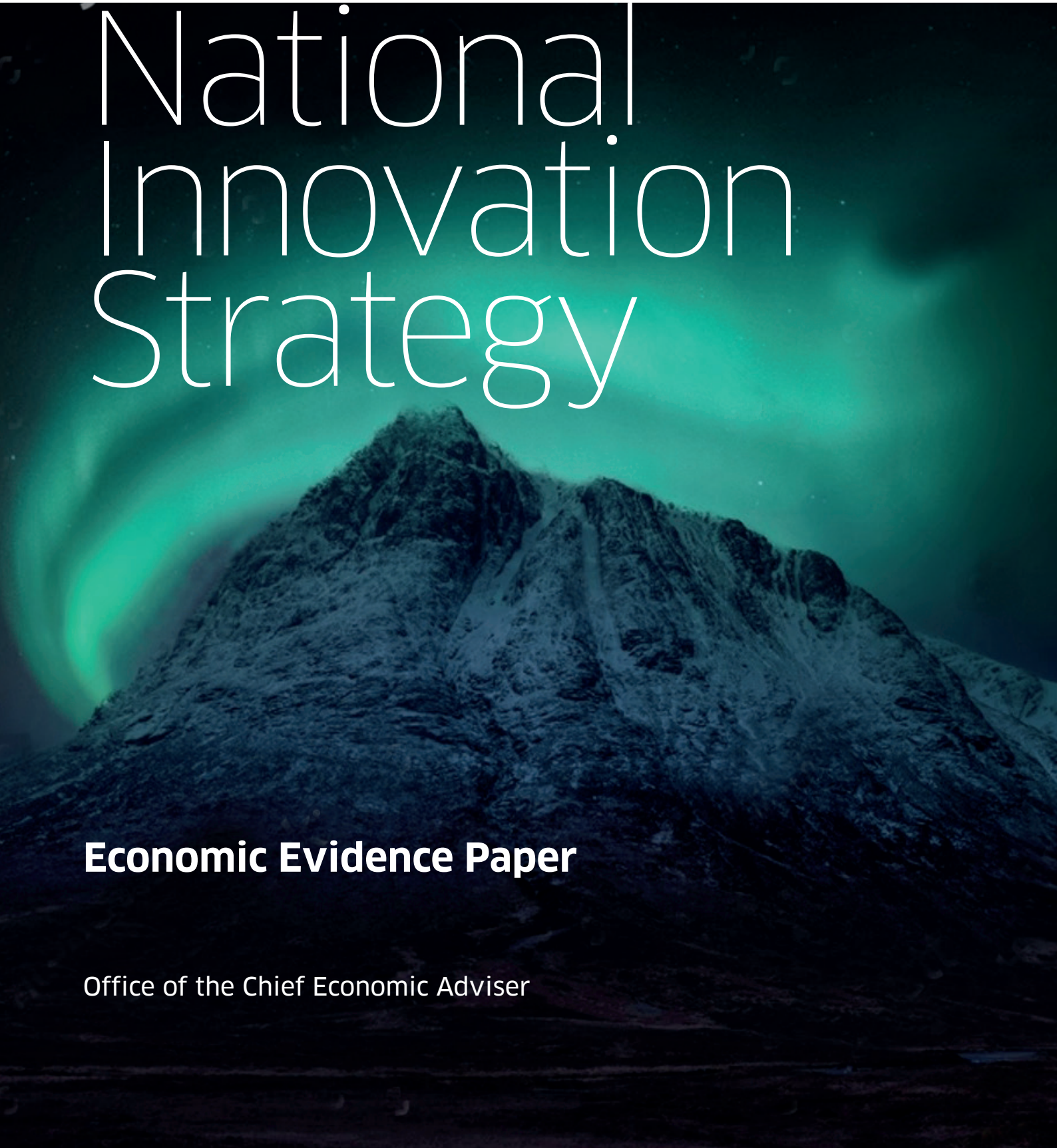
Scottish Government
Riaghaltas na h-Alba

Scotland's National Innovation Strategy



Economic Evidence Paper

Office of the Chief Economic Adviser

Contents

Executive Summary

Introduction

- This economic evidence paper provides a summary of the theory and selected evidence on the role of innovation and its drivers in generating economic growth and Scotland's innovation performance to provide context for and inform the development of Scotland's innovation strategy.
- In particular, it sets out the aspects of innovation in which Scotland currently performs well and those where it can further improve upon; identifies the sectors in which Scotland has the potential to be world-leading which can be supported through the strategy; and identifies a set of indicators (a "scorecard") for tracking Scotland's innovation performance over time to assess whether the strategy is meeting its core objective to make Scotland one of the most innovative small nations in the world.

Drivers of Innovation

- There are many factors that can influence the rate of innovation in an economy and the gains to economic growth that it brings. Key drivers of innovation include: private and public investment in research and development (R&D); organisational and management structures and practices; human capital; culture and ecosystem, both at the firm and industry level; entrepreneurship; inward investment and exporting.
- There is scope in Scotland to further improve on its strong business management practices and to build capacity for innovation and productivity enhancing business models. This includes policies to further encourage a culture of entrepreneurship within the existing business base by building experimental and innovative capacity, and facilitating peer to peer learning between businesses.
- There is a need to tackle a wide range of barriers to businesses adopting and making the most effective use of existing technologies. This will go a long way in improving both the productivity performance and innovative potential of many businesses.

Government's Role in Promoting Innovation

- If left solely to the market, economic theory suggests market failure will arise whereby investment in innovation activities will be at sub-optimal levels, providing a rationale for government intervention to encourage and support innovation. This is primarily because the benefits of innovation activity do not accrue solely to the business undertaking the innovation, in other words there is a positive externality.
- The innovation support landscape in Scotland is complex with around 90 innovation initiatives across the Scottish Government and enterprise and skills agencies, rising to around 500 initiatives when including innovation funds run by other organisations. Innovation support spending is heavily skewed towards the earlier 'concept' stage of the innovation journey.
- Innovation policy impacts are difficult to track, given the non-linear nature of innovation and sometimes lengthy timescales involved. There is currently limited evidence on the impacts of innovation activities within Scottish Government and its agencies. This does not necessarily mean that these initiatives are not achieving benefits, but this the lack of evidence makes it difficult to judge which initiatives are having the greatest impact on the Scottish economy.International evidence suggests that in the short run, R&D tax credits and direct public funding

are likely to be the most effective policy levers to stimulate innovation while, over the longer term, increasing the supply of human capital is likely to be more effective. Encouraging skilled immigration is also seen to be effective even in the short run. Competition and open trade policies are likely to have more modest benefits but incur no direct cost to government. Inward investment has also been found to boost innovation through increased R&D spend and, respectively, competition and demonstration effects.

Scotland's Recent Innovation Performance

- Scotland has a mixed performance on the international stage in terms of innovation, with areas of strength such as higher education and business spending on research and development, but also some challenges including government spending on R&D, the proportion of firms innovating and in terms of innovation outputs including patent and trademark applications.
- In 2020, Scotland ranked top among the OECD countries for HERD spend as a percentage of GDP, Scotland's BERD spend as a share of GDP was above the EU average but below the OECD average, and Scotland's GovERD as a share of GDP was lower than both the EU and OECD averages.1
- Scotland underperforms both the UK and the EU average in terms of the proportion of businesses that are innovation active. When ranked against the UK and EU-27 countries, Scotland ranked 19th in 2018-20, placing it in the middle of the third quartile.
- Scotland's broader innovation system is classed as strong when compared internationally and has improved over time. Relative to the EU average, Scotland has notable strengths in tertiary education, lifelong learning, digital skills, scientific publications and innovative SMEs collaborating. However, weaknesses remain in employment of ICT specialists, employment in innovative enterprises and trademark and design applications.

Scotland's Sectoral Innovation Strengths

- A range of evidence was considered to identify sectors in which Scotland currently excels and has the potential for further growth at three tiers: business capabilities; the application of innovation into business; and higher education sector capabilities.
- The analysis was constrained by the lack of sufficiently disaggregated sectoral data, the lack of data on emerging sectors that are not yet an established part of Scotland's economy and the lack of sectoral data on higher education sector capabilities. Despite these limitations, the analysis provides some interesting insights on Scotland's sectoral strengths at a broader level.
- While the areas of strength that emerged in each strand of the analysis differed somewhat, a number of broad sectors showed strength across the tiers. These were: Scientific R&D (part of life sciences); Computing / ICT; Business Services; Professional Services; Architectural, engineering and technical activities; Health; Energy; Emerging technologies (including fin tech, health tech and nanotechnologies) and Space.
- Given the data limitations which required this analysis to focus on broad sectors and the fact that many new disruptive and radical innovations are not happening within specific sectors but rather across sectors. To identify more specific areas

[1] These figures are currently under review by ONS, please see Box 1 for further information.

where Scotland has the potential to be world-leading, it will be necessary to supplement this analysis with expert advice from key innovation and industry academics and other stakeholders.

Innovation Scorecard Indicators

As actions to grow and scale Scotland's innovation ecosystem over the next 10 years proceed there is a need to track performance on a number of key metrics to allow assessment of progress towards the ambition to become one of the most innovative small nations in the world.

It is proposed that this will be undertaken through an Innovation Scorecard which will track Scotland's innovation performance over time on a set of key indicators against other benchmark geographies: ideally these will be international comparators, but it must be recognised that some relevant indicators only permit comparison across UK nations and regions.

Scottish Government analysts developed a set of metrics, drawing upon commonly used data and considering existing UN and EU measurement frameworks, refining this through consultation with academic experts, NESTA and the Innovation Strategy Steering Group.

The Scorecard metrics aligns to the elements of the Innovation Ecosystem, ensuring we monitor the health of the system at each stage of each process to demonstrate Scotland's performance at different stages in the innovation journey, specifically tracking progress at three stages in the innovation system defined as the *concept*, *convert* and *commercialise* stages as well as tracking *investment* and the *adoption of innovation*.

Summary of Scorecard

Concept

- Patent citations
- Academic income from business and community interactions

Convert

- Early-stage risk capital (under £10 million)
- BERD jobs

Commercialise

- High growth firms
- Later-stage investment

Adoption and diffusion

- Innovation active businesses

Investment

- Gross expenditure on R&D (which comprises)
    - Business expenditure on R&D
    - Higher education expenditure on R&D and
    - Government expenditure on R&D

Although it is important to recognise that there are often lengthy time lags until economic impacts emerge from new innovations, and that there is a need to factor in time to implement and deliver a new strategy, the Scorecard will provide a useful snapshot of the health of the Scottish innovation system over time.

1. Introduction

1.1 Purpose

The purpose of this economic evidence paper is to provide a summary of the theory and selected evidence on Scotland's innovation performance to provide context for and inform the development of Scotland's innovation strategy.

In particular, it:

- sets out the aspects of innovation in which Scotland currently performs well and those where it can further improve upon

- identifies the sectors in which Scotland currently performs comparatively strongly on innovation and where it has the potential for further growth. It is anticipated that the sectoral analysis will be used alongside other analysis and expert advice from key stakeholders to identify a number of innovative technologies and economic clusters in which Scotland has the potential to be world-leading which can be supported through the strategy

- Identifies a set of indicators (a "scorecard") to enable us to track Scotland's innovation performance over time against a set of comparator countries to assess whether the strategy is meeting its core objective to make Scotland one of the most innovative small nations in the world.

The paper sets out a brief summary of:

- the role of innovation in driving economic growth

- the key drivers of innovation

- the rationale for government intervention in promoting innovation and international evidence on policy effectiveness

- the current innovation support landscape in Scotland

- Scotland's recent innovation performance

- Scotland's sectoral strengths in innovation

- Options for indicators for tracking Scotland's innovation performance over time.

1.2 Background

1.2.1 What is innovation?

In Scottish legislation, innovation is defined as *"the introduction and implementation of a new or significantly improved product, service, process, or method with the purpose of helping to solve societal challenges or delivering economic growth".* It is

important to be aware that innovation goes far beyond the boundaries of traditional research and development[2] (R&D) it is typically associated with. The Oslo Manual[3] for measuring innovation defines four separate types of innovation:

- Product innovation: A good or service that is new or significantly improved. This includes significant improvements in technical specifications, components and materials, software in the product, user friendliness or other functional characteristics.

- Process innovation: A new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.

- Marketing innovation: A new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.

- Organisational innovation: A new organisational method in business practices, workplace organisation or external relations.

All four of these aspects of innovation have a role to play in helping Scotland deliver economic prosperity.

1.2.2 The role of innovation in driving economic growth

Widely considered essential for economic growth and productivity[4], innovation drives the development of new or improved products and services or makes their production more efficient, increasing economic output, and ultimately creating wealth and employment.

R&D is often considered central to innovation and productivity growth. While many innovations are technological – faster computers, more powerful phones and more fuel-efficient cars – innovation is also about doing things better through better business models.

While the link between innovation and productivity is complex, evidence suggests that innovation plays a key role in productivity growth, which ultimately feeds into economic growth. Indeed, work by the OECD and Nesta suggest that innovation could account for between 25% and 50% of labour productivity gains[5]. Productivity growth can be a result of increasing output at a rate faster than resource growth, but also through increasing the efficiency of firms' operations.

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[2] "Research and development comprise creative work undertaken on a systematic basis to increase the stock of knowledge and the use of this knowledge to diverse new applications" – OECD Factbook 2013

[3] OECD, 2018, Oslo Manual 2018 – Guidelines for Collecting, Reporting, and Using Data on Innovation, 4th Edition

[4] A seminal example is the work of Robert Solow which posits that, in the long-run, *only* technological change drives economic growth; Solow, Robert M. (February 1956). "A contribution to the theory of economic growth". Quarterly Journal of Economics. (Also subsequent papers).

[5] Nesta, 2009, 'Innovation, knowledge spending and productivity growth in the UK'

The gains from innovation activities also do not solely accrue to the organisations undertaking the work, as the benefits tend to spill over through adoption and further development of those innovations, further increasing productivity and output. Furthermore, benefits arising from R&D and innovation go beyond the economic. Innovation can produce, for example, better medicines, more effective public services and greener energy with resulting social and environmental benefits.

2. Drivers of Innovation

There are many factors that can influence the rate of innovation in an economy and the gains to economic growth that it brings. This section considers the key drivers, drawing on the available evidence on their role in encouraging innovation and Scotland's performance in each area.

2.1 Private and Public Investment in R&D

Investment in R&D, whether it is public or private, is generally considered a central pillar of innovation. By seeking new knowledge through research, companies innovate by developing, designing and enhancing products, services, technologies and processes.

Analysis by the UK Government[6] finds that private R&D investment successfully fosters innovation in firms, especially in terms of process innovation and the introduction of new-to-business and new-to-market innovative products. The research does not find evidence to suggest that public R&D crowds out private R&D. Instead, it finds that public R&D seems beneficial as it supports new-to-market innovative products, with different impacts by UK region and firm size.

A review of Scotland's R&D investment performance is provided in section 4.1.

2.2 Organisational and Management Structures and Practices

Innovative success is dependent on far more than just investment. Within firms, the organisational and management structures themselves can have a significant effect on the propensity to innovate. Recent ONS research[7] exploring the relationship between management practices and innovative activity found that firms with a higher management practice score were significantly more likely to undertake R&D. Additionally, the relationship between productivity and R&D was significantly stronger for firms with a higher management practice score.

Innovation policy tends to focus on how best to encourage businesses to undertake research and innovate themselves, but it is also important to consider how best to empower businesses to adapt their organisational structures to adopt existing innovative technologies and practices. This is important, because widespread productivity gains from effective utilisation of general-purpose technologies such as electricity in the 19th - 20th centuries and digital technologies in the 21st century have

[6] Department for Business, Energy and Industrial Strategy, 2021, From Ideas to growth: Understanding the drivers of innovation and productivity across firms, regions and industries in the UK
[7] Office for National Statistics, August 2021, Management practices and innovation, Great Britain

tended to emerge slowly despite obvious benefits. If technological diffusion is slow, it can dampen productivity growth because of the impact of 'laggard firms' on the performance of the overall economy.

ONS research[8] looking at management practices across the (NUTS 1) nations and regions of Great Britain over the period 2016 - 2020 found that of the 11 regions, Scotland saw the biggest improvement in its management practice score over the period and held the joint highest mean score in 2020 (along with the Southeast of England).

2.3 Human Capital

The level of human capital[9] within an economy and the skills of the labour force also play a significant role in innovation, both directly and indirectly. In a direct sense, this will spur innovation as educated and well-trained workers are more likely to introduce new products or implement new processes. In an indirect sense, highly skilled workers can drive innovation as they are more able to absorb new knowledge and ideas, thereby maximising knowledge and technology spill overs of innovations from other firms. This knowledge absorption element of human capital is especially relevant for digital skills, which are becoming increasingly more important as a driver of innovation.

For example, the 2021 Digital Economy Business Survey (DEBS) 2021 found that digital technology helped around a third of businesses to create new or significantly improved products or services. It also made business processes more efficient (59% of businesses), increased skills (48%) and enhanced competitiveness (41%). DEBS shows promising results for digitalization in Scotland[10]. 97% of businesses reported being connected to the internet, and almost all digital technologies saw an increase in use from 2017 to 2021. However, the uptake of some technologies is still fairly low, such as management software (20%) and data analytics (40%).

