innovation support on collaborative ventures that include small and medium sized businesses.*** While established initiatives do often require that SMEs are included in consortia, consideration could be given to whether and how this requirement might be extended. It is generally accepted that collaboration is important to innovation. However, as the findings of this survey and our in-depth discussions with foundation industry businesses show collaboration is not the norm in the foundation industries. In practice,

there are widespread and deep-seated concerns about commercial sensitivities and other issues. One option for addressing this issue is to ***create consortia to address issues beyond the resources of individual businesses.*** The greatest single challenge to the UK's foundation industries going forward will most certainly be reaching net-zero carbon emissions by 2050. A shift to hydrogen as the principal energy source for these industries is almost certainly the key measure that needs to be taken. However, change of this sort is beyond the resources of the majority of businesses in these sectors. Creating consortia, involving different sized businesses, to share both the costs and benefits of a shift to hydrogen might well be well received and impactful.

- ***Encourage and support industry representative bodies and trade organisations to play a more active role in promoting and supporting innovation.*** Evidence from this research suggest that many foundation industry businesses, particularly smaller ones, are not members of trade organisations or representative bodies. While most survey respondents believe that these bodies do play a role in promoting and supporting innovation, one in four members do not believe this is the case and this proportion is much higher in some sectors. This is important from a policy development perspective as working through these organisations can potentially lever the limited funding available in ways that government bodies cannot. The key here would be to encourage industry bodies to move beyond a focus on representing the usually short-term interests of their members to adopt a more strategic role in ensuring the long-term competitiveness and viability of the businesses they represent. This would represent a change of focus for these organisations as they are generally well placed to improve communication throughout the sector and to encourage networking and collaboration; particularly collaboration within supply chains. Nevertheless, consideration would need to be given to the additional resource this would require, given likely constraints around capacity and expertise. One solution may be third-party assistance to help with translation of the detail of support and partnerships available to allow trade bodies to best identify suitable businesses with which to engage. Open, meaningful engagement with downstream elements of the supply chain in sectors such as automotive and construction is important because a large proportion of innovation is demand driven.

- ***Encouraging employee participation in innovation.*** The research points to limited employee engagement with innovation decisions in foundation industry businesses – the survey evidence shows that production employees are involved in just 37 per cent of foundation industry businesses. This could result in missed opportunities to identify opportunities for product or process improvements. Exploring opportunities for organisational innovations that incentivise greater employee engagement, reduce internal barriers to innovation and contribute to collaboration efforts could further address some of the underlying causes of low levels of innovation in these sectors.

- ***Encourage more positive mindsets amongst foundation industry businesses.*** Our survey evidence shows that there is a clear association between growth ambition and innovation in foundation industry businesses – ambitious businesses are twice as likely to innovate as those with no ambition. Within this, it is clear from this research and other

studies, that many business owners have mindsets that mean they have no interest in, or indeed are often antithetic, to any form of dynamism in their business. There is good evidence that the most effective means of encouraging more dynamic dispositions and mindsets amongst business owners is to expose them to peers who have more positive outlooks. Accordingly, one potentially effective policy option would be to ***encourage networking amongst foundation industry businesses.*** The key issue here is not that networking could be used to didactically advocate innovation or to provide technical solutions. Rather, the key is to encourage business owners to engage with their peers, which would expose them to new ideas and potential new collaborations.

- ***Use fiscal measures to encourage market led solutions.*** Most current measures to encourage innovation are based on either regulation or various forms of grant funding. In a market economy such as the UK, a different approach would be to progressively increase the taxes on the carbon-based energy sources used by these businesses. This would have the advantage of leaving decisions about the most appropriate form of innovation to the businesses themselves who in practice may be best placed to make informed choices. Measures of this kind would also cost less to implement. Sector specific carbon taxes would clearly be unpopular with businesses and would be politically unacceptable at this point, not least because international competitiveness would be undermined if similar taxes were not universally established. However, such measures may well become a more credible option as 2050 approaches.

- ***Encourage greater levels of productive churn in these sectors.*** The UK's foundation industries are generally very mature sectors and the businesses involved tend to be older than those in the economy more generally. One important corollary of this is that levels of productive churn or creative destruction are particularly low in these sectors. This is important because competition is a key driver of innovation and new entrants drive dynamism and increased productivity. Accordingly, one policy option, albeit an indirect one, would be to encourage and support new entrants to sectors where entry costs can be prohibitive.

