



*R&D-intensive businesses in Wales:
Innovation and contribution
to turnover and employment*

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Contents

Executive Summary	3
1. Introduction	6
2. Understanding R&D intensity	8
3. Support for R&D intensive businesses	11
4. R&D intensive firms in Wales	14
5. Understanding R&D intensive firms	24
6. Key findings and implications	30
Annex 1: Identifying high R&D intensity sectors	32
Annex 2: Interview schedule	35
References	36

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Executive Summary

Business research and development (R&D) plays a foundational role in firms' ability to innovate and create value from new products, services and business models. In this report we focus on high-R&D intensity firms in Wales, a group of firms which through their investments in R&D demonstrate a strong commitment to innovation and future value creation.

What contribution are these firms making to employment and turnover across Wales? How does this compare to other areas in the UK? What does innovation look like in these firms? What are the barriers and enablers of change? We consider these questions through a bespoke analysis of firm-level survey and administrative data and in-depth company interviews.

But what do we mean by R&D intensive businesses? At firm level, R&D intensity is normally measured as the ratio of R&D expenditure to total sales. No data is available on R&D intensity in firms located in Wales (or those in other parts of the UK)¹. Instead, we therefore base our analysis on a sectoral classification of R&D intensity developed by the OECD. This classifies each 4-digit industry into one of five R&D intensity categories, namely, the 'high', 'medium-high', 'medium', 'medium-low', and 'low' R&D intensity industries. While most service industries are classified as either low intensity or medium-low intensity, the classification for manufacturing industries spans from medium-low intensity up to high intensity (See Annex 1 for a more detailed overview).

High R&D intensity firms in Wales emerge as facing very similar challenges to those elsewhere in the UK linked largely to the risks and costs of innovation and related resource constraints. The innovation Welsh firms are undertaking differs somewhat to that elsewhere with a stronger focus on product/service innovation and less focus on process change. Levels of university collaboration are notably lower than those in some other parts of the UK, notably Scotland. These lower levels of collaboration combine in some of the companies interviewed with a strong reliance on internal funding for innovation and limited engagement with potential sources of public funding. Both factors suggest a more 'closed' rather than 'open innovation' model and both may be limiting firms' ability to share the costs and risks of innovation.

In policy terms this suggests that there may be value in promoting the benefits of more collaborative and open approaches to innovation, a measure which would support each of the missions outlined in 'Wales Innovates'. For example, if levels of university collaboration in Wales were similar to those in Scotland this would equate to an additional 350 high and medium-high R&D intensity Welsh firms collaborating with universities. Promoting open innovation has both strategic and capability related elements. Illustrations or case study examples, for example, may provide the strategic impetus for firms to engage in more collaborative innovation. Implementing collaborative relationships, however, may be complex in contractual and managerial terms – dealing with intellectual property issues for example – suggesting the need for capability building.

"there may be value in promoting the benefits of more collaborative and open approaches to innovation, a measure which would support each of the missions outlined in 'Wales Innovates'."

¹ The analysis reported here relates to businesses located in Wales. These could be locally or externally-owned.

Executive Summary

Background from prior literature

Prior evidence emphasises the role of R&D intensive firms in both contributing to nations' economic and technological success. Continuity of R&D seems critical, supported by public R&D and innovation supports, finance and the potential for collaboration with other organisations. Firms' internal resources – skills, finance – also seem critical to maximising the benefits of intensive R&D investments.

The UK innovation system has notable strengths in terms of academic research capabilities, the availability of venture funding and a well-developed grant/loan/tax credit system for supporting R&D and innovation. Skill levels and R&D investment by UK businesses compare less well internationally creating challenges around firms' ability to adopt and maximise the value of new technologies.

Welsh firms – like those in the other devolved territories of the UK – have access to R&D and innovation support both from national UK sources (UKRI, Innovate UK) as well as regional support agencies such as Business Wales' SMART Cymru. As a result, R&D intensive firms in Wales are more strongly supported than those in England although they perhaps receive less public support than those in Scotland or Northern Ireland (see Section 3.2). Evidence suggests that where public support is provided to R&D intensive businesses this can be more impactful than that provided to other firms and that its growth effects may also develop more strongly in future years.

R&D intensive firms' contribution to turnover and employment in Wales

In 2021, high R&D intensity firms accounted for 2.1 per cent of employment in Welsh employer enterprises, a level which compares well with Northern and Midlands regions of the UK. Medium-high R&D intensity firms accounted for a further 4.8 per cent of employment in employer enterprises in Wales, a level below most other UK regions. Welsh high and medium-high R&D intensity firms contribute 3.2 per cent and 7.4 per cent of turnover respectively (see Section 4.1). Both compare well with the majority of UK regions and are notably higher than the contribution of high R&D intensity firms to business turnover in Scotland (1.2 per cent and 3.6 per cent).

Overall, high R&D intensity firms constitute around 0.4-0.5 per cent of all firms in each Welsh region (see Section 4.1). Medium-high R&D intensive firms are more strongly represented in south east Wales (3.6 per cent) compared to north and mid and south west Wales (2.2-2.6 per cent). These differences are also reflected in the contributions of R&D intensive firms to both employment and turnover in each area. High R&D intensive firms contribute 2.8 per cent of employment and 4.6 per cent of business turnover in south east Wales, both notably higher than their contributions to other Welsh regions.

Executive Summary

Innovation

In terms of innovation, evidence from the UK Innovation Survey suggests that Welsh R&D intensive firms were marginally less likely than English R&D intensive firms to introduce product innovations during this period but were slightly more active product innovators than firms in either Scotland or Northern Ireland (see Section 4.2). Larger differences are evident in the proportion of R&D intensive firms in Wales engaging in process innovation – 24.8 per cent – a level considerably below that in other parts of the UK (30.5-31.6 per cent).