Digital skills are essential if businesses are to benefit from digital adoption and to develop better business models. However, only 1 in 5 Scottish businesses felt fully equipped with digital skills in 2021 - 15% reported that they were not very well equipped and had considerable skills gaps. While many businesses reported skills gaps, 46% of those surveyed were not taking, or planning to take, any action to address digital skills gaps. Amongst businesses with relevant skills gaps who were not taking action to address them, the most commonly cited barriers include 'resource or time constraints', and costs. Of the businesses that reported skills gaps, 23% were not able to identify specific skills for improvement, highlighting some knowledge barriers.

2.4 Culture and Ecosystem

A key enabler of innovation is that of an innovative culture or eco-system, both at the firm and industry level. Innovation centres, innovation networks and clusters play an important role in supporting innovation (and, indeed, entrepreneurial) ecosystems. At

[8] Office for National Statistics, May 2021, Management practices in Great Britain, 2016-2020
[9] The term human capital refers to the economic value of a worker's experience and skills.
[10] Digital Economy Business Survey 2021: Findings

the firm level, a workplace culture that connects workers to the strategic direction of the firm and facilitates opportunities for employees to participate in organisational decisions can be instrumental in encouraging a continuous flow of ideas that support innovation efforts. At a sector wide level, peer-to-peer business networks, industry clusters, and academia-industry collaboration can have significant effects in the sharing and development of new ideas, as well as facilitating the adoption of new knowledge and technologies. A good example of a sector level innovative culture is Silicon Valley, where academia, private sector and US government have all converged to create an environment that has enabled numerous tech start-ups to flourish.

2.5 Enterprise and Entrepreneurship

Entrepreneurship is a central driver for a growing, innovating and dynamic business base. Entrepreneurship can be defined as the ability to identify business opportunities and to translate them into viable business propositions that deliver economic impact and desirable social and environmental change. By innovating through the creation of new technology and processes, entrepreneurs cause productivity increases as those innovations diffuse across the economy. Furthermore, entrepreneurs are the primary source of 'creative destruction'[11] whereby incumbent firms are displaced, and resources are reallocated in a more efficient way, leading to long term productivity growth.

While there is no target for the start-up survival rate in Scotland, there is a significant gap to close if Scotland is to match the best performing advanced economies. For instance, to match the best performing OECD countries, Scotland would need to raise its 3-year and 5-year business survival rate by around 20 percentage points[12]. Additionally, Scotland has a deficit of high-growth firms when compared with other countries, and there is evidence of constraints to business growth in the wider enterprise ecosystem.

The Scottish Government's National Performance Framework (NPF)[13] tracks Scotland's business creation using the Total Early-stage Entrepreneurial Activity (TEA) rate[14]. On this measure, Scotland's entrepreneurial activity has gradually improved over time but remains significantly below that of other advanced economies, sitting in the second quartile of OECD countries[15]. Scotland's TEA rate would have to increase by around 70% if it is to match the performance of other small, advanced economies like Ireland[16].

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[11] In his Theory of Economic Development (1961), Joseph Schumpeter maintains that the creative destruction process is mainly due to entrepreneurs' innovations that create an endogenous motion which revolutionizes economic structures.
[12] Scottish Government, March 2022, Scotland National Strategy for Economic Transformation: evidence paper. Based on OECD and ONS Business Demography data.
[13] Scottish Government, National Performance Framework - National Indicator Performance
[14] The TEA rate measures the proportion of the working age population that is actively trying to start a business or that own or manage a business, which is less than 3.5 years old.
[15] Enterprise and Skills Strategic Board Annual Analysis 2020
[16] The latest published 2019 TEA rate for Ireland was 12.4%, compared to 7.2% in Scotland in the same year.

Successful, advanced entrepreneurial economies tend to feature thriving eco-systems, often operating through a "triple helix" of private sector, public sector and universities and linked to sectoral clusters. Edinburgh is a good example of this in action within Scotland.[17] Nurturing entrepreneurial ecosystems requires building cultural, social and material attributes,[18] including education, role models, access to peers, celebration of success, learning from 'failure', social ties, entrepreneurial networks, skilled workers and access to talent and appropriate and diverse investment capital. Entrepreneurship can flourish when these attributes are supported by key institutions including universities (which are often anchor institutions), favourable government policies and appropriate infrastructure including transport, super-fast broadband and access to cultural activities including, for example, attractive places for entrepreneurs to come together in a "market-square" type environment.[19]

The funnel model outlined in Scottish Technology Ecosystem Review[20] provides a useful illustration of the importance of the local ecosystem in determining the rate of narrowing of the number of firms as they move through the stages from start-up to scale-up. It notes the opportunity that exists to improve ecosystems to close the gap between Scotland's current rate of funnel decay and the natural rate[21]. Further detail on the funnel model is provided in Annex 1.

2.6 Inward Investment and Exporting

Analysis underpinning Scotland's Inward investment plan[22] found there are strong links between Scotland's university knowledge base, inward investment and innovation, and that foreign owned businesses typically invest more in business R&D spending. Additionally, these inward investors can further boost innovation in the Scottish economy through their engagement with domestic businesses. This can either be due to increased competitive pressures spurring innovation in domestic firms (competition effects), or through domestic businesses adopting the innovative processes of foreign owned firms (demonstration effects). Demonstration effects can also drive innovations through supply chains, as inward investment companies may share knowledge with domestic suppliers in order to improve inputs to production. Furthermore, employees of innovative inward investment companies may use the knowledge they have gained to start their own innovative companies.

Similarly, Scotland's export strategy, A Trading Nation[23], notes that, as well as driving business performance and scale, access to international markets and competition drives innovation and productivity growth. Evidence indicates that there is a strong correlation between exporting and innovation. Innovative businesses are

[17] Beauhurst and Barclays Eagle Labs, 2021, Unlocking Growth report and summary
[18] Spigel, 2017, The Relational Organization of Entrepreneurial Ecosystems, Entrepreneurship Theory and Practice, vol. 41, no. 1, pp. 49-72
[19] Logan, August 2020, Scottish Technology Ecosystem Review
[20] Ibid
[21] The natural rate refers to the natural narrowing of the number of firms from start-up to scale-up given that not all start-ups do or should become scale-ups and not all scale-ups do or should become unicorns. The natural rate is impossible to improve upon.
[22] Shaping Scotland's Economy: Inward Investment Plan
[23] A Trading Nation – a plan for growing Scotland's Exports

more likely to export, and the experience of exporting can be a strong driver of investment in innovation and R&D as businesses compete in new markets. Additionally, evidence from the Enterprise Research Centre[24] finds that internationally active SMEs are three times more likely to introduce innovative products or services than those focusing entirely on the domestic market. Currently only one in five UK SMEs are exporters. However, estimates suggest that between nine and 12 per cent of non-exporting firms within the UK could become exporters.

[24] Boosting UK Productivity with SME Growth

3. Government's Role in Promoting Innovation

3.1 The Rationale for Government Intervention in Promoting Innovation

If left solely to the market, economic theory suggests market failure will arise whereby investment in innovation activities will be at sub-optimal levels, providing a rationale for government intervention to encourage and support innovation.

This is primarily because the benefits of innovation activity do not accrue solely to the business undertaking the innovation, in other words there is a positive externality. The benefits of innovation activity tend to 'spill over' to other organisations through adoption and further development of those innovations, further increasing productivity and output across the whole economy.

Additionally, businesses are often unwilling to invest in R&D activities because they are risky by nature, especially for technologies in the earliest stages of development. Because of this, smaller businesses which are less able to suffer the loss of a failed R&D project may simply not undertake any R&D activity, again resulting in sub-optimal levels of investment.

A review of existing evidence by the Research and Development Corporation Europe (RAND Europe[25]) found that there may be even greater benefits from innovation across society including impacts on culture, public engagement, social cohesion and environment, although these are difficult to measure. Thus, firms taking decisions to invest in innovation on the basis of benefits accruing to their business only will tend to underinvest.

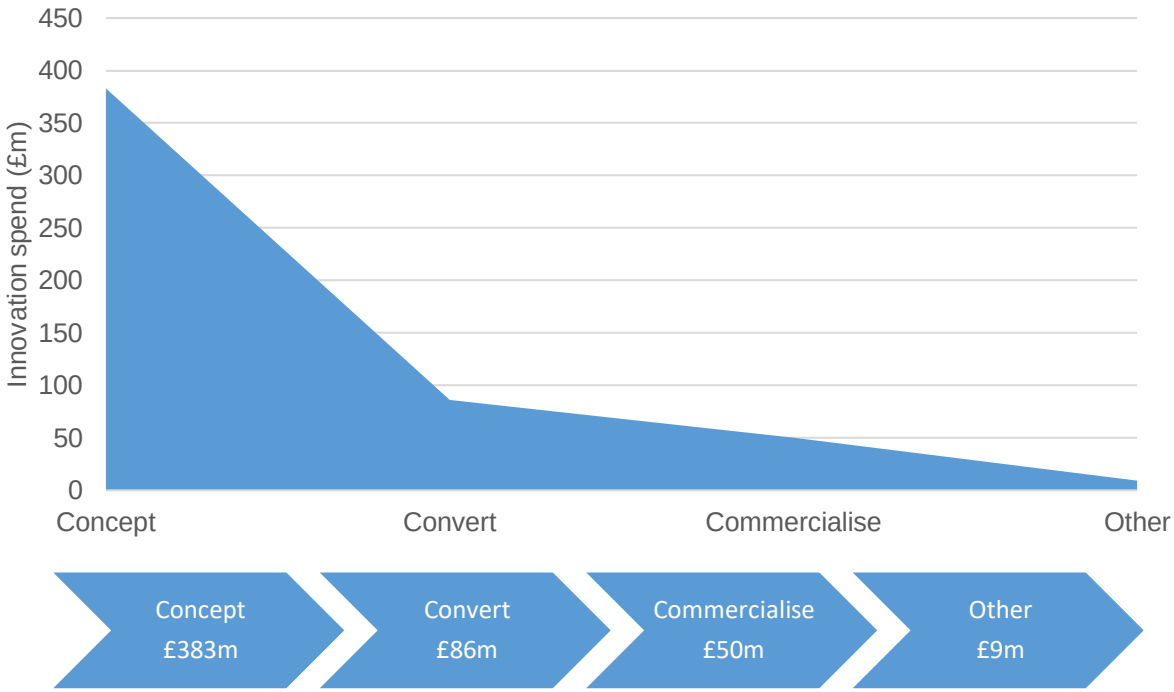
Finally, there is a role for government in providing the basic infrastructure for innovation to thrive, from digital infrastructure to skills programmes to funding for basic research.

3.2 The Innovation Support Landscape in Scotland

The innovation support landscape in Scotland is complex. It includes grants and wider non-financial support for innovation and around 90 innovation initiatives across the Scottish Government and enterprise and skills agencies, with estimated funding of around £480m in 2018-19. This rises to around 500 initiatives when including innovation funds run by other organisations, such as the UK Government, EU, and third sector.

[25] RAND Europe, 2017, Evidence synthesis on measuring the distribution of benefits of research and innovation

Figure 1: Innovation Spend in Scotland by Scottish Government and Agencies, 2018-19 (£m)



Source: Enterprise and Skills Strategic Board Innovation Review

As illustrated in the diagram above, innovation support spending is heavily skewed towards the earlier 'concept' stage of the innovation journey. A large portion of this (around £284m in 2018/19) is research funding for higher education institutions which, while potentially contributing towards innovation, has broader objectives. Even excluding this funding, there is around £200m per annum of innovation support from the Scottish Government and the enterprise and skills agencies[26]. Additionally, of the 49 initiatives across the enterprise and skills system, 85% of funds are administered by agencies, with 16 of the funds spending £100,000 or less in 2018/19.[27]

In light of this complex landscape, in September 2021 the Enterprise and Skills Strategic Board undertook a high-level review of innovation support in Scotland. As part of this, the Scottish Government Enterprise and Skills Analytical Unit drew together existing evidence on the range of different innovation support initiatives and mapped these against the established innovation framework set out by ministers. A table of this mapping is shown overleaf.

[26] Please note that for figure 10, some programmes were counted more than once if they related to multiple aspects of the innovation framework.
[27] Enterprise and Skills Strategic Board's (ESSB) Innovation Review

Figure 2: Mapping Innovation Support Initiatives in Scotland

	Infrastructure	Activities	Organisations
Commercialise	University Innovation Fund (SFC) (SG); Medicines Manufacturing Centre Oil & Gas Technology Centre	Small Innovation Grant (HIE) Innovate Your Business (Advisor Support) (HIE) Scaling Accounts (SE) HGV Advisor Support (SE) High Growth Spinout Programme (SE) Unlocking Ambition (SG) Enabling Grants (SE) Scottish co-Investment Fund (SE) Can do Innovation Challenge Fund Edge (SG)	(SG); Wave Energy Scotland Hydro Nation Water Innovation Service Scotland Can Do
Convert	The Innovation Centre Programme (SFC) University Innovation Fund (SFC) (SG); Fraunhofer Lightweight Manufacturing Centre Medicines Manufacturing Centre Oil & Gas Technology Centre	HIE Business Funding (HIE) Innovate Your Business (Advisor Support) (HIE) Northern Innovation Hub (HIE) SMART (SE) ScotGrad Innovation Support (HIE) Industry – Academia links (SFC) Innovation Voucher Scheme (SFC) (SG); Edge CivTech Unlocking Ambition	Interface (SFC) Wave Energy Scotland (SG)
Concept	Research Postgraduate Grant (SFC) Research Excellence Grant (SFC) The Innovation Centre Programme (SFC) University Innovation Fund (SFC) (SG); Research Institutes Funding Fraunhofer Medicines Manufacturing Centre Oil & Gas Technology Centre	ScotGrad –Graduate Placement (HIE) Industry – Academia Links (SFC) Innovation Voucher Scheme (SFC) Research Pools (SFC) Strategic Funds KE (SFC) (SG); EXPO Fund – festivals Innovation COIG Route Development Production Growth Fund Broadcast Content Fund Charging Points Knowledge Transfer Partnerships	Interface (SFC)

Source: Enterprise and Skills Strategic Board Innovation Review
Key: Lead organisation:
Scottish Funding Council (SFC)
Highlands & Islands Enterprise (HIE)
Scottish Enterprise (SE)
Scottish Government (SG)

The following key themes emerged from the Enterprise and Skills Board's Innovation review:

- **Strategy and promotion**: there is a need for a clear overarching strategy for innovation in Scotland which drives where funding is targeted and this needs to be accompanied by clear branding which businesses can easily recognise.

- **Complexity**: over time a substantial number of small innovation funds have been established, many of which are trying to achieve common objectives. These are often designed around the administrative arrangements for service providers rather than the needs of the end user.

- **Flexibility**: greater flexibility is required as often support is targeted at particular sectors, potentially limiting viable proposals from businesses in other parts of the economy.

- **Coordination**: there is scope for much greater coordination to maximise the impact from Scotland's investment in innovation, as most initiatives currently exist in isolation.

- **Collaboration and knowledge transfer**: existing networks and groups, such as the Innovation Forum, could be utilised to foster greater collaboration between funding organisations and a step-change is required in knowledge transfer between research organisations and Scottish businesses.

- **Language and accessibility**: innovation often means different things to different people, and this can act to limit the ability of firms to access the right support at the right time.

3.3 Effectiveness of Innovation Policy Interventions

Recent work by the Scottish Government Enterprise and Skills Analytical unit concluded that there is currently limited evidence on the impacts of innovation activities within Scottish Government and its agencies. This does not necessarily mean that these initiatives are not achieving benefits, but the lack of evidence makes it difficult to judge which initiatives are having the greatest impact on the Scottish economy.

We can however draw on international evidence to consider which types of policy interventions are most effective in stimulating innovation. Recent research from Bloom, Van Reenan and Williams[28] synthesized a wide body of evidence to produce a 'toolkit' for policymakers which ranks the effectiveness of innovation policy levers in terms of the quality and implications of the available evidence and the policies' overall impact from a social cost-benefit perspective. Policies were also scored in terms of their speed and likely distributional effects (Figure 12).

[28] Bloom, Van Reenen and Williams, 2019, A toolkit of policies to promote innovation, Journal of Economic Perspectives—Volume 33, Number 3—Summer 2019—Pages 163–184

The evidence reviewed suggests that, in the short run, R&D tax credits along with direct public funding are the most effective while, over the longer term, increasing the supply of human capital (for example, through expanding university admissions in the areas of science, technology, engineering, and mathematics) is more effective. Encouraging skilled immigration was seen to have significant effects even in the short run. Competition and open trade policies were deemed likely to have benefits that are more modest for innovation, but as they are relatively less costly in financial terms, also score highly.