- ***Find substitutes for energy intensive products.*** A key tenet of resource economics is that all resources are substitutable. Reducing carbon emissions through technical innovations that increase energy efficiency through the adoption of new energy sources such as hydrogen is possible but likely to be problematic and challenging in a number of respects. Complementing these measures by exploring the potential to innovate through shifting to lower energy products produced outside these sectors may well be an important complement to more direct measures.

Brexit and Covid-19 legacies – opportunities or challenges? The options for promoting higher levels of innovation in the UK are complicated by the still uncertain effects of Brexit and the Covid-19 pandemic. Both of these factors may well engender profound and disruptive transformations, which militate against investments in innovation, not least in the foundation industries. Whilst it is easy enough to consider how emergent conditions may undermine and negate current innovation strategies and plans, it is also possible to envisage a range of opportunities. For example, if inherently weaker businesses tend to fail as a result of these

pressures this may well create opportunities for new or more dynamic businesses to replace them. Conversely, there are clearly pressures for short-term policy measures that ensure that that impacts of Covid-19 and Brexit do not fundamentally undermine the viability of these sectors.

6.5 Next Steps

This research has shown, very clearly, that there are both structural and local, firm specific, factors that shape innovation performance in the foundation industries. Real progress in promoting higher levels of innovation depends, fundamentally, on addressing both these levels of causality. In practice, resources are limited and there are very real pressures on policy makers to implement policies that will produce quick and tangible impacts. However, unless the structural barriers to dynamism and increased innovation are effectively addressed, progress will be, at best, limited. Real progress depends on policy makers confronting the underlying causes of low and uneven levels of innovation in these sectors. Amongst other things, this will require realism about what structural changes can be achieved and the timeframes necessary for such changes to be realised.

This report has outlined a range of potential policy options. The next step for UKRI is to formulate SMART objectives that are evidence based, achievable and realistic given the resources available. Consideration can then be given to which policy options are most realistic, likely to have the greatest impacts and provide the best value for money. These potential policy options should be evaluated both in respect of their individual merits and in relation to the other options identified. As we have argued, it is important that those options that look to address the underlying causes of low levels of innovation are given serious consideration. Clearly, these options will be challenging to implement and will necessarily take time to produce impacts, but they are likely to be the key to more effective policy. In so much as addressing these challenges effectively may well require additional resource, building partnerships with BEIS and other government departments may well be important.

Annex 1 Foundation industry SIC codes

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.
19209	Other treatment of petroleum products (excluding petrochemicals manufacture)
20110	Manufacture of industrial gases
20120	Manufacture of dyes and pigments
20130	Manufacture of other inorganic basic chemicals
20140	Manufacture of other organic basic chemicals
20150	Manufacture of fertilizers and nitrogen compounds
20160	Manufacture of plastics in primary forms
20170	Manufacture of synthetic rubber in primary forms
20590	Manufacture of other chemical products n.e.c.
23110	Manufacture of flat glass
23120	Shaping and processing of flat glass
23130	Manufacture of hollow glass
23140	Manufacture of glass fibres
23190	Manufacture and processing of other glass, including technical glassware
23200	Manufacture of refractory products
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.
23510	Manufacture of cement
23520	Manufacture of lime and plaster
23610	Manufacture of concrete products for construction purposes
23620	Manufacture of plaster products for construction purposes
23630	Manufacture of ready-mixed concrete
23640	Manufacture of mortars
23650	Manufacture of fibre cement

23690	Manufacture of other articles of concrete, plaster and cement
23990	Manufacture of other non-metallic mineral products n.e.c.
24100	Manufacture of basic iron and steel and of ferro-alloys
24310	Cold drawing of bars
24320	Cold rolling of narrow strip
24330	Cold forming or folding
24340	Cold drawing of wire
24410	Precious metals production
24420	Aluminium production
24430	Lead, zinc and tin production
24440	Copper production
24450	Other non-ferrous metal production
24510	Casting of iron
24520	Casting of steel
24530	Casting of light metals
24540	Casting of other non-ferrous metals
25500	Forging, pressing, stamping and roll-forming of metal; powder metallurgy

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