Some sectoral differences are evident (see Section 4.2). In terms of product/service innovation, Welsh manufacturing companies prove less innovation intensive than those in other parts of the UK, while Welsh services companies have a significantly higher level of product or service innovation than their UK peers.

Across the UK, as in Wales, economic risks and the high costs of innovation are the main barriers to innovation in R&D intensive firms, followed by skills and the availability of finance (see Section 4.2). Both the costs of finance and technology and market information gaps were however less often mentioned as significant barriers by firms in Wales than elsewhere. For example, the cost of finance was reported as a barrier to innovation by 20.8 percent of R&D intensive firms in Wales compared to 28.1% of similar firms in Scotland.

Universities are seen as slightly less important as a source of information for innovation in Wales than in other parts of the UK, a finding reflected in a level of collaboration with universities in Wales which is considerably below that in England and particularly Scotland (see Section 4.2). Government research institutes also play less of a role as an innovation collaborator and source of information in Wales relative to England and Scotland.

"economic risks and the high costs of innovation are the main barriers to innovation in R&D intensive firms."

Interview insights

In August and September 2023, we conducted eleven in-depth interviews with firms operating in high R&D intensity sectors in Wales. Reflecting the geographical distribution of high R&D intensity businesses most interviewees were in south Wales, with two in the South East, six in the South West, and three in North Wales.

Interview data suggests the diversity of innovation activity across firms, and the diversity of related challenges. A reliance on internal resources was constraining some firms' innovation activity, although other companies had taken advantage of support from the Welsh government and the Development Bank of Wales.

Some firms which were interviewed seemed unaware of all the potential opportunities for public funding, or were misinformed about their relevance. Other firms were put off seeking public funding for their innovation activity due to the time consuming of the application process.

Customer partnerships were common among the firms interviewed. University links were limited due to institutional changes, response times and a lack of interest on the part of some potential university partners.

Constrained internal resources were limiting innovation in some cases, with other firms referencing recruitment challenges linked to more rural locations. However, there was little consensus across the firms interviewed about any additional support needs.

Business research and development (R&D) plays a foundational role in firms' ability to innovate and create value from new products, services and business models. In this report we focus on high-R&D intensity firms in Wales, a group of firms which through their investments in R&D demonstrate a strong commitment to innovation and future value creation. While sharing their strong focus on R&D, the group of R&D intensive firms includes a wide range of very different businesses: larger mid-supply chain businesses in high-tech manufacturing sectors such as chemicals or aerospace; service businesses which may be undertaking contract research for other firms; and, intellectual property (IP) based spin-outs from larger companies or universities. Each of these types of businesses will vary in the type of R&D and innovation they conduct and how they undertake that R&D, either working alone or in partnership with other organisations. Financing mechanisms may also vary with government grants, equity and loan finance all playing a potentially significant role in shaping firms' ability to invest in R&D.

In the report, following some background material on the role and policy for R&D intensive firms, we consider four main questions. First, what contribution do R&D intensive firms make to the Welsh economy and how does this compare to other UK regions? Secondly, how does this contribution vary across parts of Wales? Thirdly, we examine levels of innovative activity in R&D intensive firms in Wales and how this compares to that in other UK regions.

In each case our analysis is based on a new analysis of UK wide population and survey datasets – specifically the Business Structure Database (Office for National Statistics 2023) and the UK Innovation Survey. Finally, through a series of detailed interviews with high R&D intensity firms in Wales, we consider the specific challenges and opportunities these businesses face as well as their future support needs.

But what do we mean by R&D intensive businesses? R&D intensity generally measures the level of knowledge intensity in different economic activities. At firm level, R&D intensity is normally measured as the ratio of R&D expenditure to its total sales (e.g., Uyar et al., 2022; Fu et al., 2020; Mudambi and Swift, 2014; Alonso-Borrego and Javier Forcadell, 2010). In this report we use the most recent industry-level R&D sectoral classification by the OECD (i.e., Galindo-Rueda and Verger, 2016). Based on the International Standard Industrial Classification (ISIC) Rev.4, this identifies five R&D intensity categories, namely, the 'high', 'medium-high', 'medium', 'medium-low', and 'low' R&D intensity industries. While most service industries are classified as either low intensity or medium-low intensity, the classification for manufacturing industries spans from medium-low intensity up to high intensity (See Annex 1 for a more detailed overview). This classification is based on firms' primary SIC code. For manufacturers, for example, servitisation may mean that this links only to their primary rather than all SIC codes within which a firm operates.

"Business research and development (R&D) plays a foundational role in firms' ability to innovate and create value from new products, services and business models."

The rest of this report is organised as follows:

- Section 2 provides a brief overview of other studies which have considered R&D intensive firms, although the majority of these studies focus on the implications of variations in R&D intensity between sectors rather than firms.
- Section 3 focuses on the role of the innovation eco-system in supporting R&D intensive firms and provides a brief commentary on the contrasting position of Wales and other parts of the UK.
- Section 4 includes the main data analysis focussing on the contribution of R&D intensive firms to employment and turnover in Wales and other UK regions and profiling innovation among R&D intensive firms.
- Section 5 reports data from our interviews with R&D intensive firms in Wales to better understand their approach to innovation and the related challenges and opportunities.
- Section 6 provides a brief summary of the key findings of the report and identifies potential opportunities for future support for R&D intensive firms in Wales.

2.1 R&D intensity and performance

Prior literature on R&D intensity documents its positive effect on a variety of outcomes both at the firm and industry level. The empirical evidence suggests a strong link between the R&D activities of firms and performance measures including high-growth and profitability (Kwon et al., 2022; Del Monte and Papagni, 2003), survival (Andersson et al., 2012), product diversification (Alonso-Borrego and Forcadell, 2010), corporate social responsibility (Fu et al., 2020), high discovery rates and project payoff (Lin, 2022), new product development and R&D partnership spillover effects (Park and Lee, 2022; Kim and Kim, 2022)², and the exploration and exploitation of knowledge (Lee et al., 2014).