Figure 3: Review of International Evidence on the Effectiveness of Innovation Policies to Promote Innovation[29]

	Quality of evidence	Conclusiveness of evidence	Net benefit	Timeframe	Effect on inequality
Direct R&D grants	Medium	Medium	++	Medium run	
R&D tax credits	High	High	+++	Short run	
Patent box	Medium	Medium	Negative	N/A	
Skilled immigration	High	High	+++	Short - medium run	
Universities: incentives	Medium	Low	+	Medium run	
Universities: STEM supply	Medium	Medium	++	Long run	
Trade & competition	High	Medium	+++	Medium run	
IP reform	Medium	Low	Unknown	Medium run	Unknown
Mission-oriented policies	Low	Low	+	Medium run	Unknown

Source: Bloom, Van Reenen and Williams, A Toolkit of Policies to Promote Innovation

[29] Column 1 summarizes the authors' view of the quality (in terms of quantity and credibility) of the available empirical evidence; column 2 summarizes the conclusiveness of the evidence for policy; column 3 scores the net benefit (benefits minus costs) in terms of a '+' ranking where three is the highest. This ranking is meant to represent a composite of the strength of the evidence and the magnitude of average effects. Columns 4 considers whether the main effects would be short term (three to four years), medium term, or long term (ten years or more), and column 5, the likely effects on inequality.

4. Scotland's Recent Innovation Performance

There are various measures for tracking innovation in the economy. This section considers some of the main measures and shows that Scotland has a mixed performance on the international stage in terms of innovation, with areas of strength such as higher education and business spending on research and development, but also some challenges including the proportion of firms innovating and in terms of innovation outputs including patent and trademark applications.

4.1 Expenditure on Research and Development

4.1.1 Gross Expenditure on Research and Development

Gross Expenditure[30] on Research and Development (GERD) comprises R&D undertaken by the Business Enterprise (BERD), Higher Education (HERD), Government (GovERD) and Private Non-Profit (PNP) sectors.

Box 1: Changes to ONS research and development statistics

The Office for National Statistics are currently leading a large-scale project to transform R&D statistics which has significantly affected BERD and HERD data and therefore the overall GERD figures. The new BERD data uses an improved estimation methodology, to better account for small businesses, resulting in significant uplifts to the BERD spend (effectively doubling previous estimates for Scotland). The source of the HERD estimates has changed, resulting in uplifts to the HERD spend estimates (around 40% up on previous estimates). These methodological changes have been implemented for the period 2018 onwards, meaning that comparisons of estimates for GERD, HERD and BERD before 2018 are not possible. Further detail on these methodological changes is available in the Gross Expenditure on Research and Development, UK: 2020 publication.

There are several caveats associated with the new data which are important to bear in mind. Firstly, there is currently uncertainty around the robustness of the sub-UK BERD data, including that for Scotland. As a result, ONS has temporarily paused the National Statistics status of the sub-UK data. Secondly, the R&D spend values are expressed as a share of GDP to enable cross country comparisons. However, it is important to note that GDP was particularly low in 2020 as a result of the COVID-19 pandemic. And therefore, the share of GDP measures are particularly high in 2020. In addition, the GDP series have not yet been adjusted to incorporate the R&D spend uplifts. However, this is a lesser issue given the scale of GDP against R&D spend.

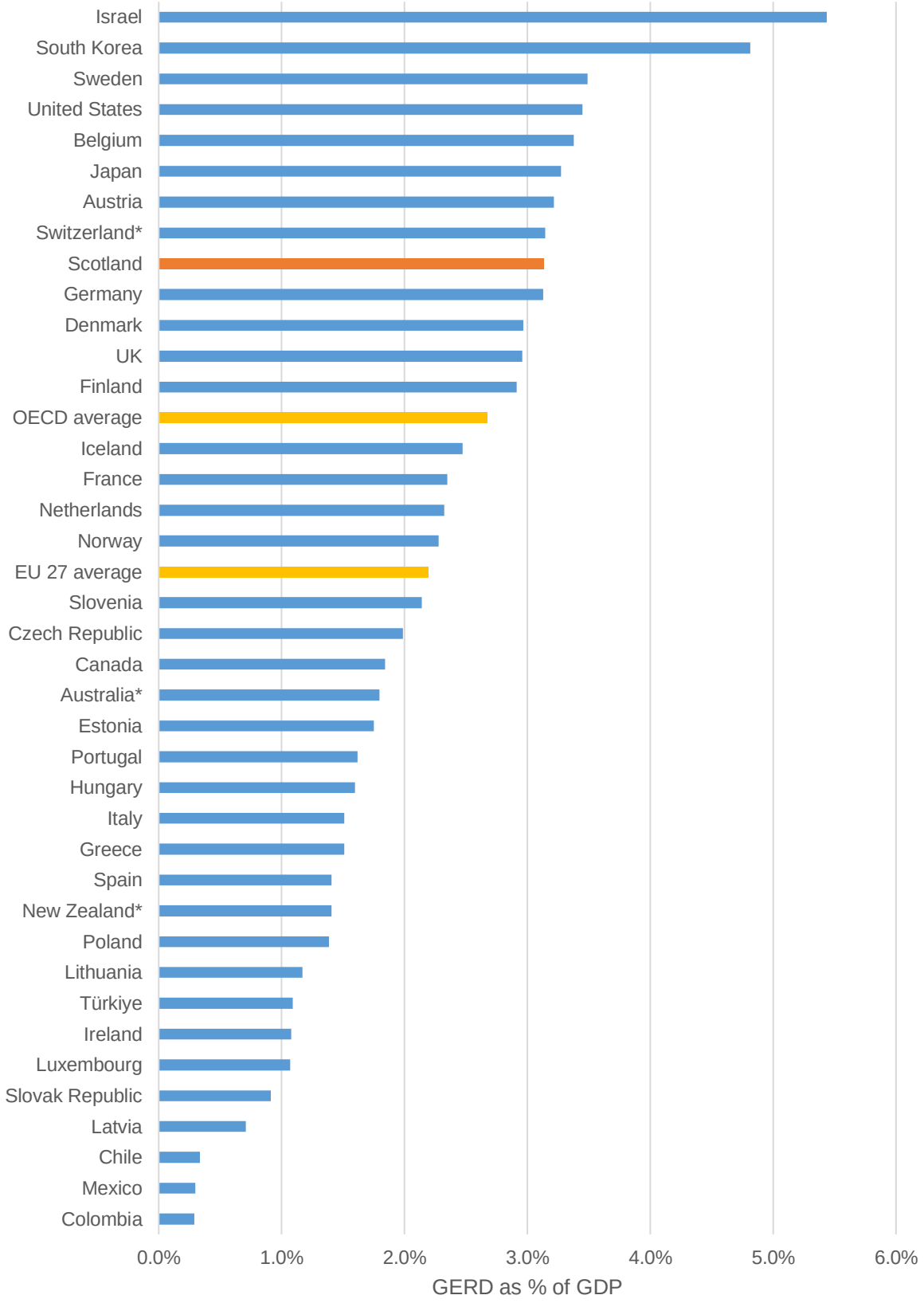
In 2020, GERD spend in Scotland was estimated at £4,795 million, an increase of 1.2% (£58 million) since 2019. In comparison, UK GERD increased by 3.5% over the same period.

[30] Scottish Government, Gross expenditure on research and development Scotland 2020

Looking at the four components of GERD, BERD spend accounted for the highest proportion of total GERD in Scotland in 2020 at 61%, followed by HERD (34%), GovERD (4%) and PNP (1%).

GERD represented an estimated 3.13% of GDP in Scotland in 2020, compared to 2.96% in the UK as a whole. Scotland's GERD as a percentage of GDP was above that of the EU-27 average (2.19%) and the OECD average (2.67%) in 2020. As a result, Scotland's GERD as a share of GDP ranked in the top quartile of the OECD countries in 2020 (Figure 4). However, it is important to note that GDP was particularly low in 2020 as a result of the Covid-19 pandemic.

Figure 4: Gross Expenditure on R&D Across the OECD, 2020



Source: GERD Scotland 2020
Note: *For these OECD countries, 2020 data is not yet available and so 2019 data used.

4.1.2 Business Enterprise Research and Development

As noted in Box 1, the methodology used to produce the BERD spend estimates has been improved to better represent smaller businesses. However, there is currently uncertainty around the robustness of the estimates for Scotland.

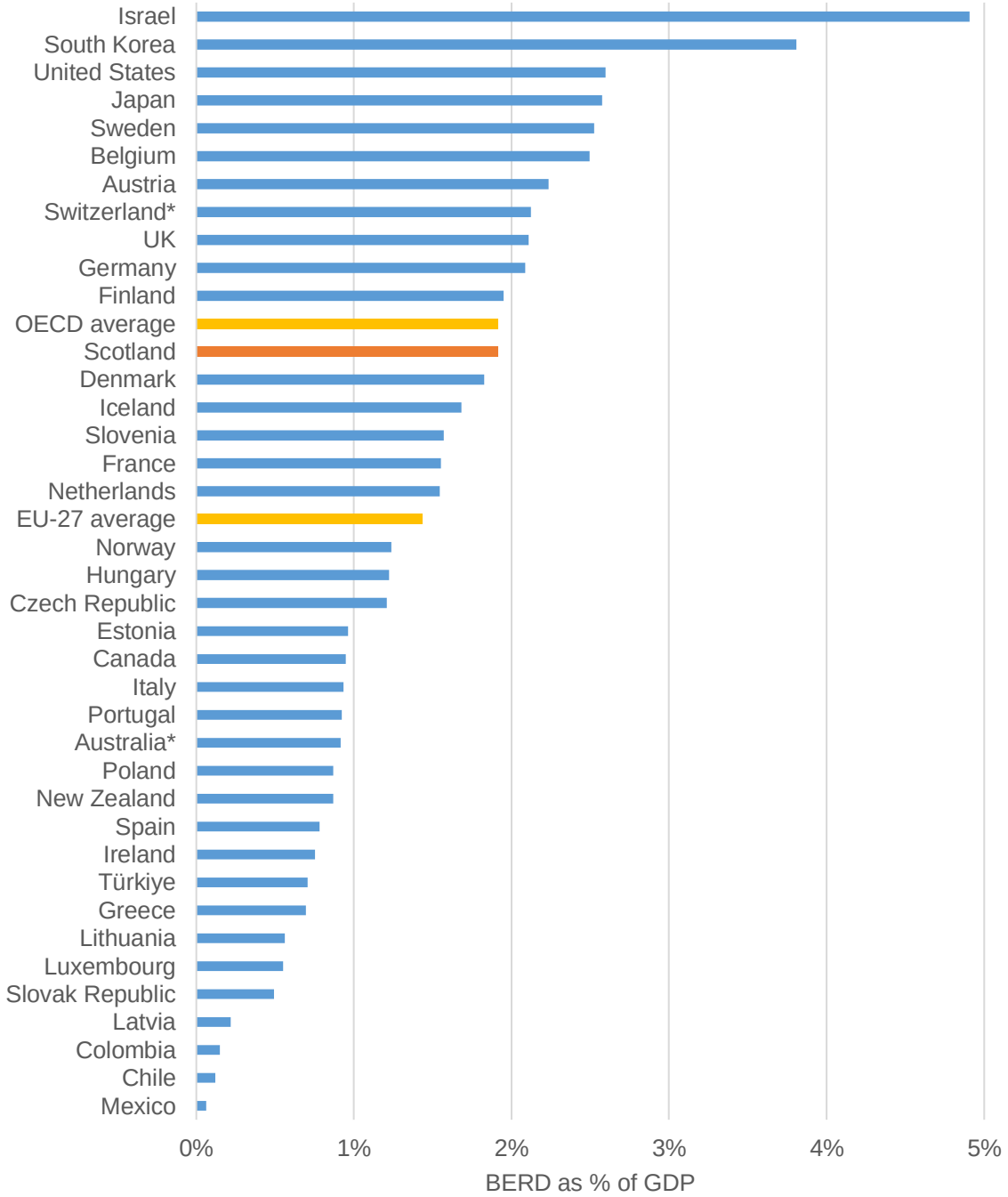
The latest data shows that BERD spend in Scotland was estimated at £3,121 million in 2021, an increase of £194 million (6.6%) since 2020 and £356 million since 2018[31].

BERD expenditure represented an estimated 1.86% of Scottish GDP in 2021, which was a decrease from 1.91% in 2020. However, it is important to note that GDP was particularly low in 2020 as a result of the COVID-19 pandemic. In 2021, BERD accounted for a lower proportion of GDP in Scotland than in the UK as a whole (2.00%).

In 2020[32], Scotland's BERD spend as a share of GDP (1.91%) ranked in the second quartile of the OECD countries, above the EU average (1.43%) but below the average for OECD countries (1.92%) and the UK (2.11%).

[31] The methodological changes to BERD (see box 1 for more detail) have been implemented for the period 2018 onwards. Comparisons prior to 2018 are therefore not possible.
[32] While 2021 headline BERD data is available for Scotland, only 2020 data is available for international comparisons.

Figure 5: Business Enterprise Expenditure on R&D across the OECD, 2020



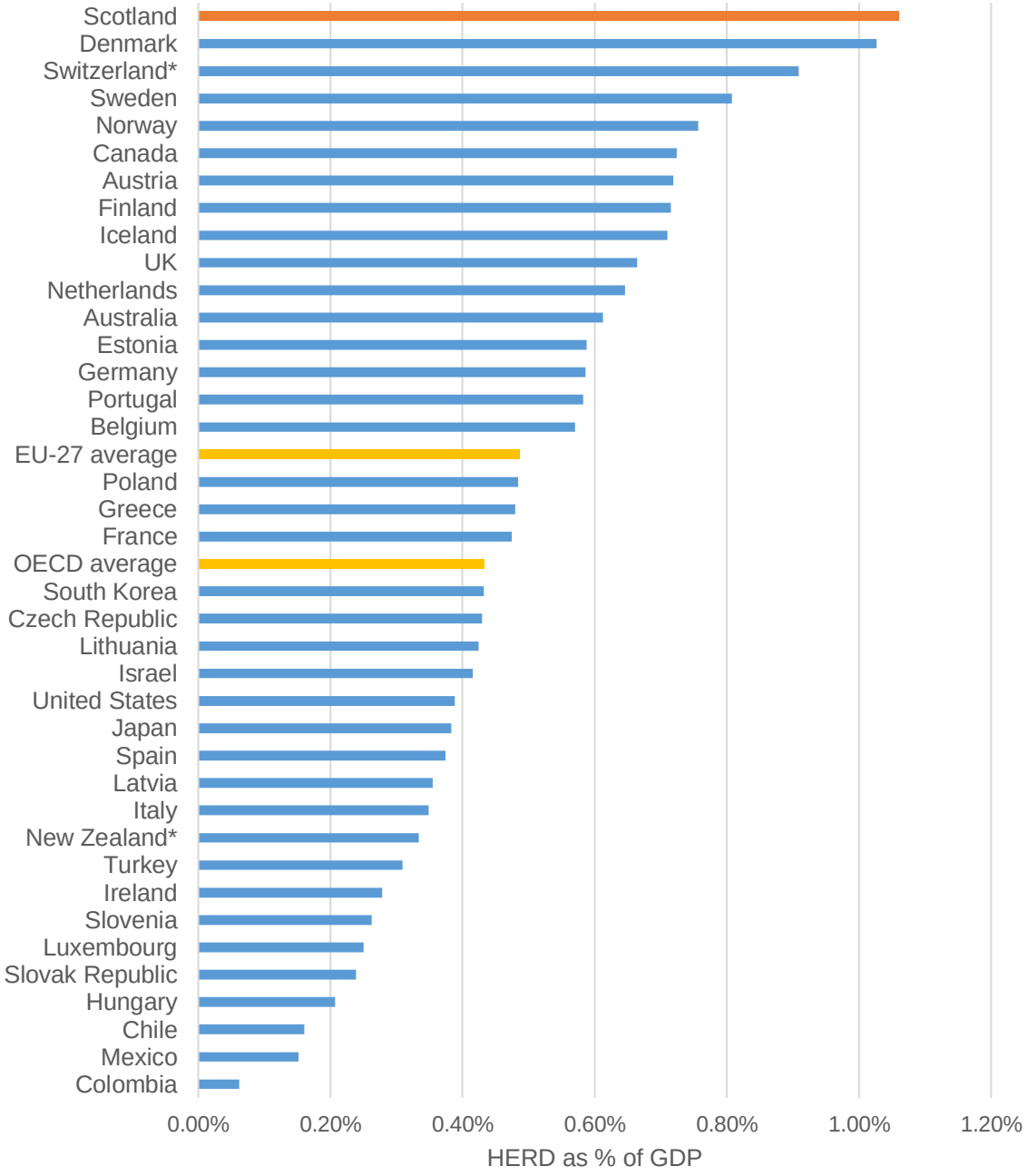
Source: Gross Expenditure on Research and Development Scotland 2020
Note: *For these OECD countries, 2020 data is not yet available and so 2019 data used

4.1.3 Higher Education Research and Development

Scotland's HERD spend was £1,623 million in 2020, 1.2% higher than in 2019. In contrast the UK's HERD decreased by -0.9% over this period.