These streams of research generally suggest that firms with strong commitment to R&D generally tend to perform better on most performance indicators compared to their non-R&D and occasional R&D performing counterparts, and may be more resilient to external shocks. For instance, it has been found that firms that continuously engage in R&D are more likely to develop a stronger innovative

capacity and are more likely to succeed at new product development than occasional R&D performing firms (Kim and Min, 2022; Xia (2012). Similarly, persistent R&D investment increases participating firms' chances of survival, particularly for start-up businesses (Andersson et al., 2012), while high-levels of R&D intensity create larger effect on the growth rate of high-growth firms (García-Manjón et al., 2012).

Prior literature particularly on R&D intensive business documents a strong link between the activities of these firms and collaboration, skills and management capabilities (Park and Lee, 2022; Islam et al., 2020), innovation, employment and turnover growth (Uyar et al., 2022; Mulier and Samarin 2021, Vanino et al. 2019). A more recent study by Aldieri et al. (2022) elaborates on how both inter-industry R&D spillovers and foreign patents acquisition trigger episodes of high growth in R&D intensive manufacturing firms. According to the authors, there is a bi-directional relationship between participating firms' R&D investment and spillover benefits from inter-industry R&D partnerships.

"The empirical evidence suggests a strong link between the R&D activities of firms and performance measures including high-growth and profitability"

² Spillover effects occur when R&D or innovation investments by one firm benefit other companies. This may occur through a number of mechanisms such as social contacts leading to knowledge sharing, copying or demonstration effects.

2.2 R&D intensity and public support

While government support for private R&D and innovation generally creates additional performance gains among beneficiary firms, R&D intensive businesses tend to experience superior performance gain compared to businesses with low R&D intensity. Vanino et al (2019) and Nana-Cheraa et al. (2023) provide a strong link between UK's R&D and innovation supports and various firm-level performance measures. Vanino et al. (2019) in particular document higher employment and turnover growth among high-tech manufacturing business that participated in publicly funded research projects. In the same spirit Nana-Cheraa et al. (2023) provides evidence which suggests that both high-tech manufacturing businesses who receive R&D tax-credits and

those who receive R&D grant in addition to R&D tax-credit not only increase their private investment in R&D but also experience higher product and process innovation performances. Mulier and Samarin (2021) examined the effect of innovation subsidies on various outcome variables including those considered by Vanino et al. (2019). According to Mulier and Samarin (2021), the effect of innovation subsidies on investment in tangible assets, turnover and employment growth, and patent applications is not only stronger among participating firms operating in R&D intensive sectors, but also these effects get significantly stronger through time for R&D intensive business while those of non-R&D intensive businesses either decline or become insignificant.

2.3 R&D intensity collaboration and skills

Typically, R&D intensive and high-tech firms are more likely to engage with external knowledge sources including universities, public and private research institutes, and these external partnerships have been found to be associated with high firm performance contingent on firm-specific context. Islam et al. (2020) looks at collaboration in nanotech R&D projects across 12 European countries and show that large nanotech R&D firms tend to have fewer inter-firm collaboration partnerships and spend less time to develop new products, due to their strong internal value networks and centralized systems of governance in collaborative partnerships. Smaller nanotech R&D firms on the other hand require more time and a greater number of inter-firm collaborative partnerships to develop new products due to their weaker internal resources

Skill shortages are a major concern for most innovative businesses including R&D intensive businesses. Similarly, quality human capital and innovative capability are crucial for high innovation performance. Generally, the quality of a firm's work force and its innovative capability could merely be enhanced by reinforcing innovative education. This assertion is reinforced by a study on semiconductor manufacturing businesses in Taiwan conducted by Huang (2018). The evidence from this study suggest that innovative education significantly impact both innovation capability and business performance. Lee and Chang (2014) findings indicate that a firm in a high-tech industry is able to achieve greater gains in its technological and marketing capabilities by complementing its internal R&D with its external focus on marketing or by focusing on both internal R&D and external knowledge acquisitions.

2.4 Summary

Prior evidence emphasises the role of R&D intensive firms in both contributing to nations' economic and technological success. Continuity of R&D seems critical, supported by public R&D and innovation supports, finance and the potential for collaboration with other organisations. Firms' internal resources – skills,

finance – also seem critical to maximising the benefits of intensive R&D investments. Evidence suggests that where public support is provided to R&D intensive businesses this can be more impactful than that provided to other firms and that its growth effects may also develop more strongly in future years.

"where public support is provided to R&D intensive businesses this can be more impactful than that provided to other firms"

Upstream influences on firms' ability to undertake R&D and innovation - e.g., collaboration, financing, skills - reflect the broader innovation system within which firms operate. Notions of innovation systems or innovation eco-systems (Edquist, 1997; Metcalfe, 1997; Nelson, 1992), have been considered at national (Dworak et al., 2021; Nelson, 1993;

Lundvall, 1992), regional (Braczyk et al., 2003; Cooke et al., 1997), sectoral (Malerba, 2004), technology (Chung, 2012) and most recently mission (Hekkert et al., 2020) levels. However, national innovation systems vary markedly in terms of their structure, governance and capability to support R&D and innovation.

3.1 The UK innovation system in an international context

The UK national innovation system has a number of notable strengths but also some significant limitations. In summary (Roper 2022):

- The UK performs well in terms of natural sciences PhDs but has a significantly smaller number of engineering PhDs than that in some other leading competitor economies (Japan, South Korea). The proportion of UK undergraduates with engineering qualifications is also low by international standards. Compared to our international competitors, engineering pathways in the UK at both undergraduate and PhD level seem narrow, and the Global Innovation Index data exposes particular issues relating to low levels of in-firm research skills in the UK.
- The UK performs well in terms of venture capital availability although any international advantage is less clear in terms of early-stage finance. EU innovation scoreboard comparisons point to the enterprise finance system in Germany as providing more plentiful and patient capital for mainstream lending. Finance barriers are regarded by UK innovators as marginally more important than skills barriers.
- UK national policy supports for R&D and leading-edge innovation are generally well developed providing a range of direct and indirect (tax) supports. These are generally effective in supporting enhanced growth among recipient firms (Vanino et al. 2019). Internationally, overall levels of support as a percentage of GDP are relatively high in the UK.
- Evidence from the Global Innovation Index suggests that the capability of UK companies in technology adoption may be weaker than the ability of leading-edge innovators. OECD data on ICT adoption confirms this picture and positions the UK somewhat behind leading competitors internationally in terms of ICT adoption. Leading adopting nations also tend to be leading innovators.
- In terms of international and global knowledge pathways, UK researchers seem open to collaboration and the share of research undertaken with international partners has increased sharply. The suggestion is that in terms of academic research the UK is well placed to take advantage of opportunities for international cooperation. Less evidence is available on firms' international collaboration as part of their innovation activity and how this influences subsequent innovation success.

The wide range of factors which influence business innovation generally – including skills, finance, collaboration – are recognised in ‘Wales Innovates’, the Welsh Innovation Strategy, which also recognises the ‘increasingly complex landscape by diverse actors’ (Wales Innovates, 2023, p. 2). The Welsh Innovation Strategy also reflects the importance of policy intervention in supporting successful innovation. This is also reflected more broadly in the UK Innovation Strategy which comments specifically in relation to R&D intensive, spin-outs from universities:

‘The case for government to promote innovation in deep and transformative technology is strong. ... The journey of tech-based innovation to market can be long, complex, and often non-linear. The UK excels at certain stages of this process but is weaker at others. We should pursue these signals of weakness and address the underlying issues. ... The UK government can build on that model, identifying barriers to innovation that are felt acutely in deep and transformative tech, and articulating how government can empower industry to overcome them’ (BEIS 2021).

3.2 Variations in policy support across the UK

Across the nations of the UK public support for R&D and innovation varies significantly although some elements of the support regime are UK-wide. Across the whole UK, tax supports – most notably the R&D tax credit – are particularly important providing over £5.1bn in 2017-18³. Other key elements of the support for R&D and innovation are direct grants to companies to fund R&D or innovation projects. In the UK this support is provided primarily through UKRI, and the evidence suggests that UKRI support has a strong, significant and positive effect on firms’ R&D investments and business growth (Scandura 2016; Vanino et al. 2019). Vanino et al. (2019) find that UKRI support contributes to strong growth in turnover and employment in participating firms both 3 and 6 years after their participation in publicly funded R&D and innovation projects. This positive growth effect is very similar regardless of whether firms are involved in Innovate UK projects (in which they receive direct funding) or other Research Council projects (e.g., EPSRC) where firms are typically unfunded partners in university-based R&D projects.

UKRI support is available to all firms across the UK and amounted to £126m in Wales in financial year 2020-21 of which £40m was provided by Innovate UK and £86m by the other Research Councils⁴. Other innovation funding mechanisms differ across the home nations, however, with funding regimes in Scotland, Northern Ireland and Wales all providing additional support to local firms. In Scotland, Scottish Enterprise have traditionally provided R&D grants, although this has recently shifted towards an emphasis on supporting the green transition⁵. In Wales innovation and R&D are supported through Business Wales’ SMARTCymru service which provides advisory support and limited funding support through Innovation Vouchers⁶, while financial support is available from the Development Bank of Wales⁷. In Northern Ireland both innovation and R&D grant support is provided by Invest NI over and above any UKRI support⁸. In England, while the primary source of R&D and innovation grant funding is UKRI, local initiatives also exist, often supported by Growth Hubs or Local Enterprise Partnerships.

³ Table RD2 R&D tax credits combined tables. Available at: <https://www.gov.uk/government/statistics/corporate-tax-research-and-development-tax-credit>.

⁴ <https://public.tableau.com/app/profile/uk.research.and.innovation.ukri/viz/GeographicalDistributionofUKRISpendin2019-20and2020-21/UKRISpend>.

⁵ See <https://www.scottish-enterprise.com/support-for-businesses/funding-and-grants/business-grants/research-and-development-grant>.

⁶ See <https://businesswales.gov.wales/expertisewales/support-and-funding-businesses/smartcymru>.

⁷ See <https://developmentbank.wales/business-need/finance-tech-ventures>.

⁸ <https://www.investni.com/support-for-business/funding-for-innovation-and-research-and-development>.

While UK-wide support for R&D and innovation is extensive, past evidence on business R&D spending in the UK puts this at a level below that of many competitor economies, although recent revisions – and further changes to come – may change this picture. Globally, however, levels of R&D investment have increased sharply over the last decade with a number of countries particularly in South-East Asia rapidly developing their domestic capabilities. In some democracies – Korea, Israel, Austria – increases in R&D spend have been a central and sustained element of national policy agendas. In Germany, the Pact for Research and Innovation provides a strong example of the type of long-term and sustained policy commitment which is necessary to build sustained R&D and innovation capability. Originally launched in 2005, the Pact guarantees basic funding for the German Federal and Lander research institutes and the Deutsche

Forschungsgemeinschaft (DFG), the main public funder for research in higher education. Now extended to 2030 the Pact provides a regular budget increase of 3 per cent pa for research organisations along with budget certainty subject to organisations meeting agreed quality criteria.

Other economies – most notably China – have structured national resources towards particular R&D missions around aspects of digital and low-carbon technologies. These changes are leading to significant shifts in the R&D landscape: 'The US continues to lead globally in R&D expenditures, Science and Engineering doctoral-level degree awards, and production of highly cited research publications ... As more countries around the world develop R&D and human capital infrastructure ... the US is playing a less dominant role in many areas of S&E activity' National Science Board (2020), p. 16).

3.3 Summary

The UK innovation system has notable strengths in terms of academic research capabilities, the availability of venture funding and a well-developed grant/loan/tax credit system for supporting R&D and innovation. Skill levels and R&D investment by UK businesses compare less well internationally, creating challenges around absorptive capacity, something recognised in the UK ranking on the Global Innovation Index.