In 2020, Scotland ranked top among the OECD countries for HERD spend as a percentage of GDP. HERD spend as a share of GDP in Scotland was 1.06% compared to 0.43% in the OECD as a whole.

Figure 6: Higher Education Expenditure on R&D across the OECD, 2020



Source: Gross Expenditure on Research and Development Scotland 2019
Note: *For these OECD countries, 2020 data is not yet available and so 2019 data used

4.1.4 Government Expenditure on Research and Development

In 2020, Government Expenditure on R&D (GovERD) in Scotland was £202 million, 9.8% (£18 million) higher than in 2019.

GovERD as a share of GDP was 0.13% for Scotland and 0.15% for the UK in 2020. Comparing internationally, Scotland ranked in the third quartile for GovERD as share of GDP (0.13%), lower the EU and OECD averages (0.26%).

4.1.5 Private Non-profit Research and Development

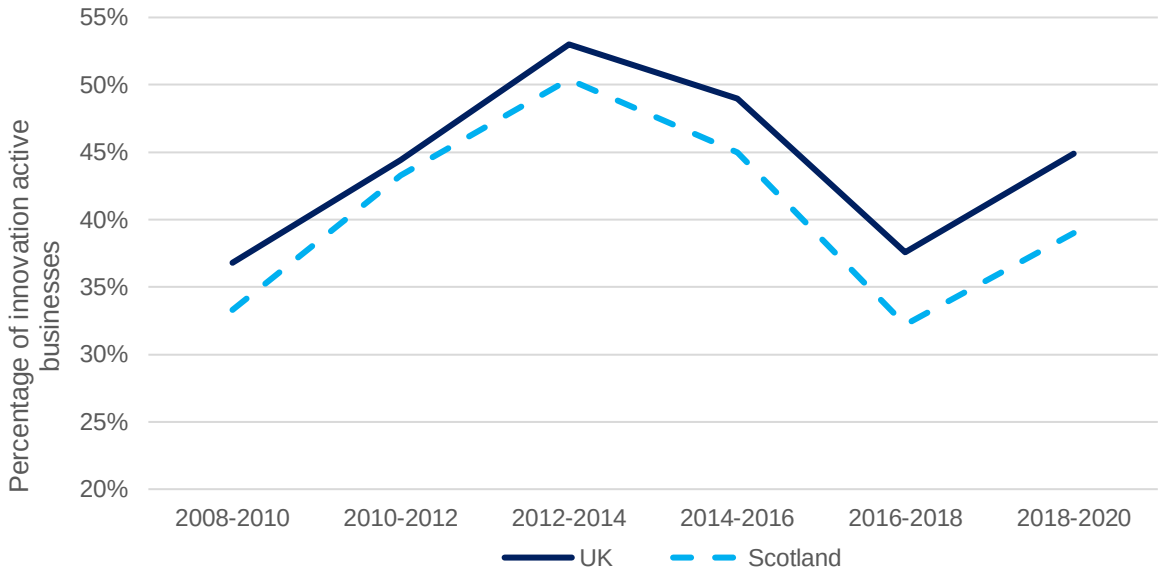
In Scotland, Private-Non-Profit (PNP) R&D spend was estimated at £43 million in 2020, 5.2% of the UK total and 0.03% of GDP.

The above evidence suggests Scotland performs very strongly on the international stage in terms of its higher education R&D spend and strongly in terms of its business R&D spend but under performs in terms of Government R&D spending.

4.2 Prevalence of Innovation Activity in the Business Base

The Scottish Government's National Performance Framework[33] tracks the level of innovation activity within Scotland's business base using data on the proportion of businesses that are 'innovation active'[34] from the UK Innovation Survey[35]. In 2018-20 (the latest period for which data is available), the share of 'innovation active' businesses in Scotland was 39.0%, lower than in the UK as a whole (44.9%). Between 2016-18 and 2018-20, innovation activity rose in both Scotland (+6.8 percentage points) and the UK (+7.3 percentage points).

Figure 7: Share of Innovation Active Enterprises in Scotland and the UK, 2008-10 to 2018-2020



Source: UK Innovation Survey 2019 – Results for Scotland

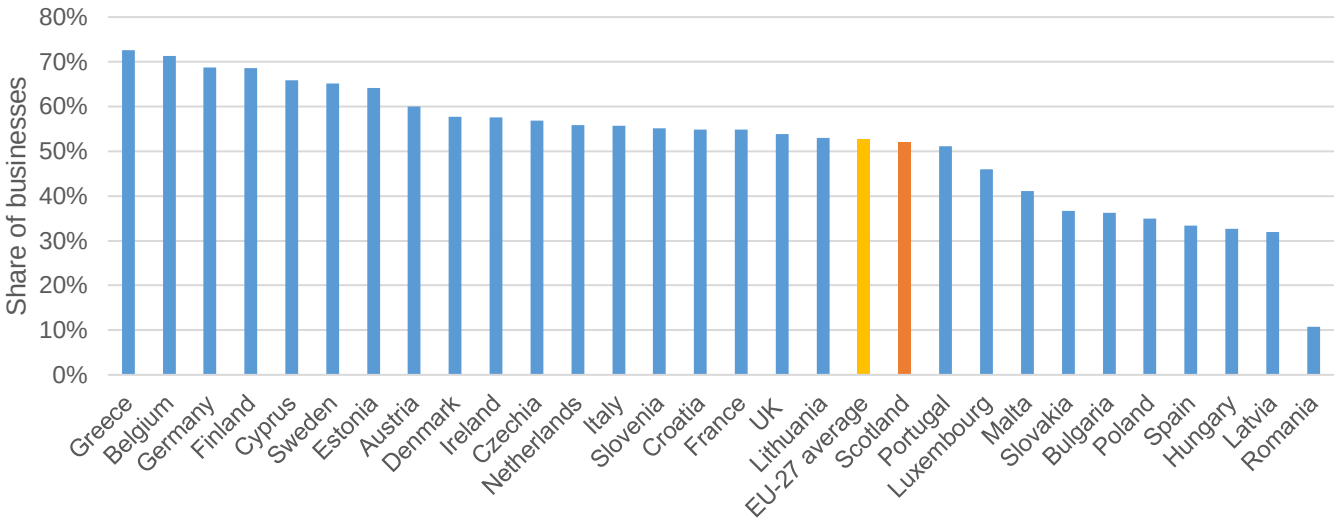
[33] Scottish Government, National Performance Framework

[34] The UKIS defines as business as being 'innovation active' if it has engaged in any of the following activities: the introduction of a new or significantly improved product (good or service) or process; engagement in innovation projects not yet complete, scaled back, or abandoned; new and significantly improved forms of organisation, business structures or practices, and marketing concepts or strategies.

[35] Scottish Government, August 2022, UK Innovation Survey 2021: Results for Scotland

When ranked against the UK and EU-27 countries[36], Scotland ranked 19th in 2018-20, placing it in the middle of the third quartile. The share of innovation active enterprises in Scotland (52.0%) was just below the EU-27 average (52.7%)[37].

Figure 8: Share of Innovation Active Enterprises, Scotland, UK and EU-27, 2018-2020



Source: Eurostat (based on Community Innovation Survey) and UKIS 2021

In terms of business size band, in 2018-2020 small (10-49 employees) businesses in Scotland were least likely to be innovation active (36.5%) and businesses with 100-249 employees were most likely to be innovation active (57.5%).

In terms of types of innovation, in 2018-2020, more businesses in Scotland were product innovators at 16.8%, than process innovators, at 13.3%. The UK outperformed Scotland in both the proportion of firms undertaking product innovation (20.5%) and process innovation (16.2%).

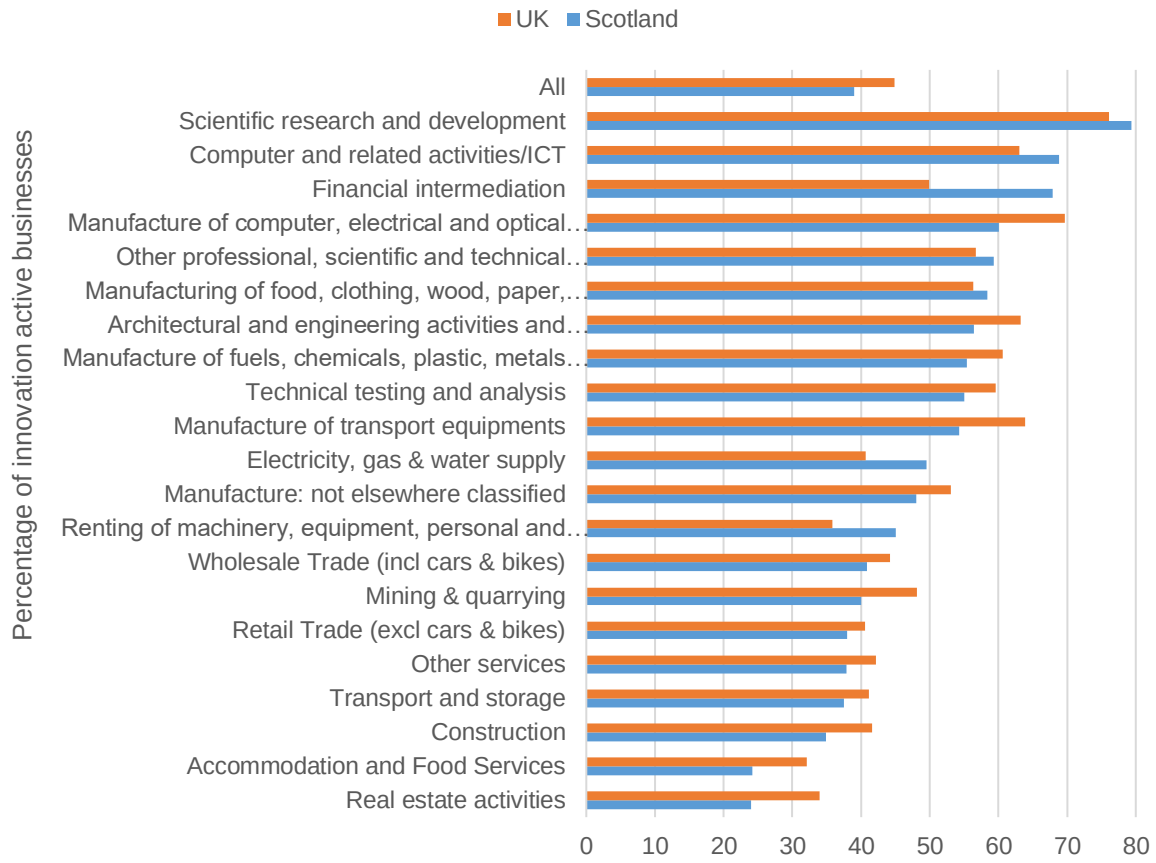
Innovation activity varies by sector. In 2018-20, businesses in the 'Scientific Research and Development' sector were the most likely to be innovation active in Scotland (79.3%). Businesses in the 'Real Estate Activities' (24.0%) and 'Accommodation and Food Services' (24.2%) sectors were least likely to be innovation active.

Compared to the UK, Scotland has a higher proportion of innovation active businesses in sectors including 'financial intermediation', 'electricity, gas and water supply', 'computer and related activities/ICT' and 'scientific research and development'. However, it underperforms the UK as a whole in a range of other

[36] Comparative data for OECD countries for 2018-20 is not yet available. Comparison is therefore with EU countries.
[37] It is important to note that for international comparisons, data on the percentage of innovation active firms is based on a subset of sectors of the sectors covered by the UKIS survey (focussing on the most innovative sectors).

sectors, most notability ‘real estate activities’, ‘manufacture of transport equipment’ and ‘manufacture of computer, electrical and optical equipment’.

Figure 9: Share of Innovation Active Businesses by Sector, Scotland and UK, 2018-20[38]



Source: Scottish Government, UK Innovation Survey 2021 – Results for Scotland

4.3 Broader Innovation Performance

The European Commission’s Regional Innovation Scoreboard[39], which assesses the performance of 240 European regional innovation systems against 21 indicators, provides an insight into Scotland’s key strengths and weaknesses in relation to innovation compared to the UK and EU. In 2021, Scotland was classified as a strong+ innovator, with its performance improving over time.

Of the 12 UK regions, Scotland ranked fifth, behind Southeast England, London, East England and South West England. Three UK regions (London, Southeast England and East England) were classified as innovation leaders with the remaining nine classified as strong innovators. Of the 240 European regions, Scotland ranked within the first quintile (43rd).

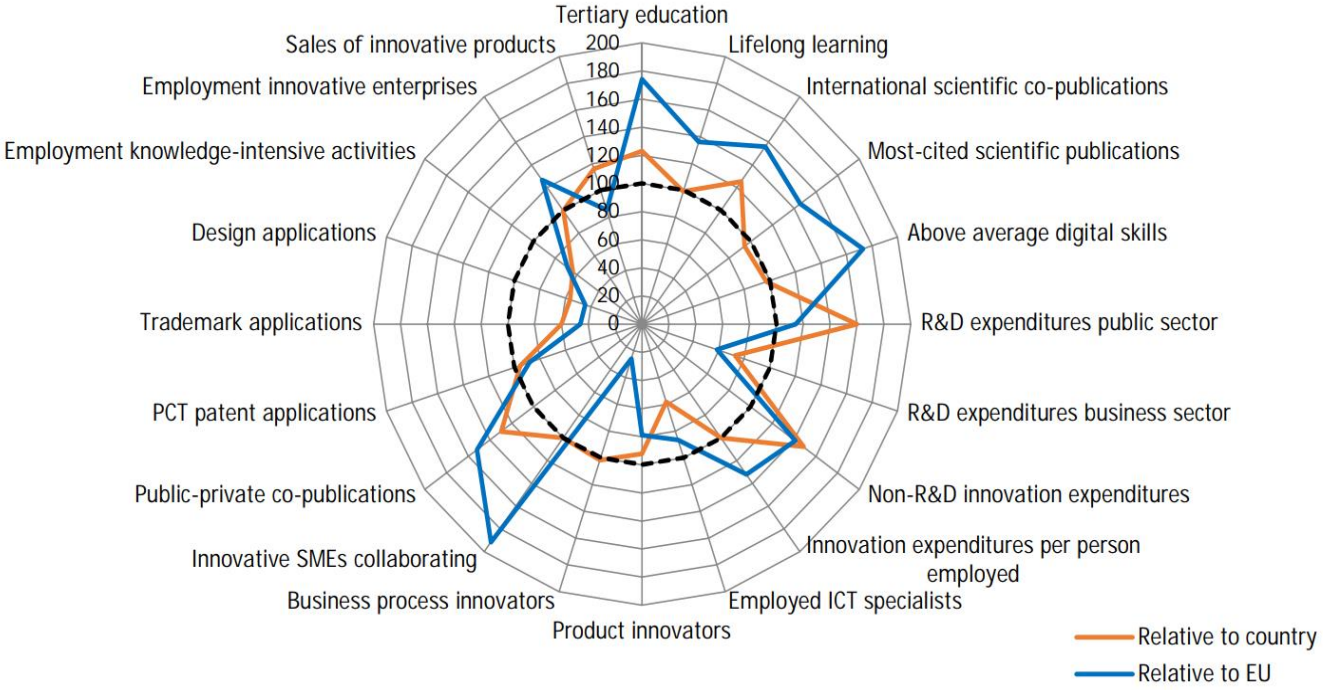
[38] A number of sectors (post and courier activities; motion picture, video and TV programme production/programming and broadcasting; telecommunications; and advertising and market research) are excluded from this chart as the data for Scotland is disclosive.

[39] European Commission, Regional Innovation Scoreboard 2021

As shown the diagram below, Scotland has mixed performance in innovation when compared to the EU, with some areas of strength but also some notable challenges. Scotland's innovation performance exceeds the EU average in the following areas: tertiary education; lifelong learning; international scientific co-publications; most-cited publications; above average digital skills; R&D expenditure public sector; non-R&D innovation expenditure; innovation expenditures per person employed; innovative SMEs collaborating; public-private co-publications; and employment in innovative enterprises.

Scotland's innovation performance falls short of the EU average in the following areas: R&D expenditure business sector[40]; employed ICT specialists; product innovators; business process innovators; patent applications; trademark applications; design applications; employment in knowledge-intensive activities; and sales of innovative products.

Figure 10: Relative Strengths of Scotland's Innovation System Compared to the UK and the EU[41]



Source: European Commission's Regional Innovation Scoreboard 2021

[40] It should be noted that this analysis will have been based on BERD data using the old methodology. Under the new methodology (see box 1 for further details), Scotland's BERD spend in 2021 as a share of GDP was higher than the EU-27 average (1.43%).

[41] Dashed black line indicates no difference, above indicates stronger performance and below indicates weaker performance.

5. Scotland's Sectoral Innovation Strengths – Analysis to Support the Choice of Priority Sectors

This section draws on existing evidence from a range of sources to identify sectors in which Scotland currently performs comparatively strongly on innovation and where it has the potential for further growth. It is anticipated that this analysis will be used alongside other analysis and expert advice from key stakeholders to identify a number of innovative technologies and economic clusters in which Scotland has the potential to be world leading.

The analysis draws on existing data to identify the sectors in which Scotland currently excels in and has the potential for further growth in three tiers:

- **Business capabilities** (closest to market): to identify sectors where businesses in Scotland currently perform most strongly in innovation. For this, we draw on Business Enterprise Research and Development (BERD) spend data and data on the proportion of innovation active businesses from the UK Innovation Survey. We also examine the relative proportion of risk capital and inward investment that sectors attract to provide an indication of which sectors have the most growth potential.
- **Application of innovation into business**: to identify the sectors where the application of innovation into business is highest. Here, we draw on analysis undertaken by NESTA which considers sectoral data on the level of patenting and business-higher education collaboration.
- **Higher education sector capabilities** (furthest from market): to identify the research areas in which Scottish higher education institutions (HEIs) currently excel in. For this, we draw on analysis undertaken by NESTA which considers how Scottish HEIs perform relative to UK HEIs on a range of research outputs including technical products, spin outs, patents and publications as well as data on the proportion of EU research funding secured by Scottish HEIs.

The strongest performing sectors are selected based on the extent to which they score highly across the metrics considered in each tier. If there is a desire to continue with this analysis, then one option might be to take a weighted composite indicator approach to further refine it.

It is important to consider the limitations of this analysis:

- The sectoral data from the existing official datasets used in this paper is not sufficiently disaggregated to identify sub-sectors at the level of detail required to identify 'niche' areas of expertise. For example, for the BERD and UKIS data, data is only available at the standard industrial classification (SIC) of economic activities division level or for groups of division level sectors. For this reason, this paper considers Scotland's innovation strengths in terms of broad sectors.
- The official data sources drawn on in this paper, by the nature of the way they are disaggregated at a sectoral level using SIC, do not provide sectoral breakdowns for emerging sectors that are not already an established part of Scotland's economy. It is therefore important that the data analysis is supplemented with

expert advice to provide the required 'forward look' on the sectors in which Scotland could and would like to be world leading.

- The sector definitions (in terms of the SIC codes they comprise) across the sources used are not consistent. It is therefore difficult to draw out the sectors in which Scotland excels consistently across the different metrics.
- Data on higher education sector capabilities at the sectoral level is not currently available, although it is possible to read across to an extent from subject specialisms.

5.1 Business Capabilities

This section seeks to identify the sectors in which businesses in Scotland currently perform most strongly in innovation and those that have the greatest growth potential. This provides an indication of sectoral innovation strengths that is 'closest to the market'. It reviews evidence on sectoral R&D spending, innovation activity and investment secured and finds that Scotland's business innovation capabilities lie primarily in the following sectors: scientific R&D (part of life sciences); computing/ICT; financial and insurance activities; professional/scientific/technical activities, with strengths also in business services; architectural, engineering and technical activities; energy; food and drink; space; fin tech and health tech.

5.1.1 R&D Spending

As noted in section 2, investment in R&D is a central pillar of innovation. By seeking new knowledge through research, businesses innovate by developing, designing and enhancing products, services, technologies and processes.

Here, data on business enterprise research and development (BERD) spending as a proportion of national gross domestic product (GDP) has been used to analyse how the level of R&D undertaken by businesses across different sectors in Scotland compares internationally (in this case, with the 16 countries for which data was available[42]). This provides an indication of whether Scotland is over or under performing on the international stage in terms of business R&D relative to its size.

It is important to note that the BERD data used for this analysis has not been revised to take account of the methodological changes to BERD outlined in Box 1 in section 4. It is therefore not comparable with the BERD data discussed in section 4.1.2 and is subject to change. Currently only headline Scotland BERD spend figures for 2018 to 2021 are available - further breakdowns (including by sector) under the new methodology are not yet available.

Figure 11 shows, for each sector[43], the percentage difference between BERD (as a proportion of GDP) for Scotland and the set of 16 other countries as a whole in 2019

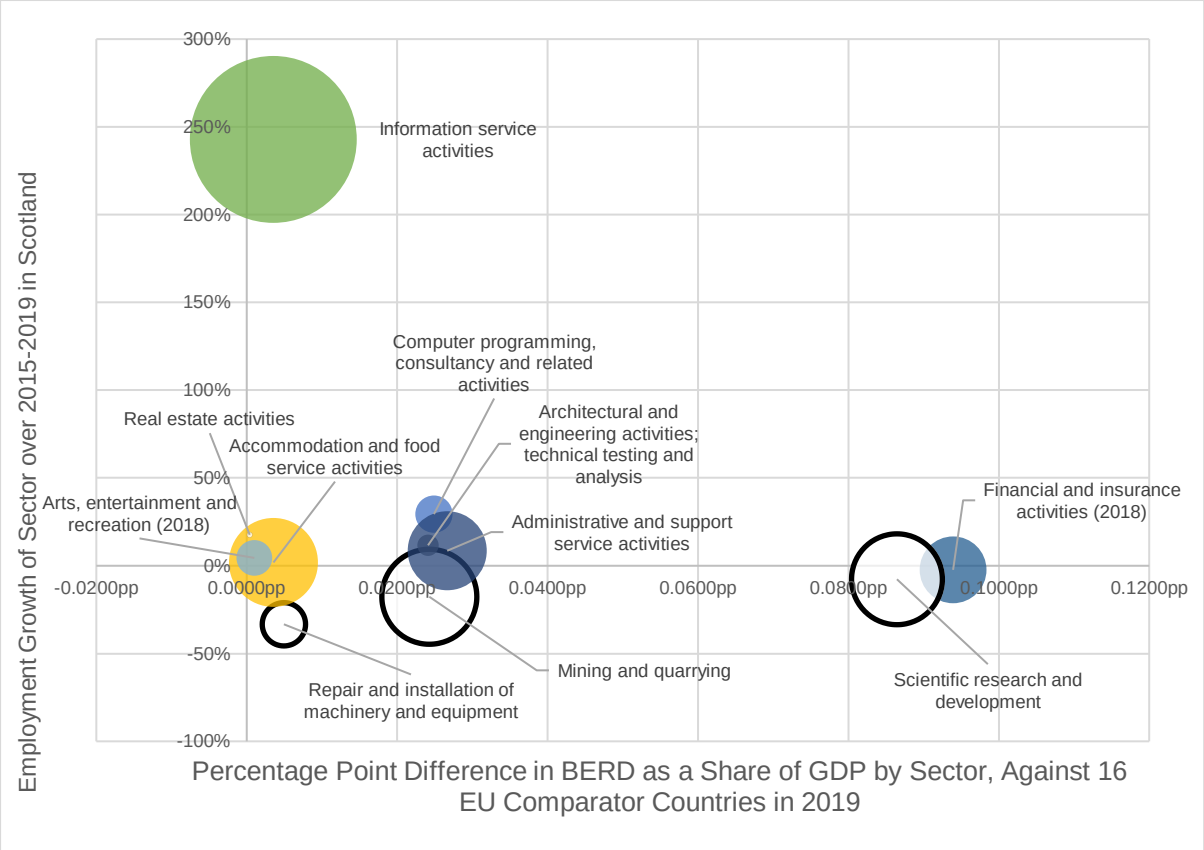
[42] The countries for which complete BERD data was available are: Czechia, Denmark, Germany (until 1990 former territory of the FRG) Ireland, Greece, Spain, Croatia, Italy, Malta, Portugal, Romania, Iceland, Serbia, Turkey, Bosnia and Herzegovina, South Korea

[43] Please note that for some sectors, larger divisions have been split, in order to draw out certain SIC codes. Please also note that only sectors in which BERD performance was positive are shown, in

(x-axis). This is mapped against the percentage difference in sectoral employment growth (percentage growth over the period 2015 – 2019[44]) for Scotland to add a dynamic element indicating potential future growth. Also shown is the level of GVA growth in each sector in Scotland (2015-2019), shown by the size of the bubble. Sectors which experienced negative GVA growth over 2015-2019 are shown as 'hollow bubbles' to indicate a fall in GVA. Together, these three elements can be taken to provide an indication of the sectors in which Scotland has a comparative advantage in business innovation.

To provide further detail, the data used in Figure 11 are set out in the table in Figure 12. Areas where the sector is performing positively are shaded green (varying from dark to light green to indicate strongest to weakest performance) and areas where the sector is performing negatively are shaded red.

Figure 11: Scotland's Sectoral Comparative Advantage in Business R&D Spend



Sources: Eurostat (EU BERD 2019) & Scottish Government Business enterprise research and development Scotland 2019 (BERD), Business Register and Employment Survey (BRES) 2015-2019 for Scottish Employment by sector, ABS (2015,2019) for GVA by division, QNAS (2015,2019) for GVA by Section.

order to only compare sectors in which Scotland's BERD growth as a share of GDP is outperforming the comparator countries considered.

[44] The latest period available for international comparisons prior to the Covid pandemic.

Figure 12: Scotland's Comparative Business R&D Spend Performance, Employment Growth and GVA Growth, by Sector[45]

Sector	Difference (% point) in BERD as a share of GDP between Scotland and comparator countries (2019)	Employment growth, Scotland 2015-2019 (%)	GVA growth, Scotland 2015-2019 (%)
Real estate activities (SIC 68)	0.0004	17.6%	-0.1%
Arts, entertainment and recreation (SIC 90 - 93)[46]*	0.0010	4.5%	3.4%
Information service activities (SIC 63)[47]	0.0035	242.9%	74.4%
Accommodation and food service activities (SIC 55, 56)	0.0036	1.9%	21.1%
Repair and installation of machinery and equipment (SIC 33)	0.0049	-33.3%	-6.3%
Architectural, engineering and technical activities (SIC 71)	0.0241	11.7%	1.2%
Mining and quarrying (SIC 5 - 9)	0.0243	-17.6%	-26.9%
Computer programming and consultancy activities (SIC 62)	0.0249	29.4%	3.7%
Administrative and support service activities (SIC 77 - 82)[48]	0.0267	8.6%	16.7%
Scientific R&D (part of Life sciences) (SIC 72)	0.0865	-7.7%	-24.7%
Financial and insurance activities (SIC 64 - 66)*	0.0939	-2.3%	11.9%

* 2018 BERD figures used due to disclosure issues with 2019 data

The following sectors perform strongly relative to the international comparator countries average for BERD spend as a proportion of GDP:

- Scientific R&D (part of Life Sciences)[49]
- Financial and insurance activities

[45] BERD 2019 Data used in conjunction with BRES (employment growth) and SABS (GVA) to create table, all data for 2019 except where otherwise specified

[46] Includes: Creative, arts and entertainment activities; Libraries, archives, museums and other cultural activities; Gambling and betting activities; Sports activities and amusement and recreation activities.

[47] Includes: Data processing, hosting and related activities; web portals; Other information service activities.

[48] Includes: Rental and leasing activities; Employment activities; Travel agency, tour operator and other reservation service and related activities; Security and investigation activities; Services to buildings and landscape activities; Office administrative, office support and other business support activities.

[49] The vast majority (99.5%) of BERD spend under SIC 72 falls into SIC 72.1 (Research and experimental development on natural sciences and engineering), which is part of the Life Sciences sector. It should be noted, however, that for the Life Sciences sector as whole, Scotland does not perform well against the international comparators due to very low BERD spending in SIC 21 (Manufacture of basic pharmaceutical products and pharmaceutical preparations).

However, the Scientific R&D sector saw negative growth for both GVA and employment while the Financial and insurance activities sector saw negative employment growth.

The following sectors achieved less strong BERD performance in comparison, but were still positive. For the most part (with the exception of Mining and quarrying and Repair and installation of machinery and equipment), these sectors also saw positive GVA and employment growth:

- Administrative and support service activities
- Computer programming and consultancy activities
- Mining and quarrying
- Architectural, engineering and technical activities
- Information service activities
- Arts, entertainment and recreation
- Real estate activities

5.1.2 Innovation Active Businesses

R&D is only one component of innovation. To provide a wider indication of Scotland's sectoral strengths in business innovation, sectoral data on the proportion of innovation active businesses[50] from the UK Innovation Survey[51] is used to determine the sectors in which Scotland has exhibited the highest growth in the innovation active businesses over recent years and where Scotland outperforms the UK in the latest period (2018-20) (Figure 13). Only sectors with around 50% or more innovation active businesses in the latest period are shown to focus on the most innovative sectors. Sectors where Scotland has both a positive average growth rate and outperforms the UK in the latest period are shown in green.

The analysis shows that Scotland performs strongly in terms of the proportion of innovation active businesses both in terms of growth over time and compared to the UK in the following sectors:

- Financial and insurance activities
- Computer and related activities/ICT[52]
- Scientific R&D (part of Life sciences)
- Other professional, scientific and technical activities[53]

[50] The UKIS defines as business as being 'innovation active' if it has engaged in any of the following activities: the introduction of a new or significantly improved product (good or service) or process; engagement in innovation projects not yet complete, scaled back, or abandoned; new and significantly improved forms of organisation, business structures or practices, and marketing concepts or strategies.
[51] UK innovation survey 2021: results for Scotland - gov.scot (www.gov.scot)
[52] Includes: Publishing activities (Publishing of books, periodicals and other publishing activities; Software publishing); Computer programming, consultancy and related activities; Information service activities (Data processing, hosting and related activities; web portals; News agency activities)
[53] Includes: Specialised design activities; Photographic activities; Translation and interpretation activities; Environmental consulting activities; Quantity surveying activities.

These sectors also saw the highest proportion of innovation active businesses in the latest period.

In addition, Scotland performs strongly relative to the UK in electricity, gas and water supply (SIC 35-39) although the sector's average growth rate in the proportion of innovation-active firms was moderately negative.

Figure 13: Scotland's Sectoral Comparative Advantage in Innovation Activity

Sector	Percentage of innovation active businesses, Scotland					Performance relative to UK in 2018-20 (% point difference)
	2012-2014	2014-2016	2016-2018	2018-2020	Average growth rate (2012-14 to 2018-20)	
Scientific R&D (SIC 72)	61.9	79.4	70.2	79.3	9.9%	3.3
Computer and related activities/ICT (SIC 58,62&63)[54]	52.7	81.2	61	68.8	14.0%	5.8
Financial and insurance activities (SIC 64-66)	67.8	46.3	28	67.9	23.8%	18.0
Manufacture of computer, electrical and optical equipment (SIC 26-28)	60.1	69.3	54.8	60	1.3%	-9.6
Other professional, scientific and technical activities (SIC 74)[55]	73.1	51.5	38	59.3	0.1%	2.6
Manufacturing of food, clothing, wood, paper, publish & print (SIC 10-18)	76.9	62	48.1	58.4	-6.8%	2.1
Architectural, engineering and technical activities (SIC 71.1)	63.1	70.3	57.3	56.5	-2.8%	-6.8
Manufacture of fuels, chemicals, plastic, metals and minerals (SIC 19-25)	51.5	60.7	50	55.4	3.7%	-5.2
Technical testing and analysis (SIC 71.2)	[c]	95	80	55.1	[c]	-4.6
Manufacture of transport equipment (SIC 29-30)	[c]	56.6	[c]	54.3	[c]	-9.6
Electricity, gas & water supply (SIC 35-39)	59.2	47.3	35.1	49.6	**-1.5%**	**8.9**

Source: UK Innovation Survey 2021: Results for Scotland

[54] Includes: Publishing activities; Computer programming, consultancy and related activities; Information service activities.
[55] Includes: Specialised design activities; Photographic activities; Translation and interpretation activities; Environmental consulting activities; Quantity surveying activities.

5.1.3 Investment: Risk Capital

While the analysis of R&D investment and innovation active businesses above primarily provides an indication of Scotland's current sectoral strengths in innovation, it is important to consider what sectors have the most growth potential. The availability of early-stage equity investment is an indicator of a strong business environment. It is a vital source of finance for start-ups and rapidly growing businesses looking to bring new technologies and innovative products and services to the market. Sectors attracting significant amounts of early-stage equity investment (risk capital) may therefore be seen to be those in which the market is signalling anticipation of bright future growth prospects.

Scottish Enterprise analysis[56] of Beauhurst data on the number of early-stage equity deals across sectors[57] in Scotland finds that the top three sectors in Scotland for risk capital have been consistent over the last six years. These are:

- Digital and IT
- Business Services
- Technology and Engineering

And to a lesser extent:

- Energy including renewables
- Food and drink
- Life sciences

In 2021, Digital and IT accounted for the largest share of deals at 26%, followed by Business Services (22%) and Technology and Engineering (20%). The remaining deals were spread across a range of sectors with Food and Drink and Life Sciences well represented alongside emerging areas such as Renewables, Fintech and Aerospace and Satellites.

[56] Scottish Enterprise, July 2022, 'Investing in Ambition: Scotland's Risk Capital Market in Context-2021'

[57] It should be noted that there is no single way of allocating companies to market sectors which paints the whole picture, because companies usually have multiple activities and multiple target markets for their sales. For the SE analysis, deals have been allocated to more than one sector where information is available - a deal can be counted in as many sectors as are relevant. The sectors chosen for analysis are a combination of those representing a core activity (Digital & IT, Business Services) and/or a target market (Fintech, Food & Drink, Oil & Gas).