Welsh firms – like those in the other devolved territories of the UK – have access to R&D and innovation support both from national UK sources (UKRI, Innovate UK) as well as regional support agencies such as Business Wales' SMARTCymru. As a result, R&D intensive firms in Wales are more strongly supported by public schemes than those in England although perhaps receive less public support than those in Scotland or Northern Ireland.

"R&D intensive firms in Wales are more strongly supported by public schemes"

There is no publicly available data source which provides details on whether (and how much) individual firms are investing in R&D either in Wales or elsewhere in the UK. Following international practice – such as that adopted by the OECD for example – we base our analysis instead on individual sectors and examine their R&D intensity. So, our focus here is on the extent to which firms in high R&D intensive sectors are present in Wales, their capabilities and the challenges they face in undertaking R&D and innovation.

We base our analysis on two main data sources – the Business Structure Database and the UK Innovation Survey. Both are described in more detail in Box 1. Our approach to identifying R&D intensive sectors follows the standard approach adopted by OECD and is outlined in detail in Annex 1.

Box 1: Data Sources

Two main data sources are used in the analysis reported here: the Business Structure Database and the UK Innovation Survey. The Business Structure Database (BSD) is an annual abstract of the Interdepartmental Business Register, a population register that contains information on all UK firms which are either registered for VAT or PAYE⁹. Here, we report an analysis based only on a sub-set of the overall BSD which covers employer enterprises, i.e., those which employ one or more individuals beyond the owner-manager of the business. The UK Innovation Survey is

a bi-annual survey run by DBT and prior to the UK exit from the EU, was the UK contribution to the EU Community Innovation Survey. The survey is a sample survey covering about 14,000 enterprises across the UK, each with more than 10 employees. This data source therefore excludes micro-firms. 857 Welsh firms provided a response to the UK Innovation Survey 2021 of which 125 (14.6 per cent) are in sectors categorised as either high or medium-high R&D intensity. Comparisons using this data should therefore be regarded as indicative rather than definitive.

⁹ See <https://integrateddataservice.gov.uk/data/business-structure-database-bsd>.

4.1 R&D intensive firms' contribution to employment and turnover in Wales

Analysis in this section is based on employer businesses included in the BSD for 2021 and turnover analysis relates to turnover in 2020-21. In each case the comparison is with other UK nations and regions. Tables 1 and 2 profile the contribution of high R&D intensity firms to employment and turnover in firms in Wales and elsewhere. Overall, this analysis considered the R&D intensity of around 1.7m UK firms, of which 75,000 were in Wales.

In 2021, high R&D intensity firms accounted for 2.1 per cent of employment in Welsh employer enterprises, a level which compares well with Northern and Midlands regions of the UK but lies below that of the East and South East of England (Table 1). Medium-high R&D intensity firms accounted for a further 4.8 per cent of employment in employer enterprises in Wales,

a level below most other UK regions. Medium R&D-intensity businesses are more strongly over-represented in Wales in terms of employment, although as in most regions around three-quarters of employment in Wales is in sectors categorised as having 'low' R&D intensity.

The turnover contribution of high R&D intensity firms is summarised in Table 2 and here there is more variation across regions than in terms of employment. This reflects differences in sectoral and firm-size composition between regions. Welsh high and medium-high R&D intensity firms contribute 3.2 per cent and 7.4 per cent of turnover respectively. Both compare well with the majority of UK regions and are notably higher than the contribution of high R&D intensity firms to business turnover in Scotland.

Table 1
Total employment across R&D intensity (%) - UK regions



UK Region	# Firms	High	Medium high	Medium	Medium low	Low
Wales	74,506	2.1	4.8	5.0	14.3	73.9
North East	65,436	1.5	6.0	4.6	15.2	72.6
North West	156,217	1.5	5.1	2.2	17.7	73.5
Yorks and The Humber	126,835	0.7	4.7	3.1	18.2	73.3
East Midlands	121,371	2.5	4.5	2.8	14.5	75.7
West Midlands	146,126	1.0	8.3	3.2	14.7	72.7
East	63,949	3.4	6.4	2.3	16.1	71.8
South East	344,746	2.7	6.6	1.8	13.2	75.7
London	295,096	0.9	5.5	0.4	19.6	73.6
South West	152,259	2.4	5.0	2.6	15.7	74.3
Scotland	119,334	1.3	4.1	1.6	17.0	76.1
Northern Ireland	49,057	3.1	5.9	3.9	15.9	71.2
Total	1,714,932					

Table 2
Total sales across R&D intensity (%) - UK regions



UK Region	# Firms	High	Medium high	Medium	Medium low	Low
Wales	74,506	3.2	7.4	10.1	13.6	65.6
North East	65,436	1.7	12.8	5.3	13.3	66.8
North West	156,217	3.0	6.8	2.0	14.5	73.7
Yorks and The Humber	126,835	0.8	5.0	3.6	18.1	72.5
East Midlands	121,371	4.5	6.0	2.9	12.7	73.9
West Midlands	146,126	1.4	13.8	4.0	17.6	63.2
East	63,949	3.9	6.5	2.4	17.5	69.6
South East	344,746	3.2	8.0	1.3	11.4	76.1
London	295,096	0.6	3.6	0.2	11.6	84.0
South West	152,259	3.3	4.8	2.0	10.3	79.7
Scotland	119,334	1.2	3.6	1.3	15.4	78.5
Northern Ireland	49,057	3.0	6.5	4.5	17.0	69.1
Total	1,714,932					

Using the same dataset – the Business Structure Database – which provides information on all employer enterprises we can also profile the contribution of R&D intensive firms to turnover and employment across Welsh regions (Table 3). Overall, high R&D intensity firms constitute around 0.4-0.5 per cent of all firms in each region. Medium-high R&D intensive firms are more strongly represented in south east Wales (3.6 per cent) compared to north and mid and south west Wales (2.2-2.6 per cent).

Regional differences are also reflected in the contributions of R&D intensive firms to both employment and turnover in each area. High R&D intensive firms contribute 2.8 per cent of employment and 4.6 per cent of business turnover in south east Wales, both notably higher than their contributions to other Welsh regions. This is largely reflected in a similar pattern in medium-high R&D intensive firms, although the contribution of these firms to turnover in the mid and south west Wales is disproportionately high (10.5 per cent). This is likely to reflect elements of industrial composition (see Annex 1).

Table 3
Employment and turnover contribution across Welsh regions



	# Firms	High	Medium high	Medium	Medium low	Low
A: Proportion of firms across R&D intensity (%)						
North Wales	17,722	0.4	2.6	1.6	11.5	83.9
Mid and south west Wales	26,293	0.4	2.2	1.6	10.0	85.9
South east Wales	30,491	0.5	3.6	1.6	14.0	80.3
B. Total employment across R&D intensity (%)						
North Wales	17,722	1.9	2.9	2.8	11.1	81.3
Mid and south west Wales	26,293	0.9	5.4	4.5	13.2	75.9
South east Wales	30,491	2.8	5.5	6.6	16.7	68.4
C. Total sales across R&D intensity (%)						
North Wales	17,722	2.2	4.3	4.5	11.3	77.8
Mid and south west Wales	26,293	1.1	10.5	5.8	17.5	65.1
South east Wales	30,491	4.6	7.8	14.9	13.2	59.5

Looking more specifically at the group of high and medium-high R&D intensity firms across UK regions and areas of Wales, Table 4 provides a breakdown by firm size. In general terms the size distribution of high and medium-high R&D firms in Wales reflects that in other parts of the UK relatively closely, with about four-fifths of these firms in the micro-enterprise category

(i.e., having 2-9 employees). Only 1:20 high or medium-high R&D intensity firms has more than 50 employees. Somewhat surprisingly, given the regional differences within Wales noted earlier, the size distribution of high and medium-high R&D intensive firms is also rather similar across areas within Wales (Table 4).

Table 4
High and medium high R&D firms across size (%) - UK regions



UK Region	# Firms	2-9 employees	10-49 employees	50+ employees
A. UK regions				
Wales	2,437	77.9	15.5	6.7
England	89,482	80.3	14.8	4.9
Scotland	4,643	78.8	15.6	5.6
N. Ireland	1,480	72.1	19.5	8.5
Total	98,042			
B. Welsh regions				
North Wales	526	77.0	16.2	6.8
Mid and south west Wales	659	80.3	14.9	4.9
South east Wales	1,252	77.0	15.5	7.5
Total	2,437			

4.2 Understanding innovation in R&D intensive firms

Data on innovation in R&D intensive firms is available from the UK Innovation Survey 2021 (UKIS). This is a sample survey covering around 13,500 firms across the UK of which only a proportion are categorised as high or medium-high R&D intensity. This means that the sample of firms in this group is relatively small so the tables presented in this section should be considered bearing this in mind. In particular, we consider here the group of high and medium-high intensity firms across sectors, although it is clear from the UK survey results that sectoral R&D and innovation intensities vary considerably (see Roper and Nana-Cheraa (2023) for a more detailed discussion). In addition, it is also important to acknowledge that this wave of the

UK Innovation Survey covered firms' innovation activity during the period 2018-2020, the latter months of which coincided with the start of the COVID-19 pandemic. This may have had some effect on firms' innovation activity, although any effect was likely to be similar in Wales and other parts of the UK.

Table 5 provides an overview of the working sample. In the UKIS 2021, 857 Welsh firms provided a response of which 125 (14.6 per cent) are in sectors categorised as either high or medium-high R&D intensity. The proportions in other UK regions are slightly lower with sample numbers in Northern Ireland particularly low reflecting the relative size of the region.

Table 5
Medium high & high R&D intensive firms in the UK Innovation Survey 2021



UK region	Number of firms in the UKIS	Number of medium-high and high firms	Percentage of medium-high and high firms
Wales	857	125	14.6
England	10,268	1,435	14.0
Scotland	1,451	164	11.3
N. Ireland	1,022	108	10.6
Total	13,598		

Table 6 provides an overview of innovation activity in the group of medium-high and high R&D intensity firms. In each case innovation measures relate to the three years prior to the survey in 2021. This relates to new and on-going innovation activity. The key points are:

- Welsh firms were marginally less likely than English R&D intensive firms to introduce product innovations during this period but were slightly more active product innovators than firms in either Scotland or Northern Ireland.
- In terms of new to the market products/ services (i.e., products/services introduced before competitors) Welsh R&D intensive firms marginally lag those in England and Scotland but again out-perform those in Northern Ireland.
- Larger differences are evident in the proportion of R&D intensive firms in Wales engaging in process innovation – 24.8 per cent – a level considerably below that in other parts of the UK (30.5-31.6 per cent).

Table 6

Innovation in medium high & high R&D intensity firms (% firms)



UK region	# Firms	Product innovators (%)	New-to-Market innovators (%)	Process innovators (%)
Wales	125	42.4	28.0	24.8
England	1,435	44.3	29.5	31.6
Scotland	164	41.5	30.5	30.5
N. Ireland	108	40.7	23.2	31.5
Total	1,832			

Table 7 provides a more detailed breakdown of the proportion of innovating R&D intensive businesses looking separately at manufacturing and services companies. In terms of product/service innovation, Welsh manufacturing companies prove less innovation intensive than those in other parts of the UK, while Welsh services companies have a significantly higher level of product or service innovation than their UK peers. This pattern is largely repeated for new to the market innovation in products or services, i.e., those produced before

competitors. Here again, R&D intensive services firms in Wales have a slightly higher level of innovation than those elsewhere in the UK, while Welsh manufacturing firms lag slightly behind those in other UK regions. In terms of process innovation, we see little difference between the proportion of R&D intensive services companies which innovate in Wales and the rest of the UK. However, R&D intensive manufacturing firms in Wales have significantly lower levels of process innovation than firms in other parts of the UK.