Figure 14: Number of Early-Stage Equity Investment Deals in Scotland by Sector, 2016-2021

	2016	2017	2018	2019	2020	2021
SE - Aerospace and satellites	4	7	1	2	7	12
SE - Business services	104	165	140	185	164	162
SE - Digital & IT	153	200	203	228	243	193
SE - Energy-other	20	20	21	21	26	16
SE - FinTech	11	16	13	21	23	21
SE - Food & drink	43	56	66	58	64	67
SE - Life sciences	34	59	48	23	61	50
SE - Oil & gas	9	19	15	23	22	11
SE - Other	23	29	23	25	33	32
SE - Renewable energy	15	19	14	22	20	24
SE - Technology & engineering	90	141	115	165	155	145

Source: Scottish Enterprise, July 2022, Investing in Ambition: Scotland's Risk Capital Market in Context 2021

5.1.4 Investment: Inward Investment

As noted in section 2, there are strong links between innovation and inward investment, through knowledge exchange, technological diffusion, competition effects and supply chain linkages[58]. It is therefore important to consider which sectors Scotland performs most strongly in attracting foreign direct investment (FDI) to inform the choice of sectors for the Innovation Strategy.

Shaping Scotland's Economy: Inward Investment Plan,[59] published in October 2020, analysed Scotland's strengths in attracting FDI relative to European flows, then mapped these sectors according to their potential wider economic impacts, such as in supply chain impacts and innovation (see Figure 5 overleaf). This used a bespoke global database of FDI (fDi Markets) which allowed for detailed sectoral analysis. The following sectors were selected, following discussion with key stakeholders with knowledge in the area:

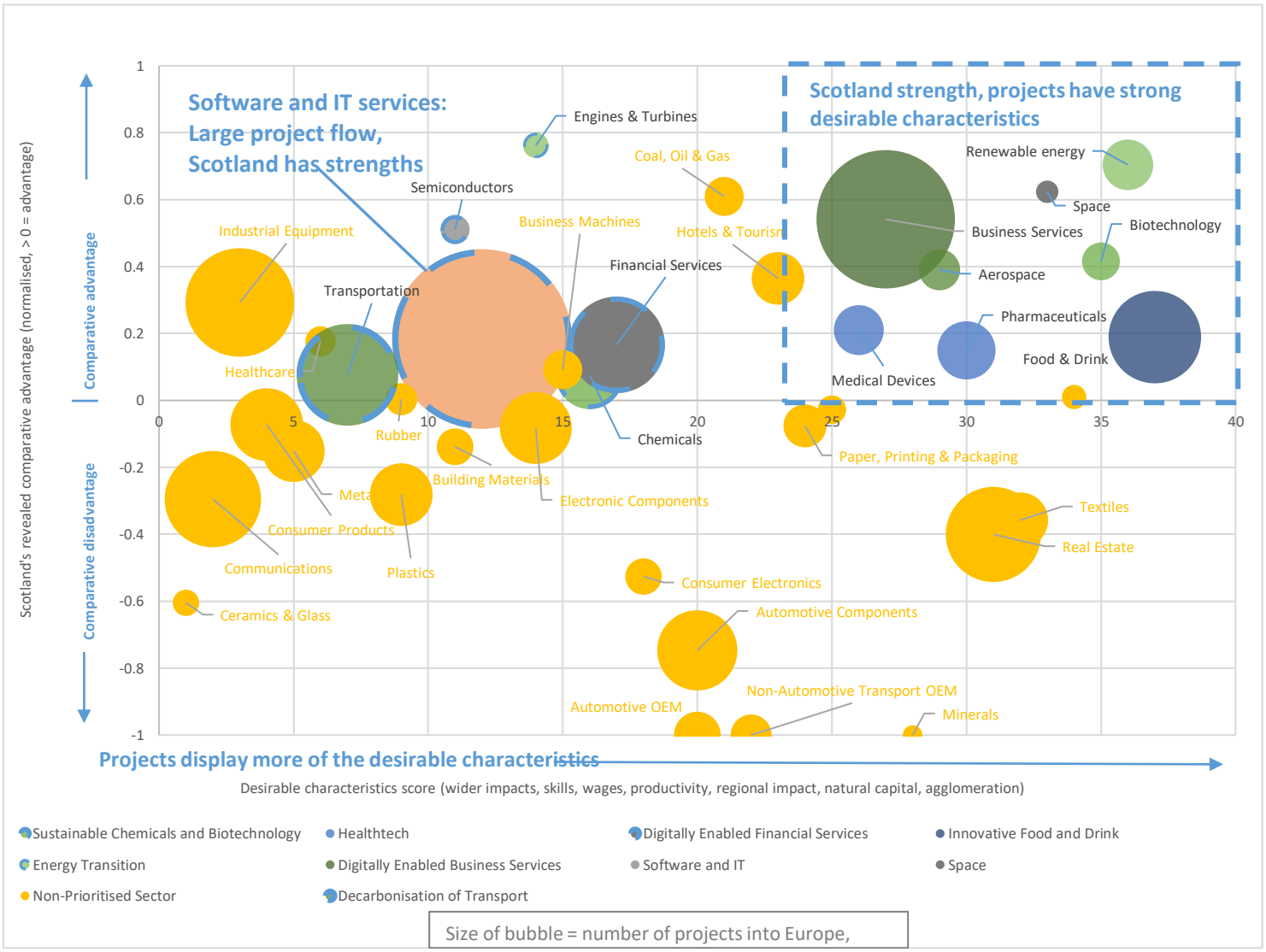
- Energy transition
- Decarbonisation of Transport
- Software and IT
- Digital Financial Services
- Digital Business Services
- Space

[58] See, for example, Does inward investment make regions more innovative? | Global Investments & Local Development (lse.ac.uk)
[59] Shaping Scotland's economy: inward investment plan - gov.scot (www.gov.scot)

- Healthtech
- Transformation of Chemical Industries
- Food & Drink Innovation

These nine opportunity areas broadly fall under three overarching areas: Net Zero; Digital; and High Value Manufacturing, with several of the opportunity areas contributing to more than one of these priority themes.

Figure 15: Inward Investment Plan Sector Analysis[60]



Source: Shaping Scotland's Economy: Scotland's Inward Investment Plan

[60] Scottish Government Inward Investment Plan, 2020

5.2 The Application of Innovation into Business

Whereas the previous section sought to identify sectors where businesses in Scotland perform strongest on innovation and have the most growth potential, this section draws on NESTA analysis using data on patenting and business-higher education collaboration and finds that the sectors where the application of innovation into business is highest are: computing/ICT; scientific R&D (part of life sciences); administrative services (part of business services); professional services; creative services; and health.

5.2.1 Patents

Patents are legal documents capturing inventive activity. As such, they provide a useful proxy for innovation that is likely to have commercial application, particularly in sectors where new knowledge is embodied in new products and machinery.

Research undertaken by NESTA[61] for the Scottish Government analysed levels of patenting in Scotland by sector between 2012 and 2019. It should be noted that the sectors used in the NESTA analysis are not directly comparable with those used in the BERD and UKIS analysis above[62]. The analysis showed that the top five sectors in terms of the level of patenting in Scotland are:

- Computing/ICT[63]
- Scientific R&D (part of Life Sciences)[64]
- Administrative Services (part of Business Services)[65]
- Creative Services[66]
- Health[67]

[61] NESTA, *Mapping Innovation in Scotland (*unpublished 2020)

[62] The NESTA analysis segmented official 4-digit SIC codes used to classify businesses into sectors into a set of 72 industries based on their economic similarities, which they estimated using measures of geographical co-location, distribution of occupations in their workforce and input-output flows.

[63] Includes: Computer consultancy activities; Computer programming activities; Accounting, bookkeeping and auditing activities; tax consultancy; Computer facilities management activities; Other information technology and computer service activities; Other information service activities n.e.c.; Data processing, hosting and related activities.

[64] This relates to SIC 72 only: Scientific R&D.

[65] Includes: Other business support service activities n.e.c; Combined office administrative service activities; Activities of call centres; Activities of collection agencies and credit bureaus; Photocopying, document preparation and other specialised office support activities. Note that these fall under the Business Services sector as defined by the Scottish Government's growth sectors.

[66] Includes: Specialised design activities; Photographic activities; environmental consulting activities; quantity surveying activities; Translation and interpretation activities; Convention and trade show organizers. NESTA note that "hidden in uninformative SIC codes we find what seems to be a thriving ecosystem of technical and architectural consultancies developing innovations related to Oil and Gas, Civil Engineering and Measurement. Perhaps their innovative capabilities could be deployed in other sectors in order to make Scotland's economy more diversified and resilient."

[67] Includes: Human health activities; Fitness facilities; Physical well-being activities; Hairdressing and other beauty treatment; Washing and (dry-)cleaning of textile and fur products.

The analysis also shows that, with the exception of R&D, these sectors also have a high level of specialisation in patents relative to the UK, which can be interpreted as evidence of competitive inventive advantage. Other sectors performing strongly on this measure include:

- Utilities[68]
- Manufacture of instruments[69]
- Oil and Gas (part of energy sector)[70]

5.2.2 Higher Education Institution and Industry Collaboration

Higher education institution (HEI)-industry collaboration can have significant effects in the sharing and development of new ideas, as well as facilitating the adoption of new knowledge and technologies. Like the patent data discussed above, sectoral data on collaborations can provide an indication of the sectors in which Scotland excels in more applied R&D and innovation that is likely to have commercial application.

NESTA analysed data on business participation in research collaborations with HEIs by sector[71]. Figure 16 shows the proportion of business collaborations with HEIs that each sector accounts for in Scotland (left hand figure) and the relative specialisation of Scotland in different sectors (the extent to which these sectors are over or underrepresented in university collaborations compared to the UK average) (right hand figure). The analysis considers only the top 30 sectors by share of activity in Scotland.

The analysis shows (left hand figure) that the top five sectors in terms of share of overall research collaboration activity in Scotland are very similar to the sectors identified through the analysis of patents:

- Computing/ICT
- Scientific R&D
- Creative services
- Administrative services (part of business services)
- Professional services (including architecture and creative, arts and entertainment activities) [72]

[68] Includes: Water collection, treatment and supply; Construction of utility projects for fluids; Engineering activities and related technical consultancy; Technical testing and analysis.
[69] Includes: manufacture of optical instruments and photographic equipment; Manufacture of medical and dental instruments and supplies; Repair of electronic and optical equipment; Manufacture of watches and clocks; Manufacture of motorcycles.
[70] Includes: Extraction of crude petroleum and natural gas; Support activities for petroleum and natural gas extraction.

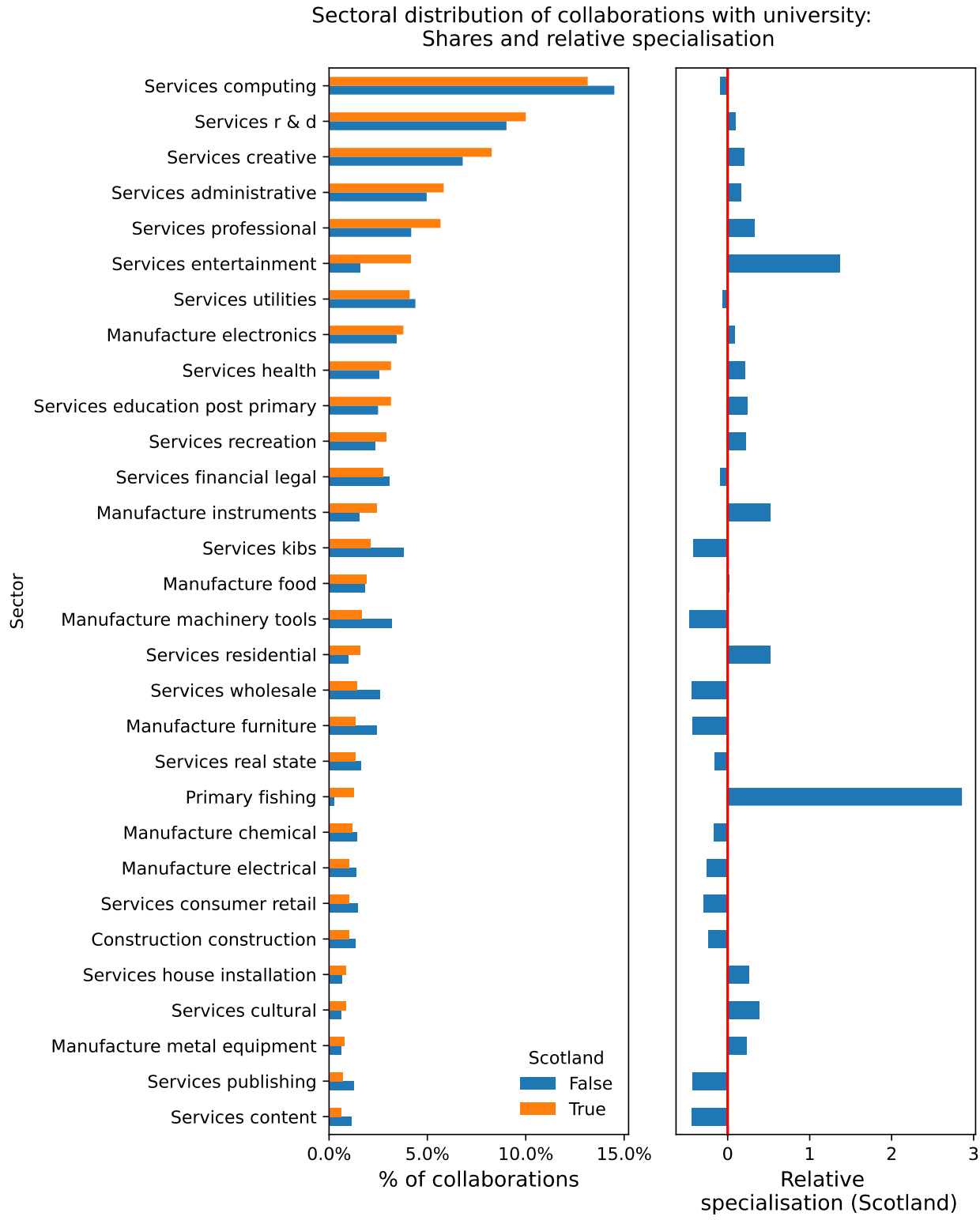
[71] The analysis matched the organisations that participate in UKRI-funded research collaborations with Companies House. This allowed NESTA to assign each of these organisations a SIC code, and to analyse the sectoral distribution of collaboration between different industries and universities.
[72] Includes: Architectural activities; Creative, arts and entertainment activities; Activities of membership organisations Web portals; News agency activities.

The analysis also shows (right hand figure) that these sectors (with the exception of computing) also perform strongly relative to the UK (in terms of the share of research collaborations the industry in Scotland accounts for relative to the UK). However, the sectors in which Scotland performs strongest relative to the UK are:

- Fishing
- Entertainment
- Manufacture of Instruments
- Residential Services
- Cultural

It should, however, be noted that these sectors (with the exception of entertainment) do not account for a significant share of Scotland's patenting activity).

Figure 16: Sectoral Distribution of Collaborations with HEIs, Scotland: Shares and Relative Specialisation[73]



Source: NESTA

[73] NESTA, Mapping Innovation in Scotland (unpublished 2020)

5.3 Higher Education Sector Capabilities

Whereas the previous section sought to identify sectors where the application of innovation into business is highest, this section focusses purely on Scotland's HEIs' research strengths in terms of research outputs and research funding secured. This includes both applied research likely to have direct commercial application (through examining data on research outputs including technical products, spin outs and patents) but also research outputs 'further from the market' including academic publications and competitive research funding secured.

The evidence reviewed on HEI research outputs and research funding secured indicates that Scotland's higher education institutions' innovation capabilities lie primarily in the following disciplines: health; computing/ICT; energy; biological sciences; nanotechnologies and emerging technologies; and physics and space.