Table 7
Innovation across R&D intensive manufacturing and services firms



	Manufacturing		Services	
	# Firms	Innovators (%)	# Firms	Innovators (%)
A. Product innovation				
Wales	90	38.9	35	51.4
Non-Wales	774	44.6	933	43.1
B. New to market product innovation				
Wales	90	26.7	35	31.4
Non-Wales	774	30.9	933	27.8
C. Process innovation				
Wales	90	22.2	35	31.4
Non-Wales	774	33.2	933	30.1

"R&D intensive services firms in Wales have a slightly higher level of innovation than those elsewhere in the UK"

Another key theme covered by the UK Innovation Survey relates to the barriers firms experience during their innovation activity. Again, questions relate to the three years prior to the survey itself. Among high and medium high R&D intensity firms in Wales the most frequently mentioned innovation barriers are economic risks and the high costs of innovation, both mentioned by around 1/3 of firms. A second group of factors - finance availability and skills gaps - were mentioned by around 1/4 of businesses. Information gaps relating to new technologies or market opportunities were seen as a less significant barrier by Welsh R&D intensive firms.

As Table 8 suggests, there are some differences in the profile of barriers to innovation between Wales and other parts of the UK. Across the UK,

as in Wales, economic risks and the high costs of innovation are firms' predominant concerns, followed by skills and the availability of finance. Both the costs of finance and technology and market information gaps were however less often mentioned as significant barriers by firms in Wales than elsewhere. For example, the cost of finance was reported as a barrier to innovation by 20.8 percent of R&D intensive firms in Wales compared to 28.1% of similar firms in Scotland (Table 8). This may reflect greater availability of innovation related finance in Wales than elsewhere. Another possible interpretation, however, is that fewer firms in Wales actually encounter these barriers due to lower levels of more costly radical innovation locally.

Table 8

Innovation barriers: medium high & high R&D intensity firms (% firms)



UK region	# Firms	Economic risks	High cost	Finance cost	Finance availability	Skill gap	Information gap (technology)	Information gap (market)
Wales	125	35.2	36.0	20.8	27.2	27.2	12.8	16.8
England	1,435	36.5	38.4	28.0	31.3	36.9	21.6	23.8
Scotland	164	40.2	37.8	28.1	31.7	31.7	19.5	22.0
N. Ireland	108	35.2	37.0	33.3	36.1	41.7	29.6	31.5
Total	1,832							

"Among high and medium high R&D intensity firms in Wales the most frequently mentioned innovation barriers are economic risks and the high costs of innovation, both mentioned by around 1/3 of firms."

In the UK Innovation Survey, firms undertaking some form of innovative activity are also asked about the importance of various sources of information for their innovation activity and also about collaboration with external partners. Reflecting discussion in the literature about open innovation both provide an indication of the extent to which innovative activity is supported by the ecosystem within which the firm is operating. Note, however, that here due to small sample sizes and unrelated disclosure issues we are only able to provide information on a subset of potential information sources and partner types.

Table 9 summarises data on the importance of universities, government research institutes, and firms within the same sector for the innovation activity of high R&D intensity firms. Universities are seen as slightly less important as a source of information for innovation in Wales than in other parts of the UK (Table 9), a finding reflected in a level of collaboration with universities in Wales which is considerably below that in England and particularly Scotland. Government research institutes (e.g., Public Health Wales, Natural Resources Wales) also play less of a role as an innovation collaborator and source of information in Wales relative to England and Scotland. Levels of collaboration in Wales with firms in the same industry is also lower than that in all other UK nations (Table 10).

Table 9

Source of information for innovation: medium high & high R&D intensity firms (%) - UK regions



UK region	# Firms	University (%)	Government research institute (%)	Within same Industry (%)
Wales	125	20.0	15.2	45.6
England	1,435	23.2	21.1	47.2
Scotland	164	31.7	25.6	39.0
N. Ireland	108	20.4	21.3	43.5
Total	1,832			

Table 10

Collaboration source: medium high & high R&D intensity firms (%) - UK regions



UK region	# Firms	University (%)	Government research institute (%)	Within same Industry (%)
Wales	125	20.0	12.8	16.8
England	1,435	26.8	20.4	24.0
Scotland	164	35.4	25.0	21.3
N. Ireland	108	18.5	9.3	17.6
Total	1,832			

4.3 Summary

In 2021, high R&D intensity firms accounted for 2.1 per cent of employment in Welsh employer enterprises, a level which compares well with Northern and Midlands regions of the UK. Medium-high R&D intensity firms accounted for a further 4.8 per cent of employment in employer enterprises in Wales, a level below most other UK regions. Welsh high and medium-high R&D intensity firms contribute more to turnover than employment, 3.2 per cent and 7.4 per cent respectively. Both compare well with the majority of UK regions and are notably higher than the contribution of high R&D intensity firms to business turnover in Scotland.

Overall, high R&D intensity firms constitute around 0.4-0.5 per cent of all firms in each Welsh region. Medium-high R&D intensive firms are more strongly represented in south east Wales (3.6 per cent) compared to north and mid and south west Wales (2.2-2.6 per cent). These differences are also reflected in the contributions of R&D intensive firms to both employment and turnover in each area. High R&D intensive firms contribute 2.8 per cent of employment and 4.6 per cent of business turnover in south east Wales, both notably higher than their contributions to other Welsh regions.

In terms of innovation, Welsh firms were marginally less likely than English R&D intensive firms to introduce product innovations during this period but were slightly more active product innovators than firms in either Scotland or Northern Ireland. Larger differences are evident in the proportion of R&D intensive firms in Wales engaging in process innovation – 24.8 per cent – a level considerably below that in other parts of the UK (30.5-31.6 per cent).