5.3.1 Higher Education Institution Research Outputs

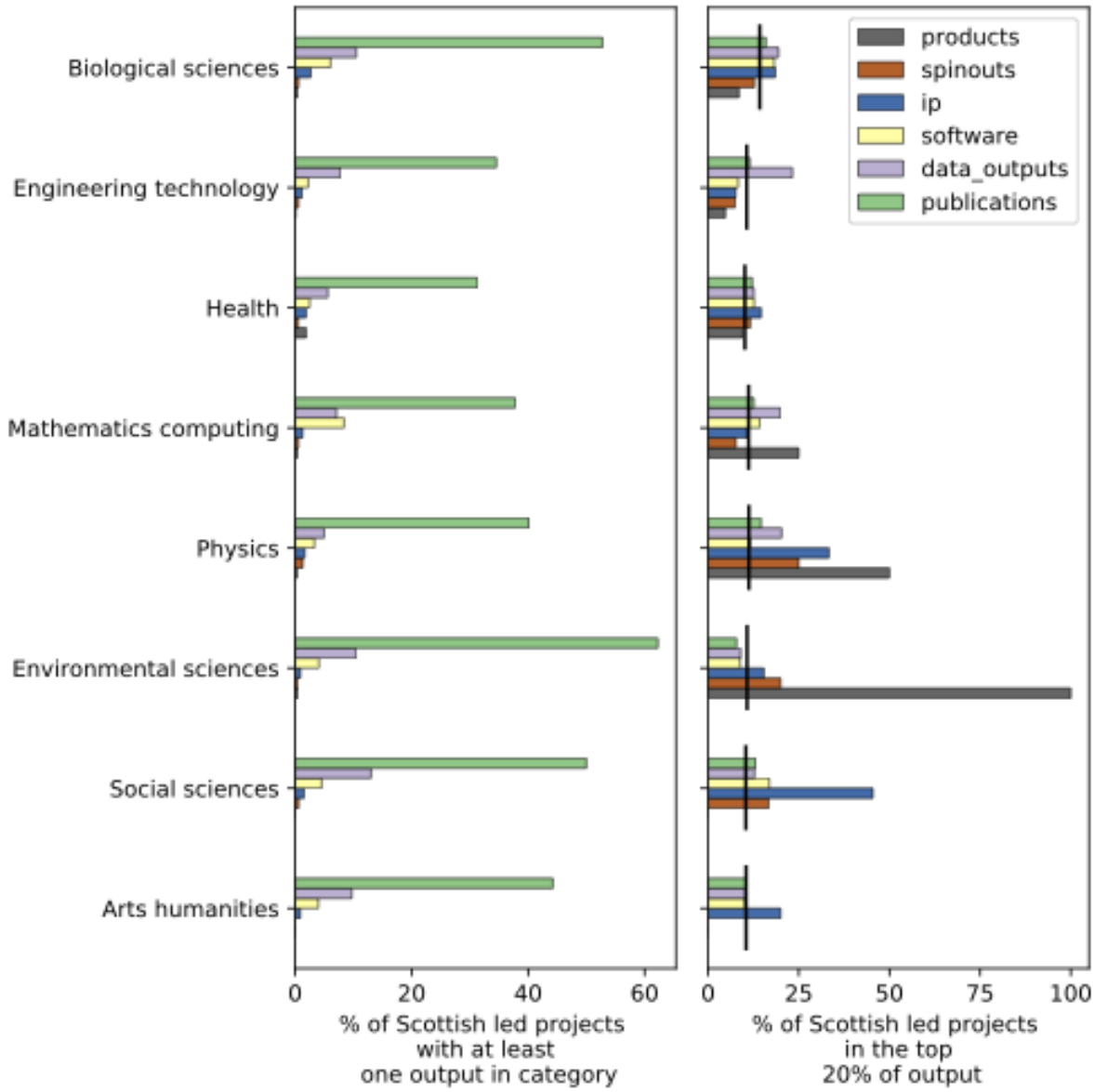
NESTA analysed research outputs from Scotland's universities and linked project data with information in the Gateway to Research about various research project outputs including academic publications, intellectual properties (including patents), technical products such as software, databases and models, products (generally health-related) and spinouts. Results are shown by discipline rather than by sector in figure 17. Difficulty in mapping subject disciplines to sectors is an issue prevalent in all of the HE data that has been assessed for this paper.

The left-hand panel shows the proportion of projects producing at least one output of each type in various disciplines – naturally publications dominate. More interesting for this piece is the right-hand panel, which focusses on the top quartile of productivity in each research output category. The vertical lines represent Scotland's share of projects in each discipline, helping us get a sense of whether Scottish projects are over or under-represented in the top productivity tier in each discipline and output category. It finds that Scottish-led projects tended to be overrepresented amongst the most productive in a variety of disciplines and categories. This was particularly visible in the following disciplines:

- Physics
- Biological Sciences
- Health
- Mathematics and Computing

Engineering and Technology projects tend to be underrepresented amongst the most productive. The spike in Environmental Science products is explained the fact that the only project in that discipline with one product output was led by a Scottish institution.

Figure 17: Higher Education Institution Research Outputs[74]



Source: NESTA

5.3.2 Higher Education Institution Competitive Research Funding Secured

Data on the proportion of competitive international research funding that Scotland's HEIs secure can provide an indication of Scotland's HEIs' relative areas of research strength on the international stage.

[74] NESTA, Mapping Innovation in Scotland (unpublished 2020)

This section draws on data on funding secured by Scottish HEIs[75] from the EU Horizon 2020 programme which was the EU's research and innovation funding programme from 2014-2020 with a budget of approximately €80B, allocated via open competition to projects in EU member states. Organisations could apply for funding for projects falling within the programme's three pillars[76], each of which contained a set of 'thematic objectives' – broad subject areas considered to be a priority for innovation in the EU. Given that funding could only be secured within the EU's 'thematic objectives' areas, this analysis does not cover research across all subject areas. It does however still provide an indication of where Scotland's HEI research strengths lie.

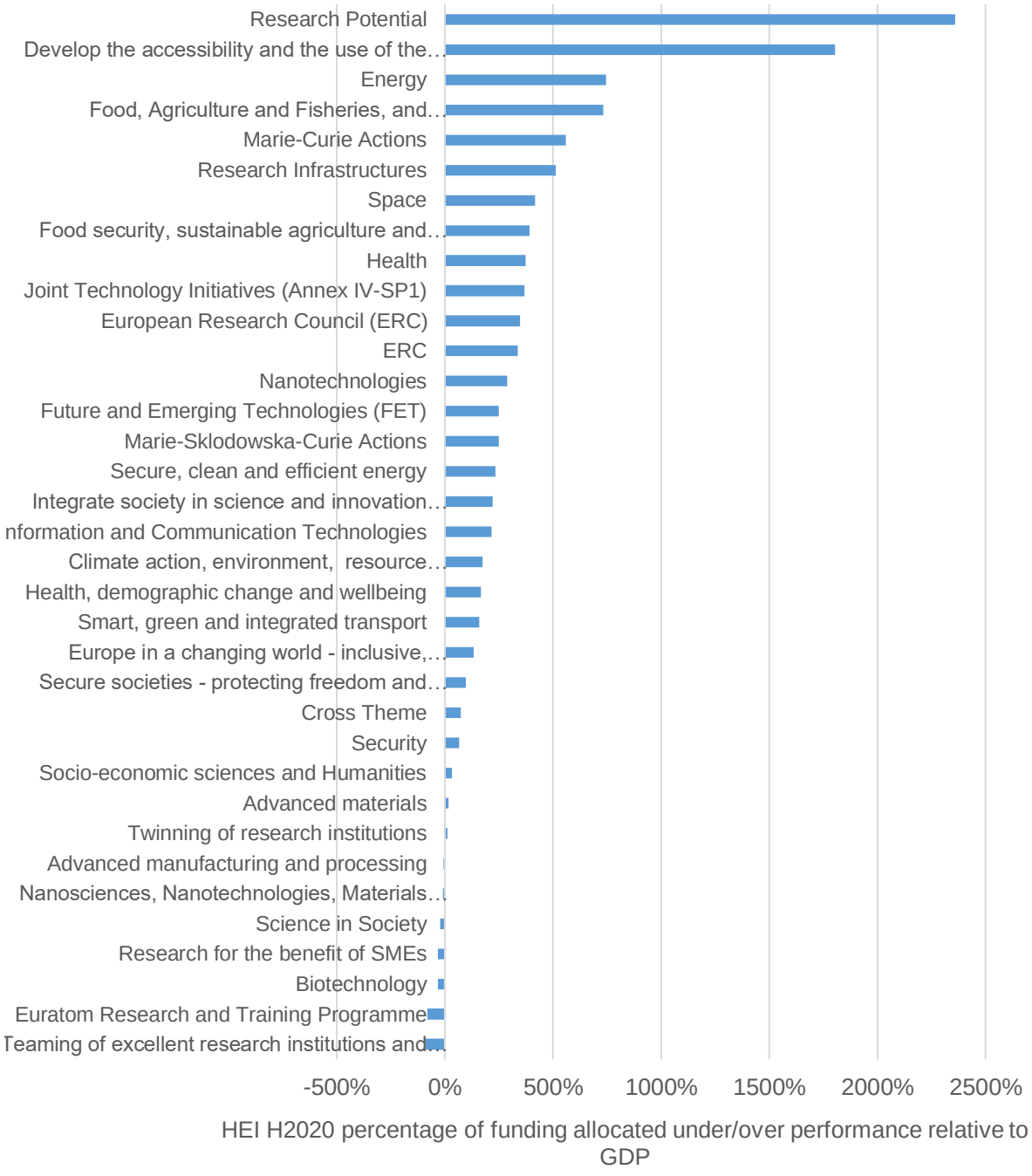
It is important to note that whilst this analysis focuses only on Horizon 2020 funding secured by HEIs, Horizon 2020 funding could also be secured by businesses, public bodies and research organisations. Whereas HEIs accounted for around three quarters (76%) of Horizon 2020 funding secured by Scottish organisations, the proportion of funding accounted for by HEIs across the EU as a whole was much lower at 34%. This potentially skews the results of this analysis which focuses only on HEI funding, with Scottish HEIs more likely to receive a higher proportion of funding in each 'thematic objective'.

To determine the areas in which Scotland's HEIs perform comparatively strongly in securing research, for each thematic objective, funding secured by EU HEIs as whole was normalised to Scottish GDP[77] and compared with actual funding secured by Scottish HEIs. The difference between this theoretical 'Scottish expected contribution' and the observed figures for received funding was then used a measure for Scottish over/under performance when the size of the Scottish economy is taken into account. As shown in Figure 18, the results indicate that Scottish HEIs perform comparatively strongly in research in the following areas[78]:

- Energy including clean and efficient energy
- Food, agriculture and fisheries, and biotechnology
- Space
- Health
- Nanotechnologies
- Future and emerging technologies
- Information and Communication Technologies

[75] The data covers funding secured by HEIs and secondary education establishments.
[76] The three pillars were *'Excellent Science', 'Industrial Leadership', and 'Societal Challenges'*.
[77] Scotland in 2019 had a nominal GDP approximately 1.2% the total size of the EU-27. All funding allocations by thematic objective were therefore reduced to 1.2% of their value for comparison with real Scottish observed figures.
[78] The areas highlighted below are those that correspond most closely with sectors. The 'thematic objectives' where Scotland performed strongest were 'research potential' and 'develop the accessibility and use of publically-funded research'.

Figure 18: Relative Performance of Scottish HEIs in Securing Horizon 2020 Research Funding by Thematic Bbjectives



Source: Horizon 2020 data (EU)

5.4 Summary Findings

This section has considered a range of evidence to seek to identify sectors in which Scotland currently performs strongly on innovation and where it has the potential for further growth at three tiers: business capabilities; the application of innovation into business; and higher education sector capabilities. The strongest performing sectors are selected based on the extent to which they score highly across the metrics considered in each tier.

The analysis was constrained by the lack of sufficiently disaggregated sectoral data, the lack of data on emerging sectors that are not yet an established part of Scotland's economy and the lack of sectoral data on higher education sector capabilities. The analysis therefore focused on Scotland's innovation strengths in terms of broad sectors. Despite these limitations, the analysis has provided some interesting insights on Scotland's sectoral strengths at a broader level.

- In terms of business capabilities, the evidence reviewed on sectoral R&D spending, innovation activity and investment secured indicates that Scotland's business innovation capabilities lie primarily in the following sectors: scientific R&D (part of life sciences); financial and insurance activities; professional services; architectural, engineering and technical activities; business services; and computing/ICT with strengths also in: communications; energy; food and drink; space; fin tech; and health tech.

- With regard to the application of innovation into business, the evidence reviewed on patents and business-higher education collaboration indicated that the sectors in which Scotland performs well compared to the UK are: computing/ICT; scientific R&D (part of life sciences); administrative services (part of business services); professional services and architecture; creative services; and health.

- Finally, in terms of higher education sector capabilities, the evidence reviewed on HEI research outputs and research funding secured indicated that Scotland's strengths lie primarily in the following disciplines: health; computing/ICT; energy; biological sciences; nanotechnologies and emerging technologies; and physics and space.

While the areas of strength that emerged in each strand of the analysis differ somewhat, a number of broad sectors showed strength across the tiers, as outlined in Figure 20. These are:

- Scientific R&D (part of life sciences)
- Computing / ICT
- Business Services
- Professional Services
- Architectural, engineering and technical activities
- Health
- Energy
- Emerging technologies (including fin tech, health tech and nanotechnologies)
- Space

It is important to note that data limitations have required this analysis to focus on broad sectors, that the exercise is necessarily backward looking, and that many new disruptive and radical innovations are not happening within specific sectors but rather between sectors. To identify our innovation priorities for the next ten years, our current strengths and potential must be balanced with industry insight into future opportunities and emerging markets where Scotland can claim a comparative advantage. Therefore, data analysis has been only one stage of the prioritisation exercise to identify more specific areas where Scotland has the potential to be world leading. Specifically, it has been necessary to build on this analysis with expert advice from industry, academia and the public sector.

Figure 19: Scotland's Broad Sectoral Innovation Strengths

Sector	Business capabilities	The application of innovation to business	Higher education sector capabilities
Scientific R&D (part of life sciences)	✓	✓	✓
Computing/ICT	✓	✓	✓
Financial and insurance activities	✓		
Business services	✓	✓	
Professional services	✓	✓	
Architectural, engineering and technical activities	✓	✓	
Creative services		✓	
Health	✓	✓	✓
Energy	✓		✓
Emerging technologies	✓		✓
Physics and space	✓		✓

Following this process, the final innovation priorities identify a number of opportunity areas - a mixture of vertical sector-specific priorities and complimentary horizontal underlying enabling technologies that support all verticals - of emerging excellence and in which Scotland has existing strength as pillars of our economy and a high potential for further innovation-driven scale and growth.

- Energy Transition

- Health & Life Sciences
- Data & Digital Technologies
- Advanced Manufacturing

6. Innovation Scorecard Indicators

As actions to grow and scale Scotland's innovation ecosystem over the next 10 years proceed there is a need to track performance on a number of key metrics to allow assessment of progress towards the ambition to become one of the most innovative small nations in the world.

It is proposed that this will be undertaken through an Innovation Scorecard which will track Scotland's innovation performance over time on a set of key indicators against other benchmark geographies: ideally these will be international comparators, but it must be recognised that some relevant indicators only permit comparison across UK nations and regions.

The Scorecard metrics aligns to the elements of the Innovation Ecosystem, ensuring we monitor the health of the system at each stage of each process to demonstrate Scotland's performance at different stages in the innovation journey, specifically tracking progress at three stages in the innovation system defined as the *concept*, *convert* and *commercialise* stages as well as tracking *investment* and the *adoption of innovation*.

- Concept – this aims to track the generation of new ideas both within universities and the private sector
- Convert – this aims to measure the movement of early-stage research towards being closer to market
- Commercialise – this aims to track the realisation of the early economic benefits of innovation

In addition, "adoption and diffusion" across the business base in general and overall research and development "investment" will be tracked.

Although it is important to recognise that there are often lengthy time lags until economic impacts emerge from new innovations, and that there is a need to factor in time to implement and deliver a new strategy, the Scorecard will provide a useful snapshot of the health of the Scottish innovation system over time.

Process

Scottish Government analysts developed a set of metrics, drawing upon commonly used data and considering existing UN and EU measurement frameworks, refining this through consultation with academic experts, NESTA and the Innovation Strategy Steering Group.

Existing frameworks

Existing innovation measurement frameworks that allow comparison with other geographies have been reviewed to assess their fit for this purpose.

The Global Innovation Index (GII) is produced annually by the World Intellectual Property Organisation (WIPO) and ranks countries' performance. It is considered to be too broad-based, tracking measures such as political stability, regulatory effectiveness, educational attainment, infrastructure and trade diversity, as well as measures that had already been considered such as BERD jobs and patents. Our own Innovation Strategy has a narrower focus on delivering business benefits; moreover, the GII does not include Scotland in its data collection.

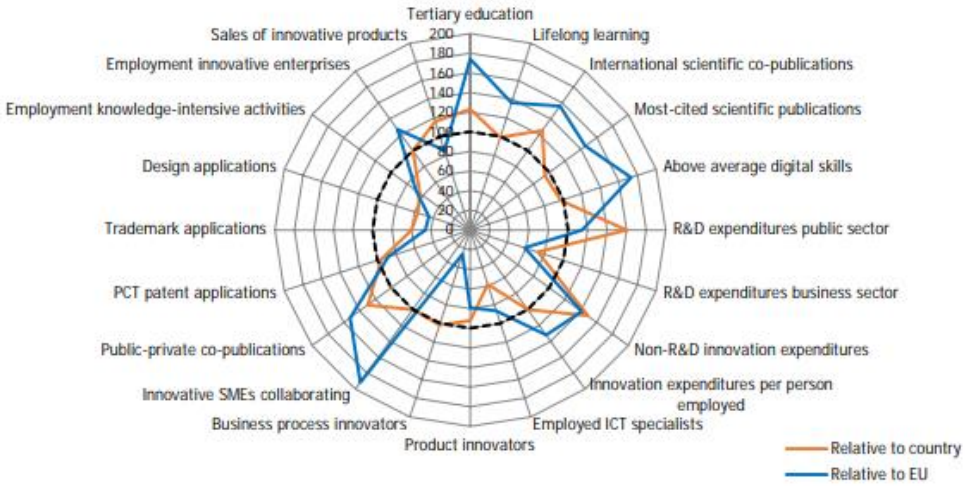
Figure 20: Innovation Ranking by Country

GII rank	Economy	Score	Income group rank	Region rank
1	Switzerland	64.6	1	1
2	United States	61.8	2	1
3	Sweden	61.6	3	2
4	United Kingdom	59.7	4	3
5	Netherlands	58.0	5	4
6	Republic of Korea	57.8	6	1
7	Singapore	57.3	7	2
8	Germany	57.2	8	5
9	Finland	56.9	9	6
10	Denmark	55.9	10	7

Global Innovation Index | What is the future of innovation-driven growth?

The EU Regional Innovation Scoreboard – also considered in section 4 – includes data for Scotland and thus has the advantage of allowing comparison across Europe. However, it features a large number of metrics and so does not suit the desired approach which is to track progress across the ecosystem in a targeted way.

Figure 21: EU Innovation Scorecard



European Commission's Regional Innovation Scoreboard 2021

Alternative measurement frameworks/ techniques

This process will utilise the best and most up to date data and evidence available taking a flexible approach to the selection of metrics; if alternative effective metrics are identified in future these will be considered.

Given that much innovation activity is informal and goes "under the radar", novel techniques are being employed to capture a wider range of activity. Various techniques such as web-scraping have been used, for example, the following article measures product/ service launch: https://www.sciencedirect.com/science/article/pii/S0048733321001700.

Over time, it may be that new techniques can be employed to fill gaps not currently well served by existing indicators or to complement these, either as part of the continuing development of a Scorecard or as part of evaluation activity.

Given the focus on public sector innovation in the strategy, there will be some focus on the development of an appropriate measure, although it is recognised that this will be very difficult to achieve. The GOVERD measure

Summary of current position

Concept

- Patent citations
- Academic Income from Business and Community Interactions

Convert

- Early-stage risk capital (under £10 million)
- BERD jobs

Commercialise

- High growth firms
- Later-stage investment

Adoption and diffusion

- Innovation active businesses

Investment

- Gross Expenditure on R&D (which comprises)
    - Business Expenditure on R&D
    - Higher Education Expenditure on R&D and
    - Government Expenditure on R&D

Description of measures

Concept

This aims to track the generation of new ideas both within universities and the private sector.

Patents – are often used to track innovation in the literature and allow for international comparison. This has weaknesses as an indicator – it is skewed towards new products; most patents are lodged speculatively and are never successfully commercialised and most innovation is not covered by such protections. However, it is widely used in the literature as a proxy for innovation and covers both private business and HE innovation.

Academic income from business and community interactions – tracks Higher Education innovation activity that is directly outward focussed. The collaborative nature of the measure is attractive as is the fact that it includes financial commitment which signifies anticipated value.

Convert

This measures the movement of early-stage research to being closer to market.

Early-stage risk capital – the attraction of investment capital in deals below £10 million is a good indicator of innovation that is closer to market, by way of "following the money". Although not all deals are strictly innovation driven, this a sufficiently good proxy for innovation at this stage because the top sectors for deals are generally those associated with innovation:

- Digital and IT
- Business Services
- Technology and Engineering

And to a lesser extent:

- Energy including renewables
- Food and drink
- Life sciences

BERD jobs – measure the number of workers in the private sector employed in R&D activities. These people are likely to be directly engaged in new innovation with an eye to market or in making existing ideas marketable. Though absolute job numbers are relatively small there will be associated employment multipliers (additional jobs within the companies and their supply chains which will typically offer relatively high wages).

Commercialise

This tracks the realisation of the early economic benefits of innovation.

High growth companies – these generate disproportionate jobs and innovation and are seen as key to economic transformation. Again these are not necessarily innovation driven but will disproportionately be in innovative sectors. Though these are difficult to measure as their growth tends to be episodic, the agreed (OECD)

definition is of firms growing their employment numbers and/or turnover by more than 20% a year over a period of three years, with at least 10 employees at the start of the period. This three-year period may present issues given that Covid-19 impacts will be seen for a number of years, affecting comparisons where there are differences between Scotland and other parts of the UK in the sectoral composition of high growth firms.

Later stage investment – equity deals at £10 million and above provides strong evidence of commercialisation which is closer to market.

Adoption and diffusion

Every business or organisation should have the opportunity to adopt innovation. Innovation should be accessible to all, not just those businesses working at the cutting edge

Along with BERD, measures drawn from the Community Innovation Survey provide key metrics for private sector innovation, particularly *the percentage of innovation active businesses*. The overall measure covers both product and process innovation. This measure allows for international comparison.

Investment

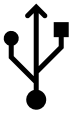
Gross expenditure on R&D covers such expenditure from business, higher education and government combined and is a reasonable proxy for overall investment. When expressed as a percentage of GDP this allows for international and cross-UK comparisons.

The baseline scorecard, figure 22, is shown on the next page.

Figure 22: Baseline Innovation Scorecard

Ecosystem	Tracking	Metrics Used in Scorecard	Current Performance	Comparison	Progress Since Last Year
Concept 	The generation of new ideas within universities and the private sector	• Patents granted • Academic Income from Business and Community Interactions	• Scotland underperforms compared to the UK on patents when considering population size. (approx. 31%) • Scotland underperforms in patents granted compared to the EU when considering GDP size. • income from Business Community interactions in 2020/21 was £690,907, which has grown by 45% over the past 4 years. • In 2020/21 the value of contracts held by Scottish HEIs was £292.4M, which has been	• Scotland had 251 patents granted in 2020. This represents an underperformance per capita compared to the UK of around 31%. • The EU granted 58,656 patents in 2020, which is 4.4 patents per billion GDP. In contrast, Scotland achieves only 1.2 patents per billion GDP. • Scotland is in the top 3 regions for value of HEI community to business interactions, and this figure is fast growing	• Scotland has seen growth in academic & community interactions since the previous year • Scotland has improved from 4th to 3rd in comparisons with UK regions.  • Scotland saw its patents granted per GDP increase over 2019/2020 by 0.28pp while patents granted in both the UK and EU fell. However, Scotland still underperforms despite this growth, making the performance in this metric mixed. 

			trending upwards for 4 years from £196.8M in 2017/18.	over the past 4 years. In the previous period, Scotland ranked 4th	
Convert 	The movement of early-stage research to being closer to market	• Risk capital (deals under £10m) • BERD jobs (as % of 16-64 labour force)	• For deals under £10M, £305 million was invested across 440 deals in 2020, this is down 5% over 2019. • BERD Jobs made up 0.61% of the total Scottish 16-64 labour force in 2020, up from 0.56% in 2019.	• Deals under £10M has recently fallen, though not as severely as the UK average. • Scotland ranks 4th lowest in the UK for BERD jobs as a % of the workforce. For context, 1st place is almost three times higher at 1.51%.	• Performance in risk capital has seen an increase in the number of deals, however total investment has stalled.  • BERD jobs has seen a slight increase over 2019/2020. However, Scotland remains ranked 4th lowest of the UK regions. 
Commercialise 	The realisation of the early economic benefits of innovation.	• High growth businesses • Later-stage equity (deals £10m and over)	• 9.7% of businesses in Scotland were 'high growth' in 2020. This fell to 7.2% in 2021 likely due to	• The UK rate of 'high growth' businesses in 2020 was 10.1%. This fell to 8.2% in	Both the UK and Scotland have seen a roughly 2% fall in high-growth businesses over 2020/2021. However, Scotland has fallen from being the middle performer (6th of 12) to rank second lowest

			the impact of the COVID-19 pandemic.	2021 likely due to the impact of the COVID-19 pandemic.	of the UK regions in 2021.
Adoption 	Organisations that are adopting innovation and have become innovation active	% of innovation active businesses	• In Scotland in 2021, 39% of businesses were measured as being 'Innovation Active' in the UK Innovation Survey. • This is a 6.8% increase on the figure from 2018, however still lower than the previous high of 2014, which saw an innovation active businesses rate of 50.4%	• Scotland underperforms in terms of innovation active businesses, both in the UK and EU. • Scotland is second lowest after NI in innovation active firms, and 9th lowest among the 27 EU member states. • However, the percentage of innovation active businesses has grown over the past 3 years. (6.8%)	• Scotland has seen an increase in innovation active businesses over the last 2 editions of the UK Innovation Survey (2018-2021) • However, Scotland continues to underperform relative to the UK and EU.
Investment	Expenditure on research and development	GERD as a % of GDP • BERD as a % of GDP[79]	• Scotland saw an expenditure on GERD as	• In terms of BERD spend by GDP in	• In terms of BERD spend by GDP in 2020, Scotland

[79] The methodology used to produce the Business Enterprise R&D spend estimates has been improved to better represent smaller businesses. However, there is currently uncertainty around the robustness of the estimates for Scotland. Therefore the Scottish Government has temporarily paused the National Statistics status of the Scottish Government R&D publications. Scottish Government statisticians will be working with the

		• HERD as a % of GDP • GovERD as a % of GDP	a % of GDP in 2020 of 3.13%, this is a 0.29pp increase on the previous year. • Scotland saw an expenditure on BERD as a % of GDP in 2020 of 1.91%, this is a 0.17pp increase on the previous year. • Scotland saw an expenditure on HERD as a % of GDP in 2020 of 1.06%, this is a 10pp increase on the previous year.	2020, Scotland ranked in the middle of the UK regions (3rd highest)[80] • Scotland outperforms the EU 27 group of countries in terms of HERD in 2020, as the EU average was 0.51% of GDP. • Scotland outperforms the EU 27 group average for BERD, which was 1.51% of GDP in 2020. • In terms of total gross R&D expenditure, Scotland outperforms the EU 27 average for 2020, which was 2.26% of GDP.	ranked in the middle of the UK regions (3rd highest)[81] this is the same placement relative to other regions as 2019.  • Scotland outperformed the UK in terms of total GERD expenditure in 2020, at 17pp higher GERD spend as a % of GDP.  • Over the past 3 years, Scotland has consistently outperformed the EU average levels for BERD/HERD/GERD as a

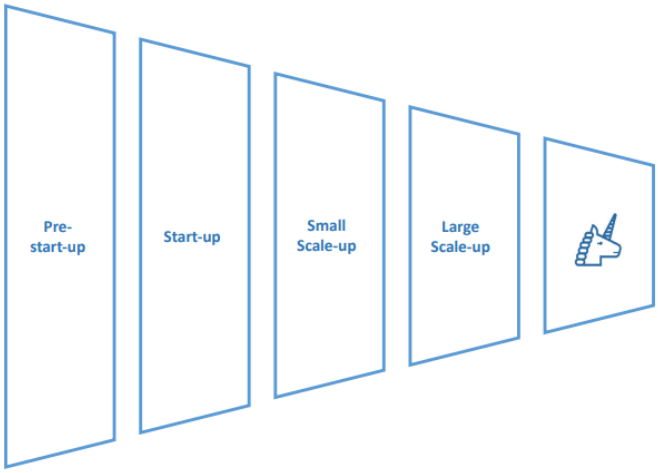
ONS on the next stage of the data development and hope to be able to resume with the National Statistics badge on the Scottish Government R&D publications in 2023. More information is available at: Gross expenditure on research and development Scotland 2020 - gov.scot (www.gov.scot)

[80] Regions in this case have been combined into; Wales, Northern Ireland, North (North East, North West, Yorkshire and the Humber), Midlands and South West (East Midlands, West Midlands, South West), East of England, London and South East

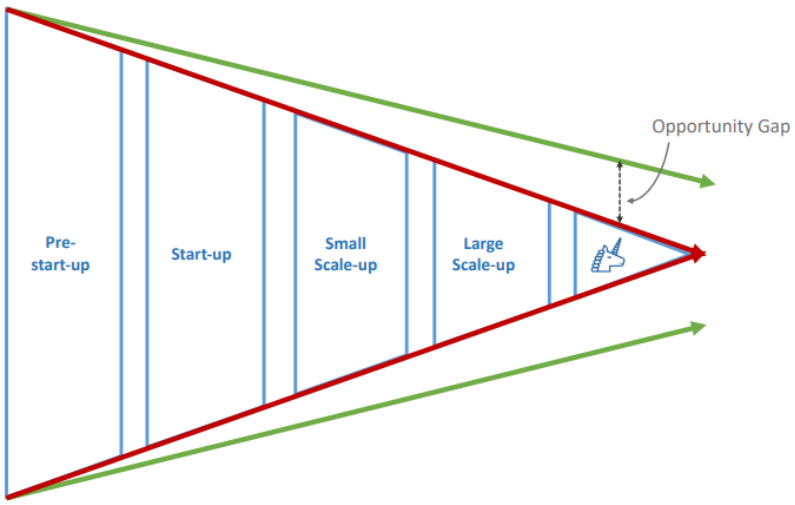
				• Total GERD spend as a percentage of GDP in the UK on was 2.96% in 2020.	percentage of GDP. 

Annex 1: Funnel Model of Innovation

Scotland's innovation funding ecosystem is outlined in a funnel model system by the Scottish Technology Ecosystem Review.[82] This model can be explained visually as a flow between stages of development from pre-start up, to 'unicorn', as shown below.



The model funnels from left to right, with the smaller scale stages later in the process showing that not all start-ups progress to scale-ups, etc. This provides a useful visual tool for understanding that the rate of narrowing between steps of the model influences the number of successful 'unicorns' which emerge.



[82] Scottish technology ecosystem: review - gov.scot (www.gov.scot)

The funnel model asserts that the difference in the rate of narrowing between each of these steps is a function of how supportive the local ecosystem is for start-ups and scale-ups. If one of these steps or more becomes too narrow, then the funnel model breaks down, and it becomes unlikely that start-ups reach the final stage. Potential reasons for the collapse of the model are:

- There just aren't enough companies to create a sustained learning and experiential environment. This, in turn, means that there aren't enough experienced employees emerging who know how to take a start-up to scale.

- The ecosystem is too small to attract outside talent. The risk is just too great that if a job doesn't work out at a particular company for which an executive relocated her family from London, then there aren't other companies to move to locally, and she has to return home. Few people will relocate their families in the first place, in these circumstances.

- The ecosystem doesn't attract larger investors. Venture Capitalists regard the ecosystem as too small to be worth exploration or they consider it unlikely that the ecosystem is capable of producing viable scale-ups. Consequently, they don't invest or limit their investments. This in turn reduces the number of viable start-ups flowing through the funnel. The gap is partly filled by private individual investors and government, but their limited aggregate capital is unable to fuel the growth of businesses beyond the earliest stages of the funnel.

Annex 2: Sectors identified by key current Scottish Government strategies

It is important that the choice of sectors for the Innovation Strategy is considered in the context of the sectors identified in analysis undertaken for other existing relevant Scottish Government strategies. Given the strong links that exist between innovation and exporting[83] and inward investment[84], key strategies to consider include 'Scotland's Inward Investment Plan' and 'A Trading Nation' – Scotland's export strategy. In addition, it is important to consider the sectors identified by Scotland's overarching economic strategy, 'Scotland's National Strategy for Economic Transformation' (NSET)[85]. The table below outlines the sectors identified in each of the three strategies.

	Scotland's National Strategy for Economic Transformation	**Scotland's Inward Investment Plan**	**A Trading Nation**
Renewable energy	✓	✓	
Hydrogen economy	✓		
Decarbonisation of transport	✓	✓	
Space	✓	✓	
Circular economy	✓		
Blue economy	✓		
Sustainable farming & forestry, nature restoration, ecotourism & nature-based climate change solutions	✓		✓
Financial services and fintech, business services	✓	✓	
Education, tourism and creative industries	✓		✓

[83] Scotland's export strategy notes that, as well as driving business performance and scale, access to international markets and competition drives innovation and productivity growth. Evidence indicates that there is a strong correlation between exporting and innovation. Innovative businesses are more likely to export and the experience of exporting can be a strong driver of investment in innovation and R&D as businesses compete in new markets.

[84] Analysis underpinning Scotland's Inward investment plan finds that there are strong links between Scotland's university knowledge base, inward investment and innovation, and that foreign owned businesses typically invest more in business R&D spending. Additionally, these inward investors can further boost innovation in the Scottish economy through their engagement with domestic businesses.

[85] NSET identified a number of sectors in which Scotland already occupies a position of global leadership in and/or has the opportunity for growth

	Scotland's National Strategy for Economic Transformation	**Scotland's Inward Investment Plan**	**A Trading Nation**
Life sciences, chemical sciences, health tech and biotechnology	✓	✓	✓
Enabling and emerging technologies inc. photonics and quantum technologies	✓		
Digital technology	✓	✓	
Food and drink innovation	✓	✓	✓
Creative industries, major events and tourism	✓		
Engineering and advanced manufacturing			✓

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