Across the UK, as in Wales, economic risks and the high costs of innovation are the main barriers to innovation in R&D intensive firms, followed by skills and the availability of finance. Both the costs of finance and technology and market information gaps were however less often mentioned as significant barriers by firms in Wales than elsewhere. For example, the cost of finance was reported as a barrier to innovation by 20.8 per cent of R&D intensive firms in Wales compared to 28.1% of similar firms in Scotland.

Universities are seen as slightly less important as a source of information for innovation in Wales than in other parts of the UK, a finding reflected in a level of collaboration with universities in Wales which is considerably below that in England and particularly Scotland. Government research institutes also play less of a role as an innovation collaborator and source of information in Wales relative to England and Scotland.

"Both the costs of finance and technology and market information gaps were however less often mentioned as significant barriers by firms in Wales than elsewhere."

5.1 Introduction

In August and September 2023, we conducted eleven in-depth interviews with firms operating in high R&D intensity sectors in Wales (see Annex 1). Reflecting the geographical distribution of high R&D intensity businesses noted earlier, most interviewees were in south Wales, with two in the South East, six in the South West, and three in North Wales. Businesses ranged in size (number of employees) from 9 to 100, with one not having employees, but having engineers working on a 'sweat equity' basis. Seven of the businesses were established more than 20 years ago, three established 10-20 years ago and one 5-10 years ago. The types of innovation businesses are engaged in included pharmaceuticals, electronics, aviation, advanced manufacturing and software.

Most businesses are independently owned, with ownership in the hands of managers and/or a small number of shareholders, but one is a subsidiary of another UK firm (as a major shareholder) and another owned by US Venture Capital. The majority are mid-supply chain businesses, designing and producing their product and services. Two defined themselves as 'R&D firms', and these designed and assembled, rather than produced their products.

Interviews were conducted on-line using an open-ended question schedule (Annex 2). Where interviewees gave permission discussions were recorded for later analysis. Comments below are anonymised and in some cases minor edits have been made to preserve anonymity.

5.2 Thinking innovation

Innovation is important to most of the businesses interviewed and all except one had a dedicated internal resource for research and development. To understand more about their innovation, we explored a specific new product, service or process introduced or worked on in the last year. Again, all except one had one innovation. The innovation ranged from new products to developments of existing products to new processes to underpin and systemise R&D within the firm. The drivers, and type, of innovation vary across firms and market contexts:

- One firm was developing a new software system because parts had become obsolete. To continue providing their customer with their required goods, they had to develop a new product with different raw materials.
- The youngest firm in the sample has a product on the market but is still developing it. It hopes the latest evolution will outsell its existing product and allow the company to break even.
- R&D is essential to three firms because the technology they use keeps evolving and/or raw materials become obsolete, and they must keep up to date. In one of these firms, the latest product they are developing has a specific application for an existing customer, but they hope to be able to apply the technology to other markets; whereas for another they are developing a new product to widen their market.
- One established firm is transferring manufacturing technology from an existing manufacturer who want to offload that part of their business. This has been a complex and lengthy process as it is in the pharmaceuticals sector, but it will enable the Welsh firm to become the main European supplier and secure their position in the market.
- Competition was the key driver for another firm who have major competitors, with bigger funds for R&D, in the US - 'you've got to keep developing your products just

to make sure that you remain competitive'. They are broadening the application of their health tech product to other medical conditions. As with the other innovating firms, R&D and innovation is an on-going process, but this firm had a particular strategy:

'I am working on a cycle of having at least a product iteration or a new product every six months. A lot of the time it could just be an iteration of a product, so we've just done the software updates, or we've introduced a new feature...But we do have in the pipeline some that will be novel products that we will be launching in the next 12 to

18 months. So yeah, we have a range of projects on the go at any one time'. (**Health Tech, 20+ years, South West**).

- Another firm's core business is the design and manufacture of new or evolving systems for customers. They occasionally develop novel solutions, but largely driven by customer demand:

'we don't really make up product we make lots and lots of different products...we're making for an application which is usually a bespoke application'. (**Electronics, 20+ years, North**)

5.3 Funding

All of the businesses engaged in innovation are funding their current innovation through their own resources:

'We're just relying on the sales and the revenue that we generate to fund our own R&D expenditure'. (**Health Tech, 20+ years, South West**)

One firm has a major UK shareholder who invests, but this is limited to the major innovation project they are currently undertaking. This firm has also received support from the Welsh Government for the new building needed.

Most of the firms' previous innovation has also been self-financed, although two have had support from the Development Bank of Wales in the past and one is still part owned by the Development Bank. One firm reported they had looked at the website and were not clear on what the Development Bank did or who it would lend support to, and another was unaware of the Development Bank. None have had funding from Innovate UK. The firm which has another UK shareholder reported (wrongly) they were unable to access Innovate UK funding because they did not fall into the SME category, and another reported they could not because they are owned by US Venture Capital. A small number of firms had received Business Angel investment in the past.

"All of the businesses engaged in innovation are funding their current innovation through their own resources"

5.4 Partnerships

Surprisingly, most of the businesses interviewed did not get information or support from external organisations – the businesses themselves were the experts. One firm commented:

‘there isn't really anybody in our sector that's as advanced as us’. **(Advanced manufacturing, 10-20 years, South East)**.

At most, the businesses worked with customers to gain feedback on the implementation of their innovation or in the ongoing development of bespoke solutions. Around half of the businesses interviewed referred to other sources of expertise that they did or sought to tap into, including a UKRI research grant, a Government Executive Agency and a Trade body. These were useful, but the firm which engaged with the Trade body was not sure the benefits would outweigh the cost of membership because of their own internal expertise.

Perhaps reflecting the lack of connectivity with universities noted earlier, only one was currently working with a university (on a PhD student

who was developing software for them and by offering placements to students), though some had in the past. One in the North had worked with the local university until it closed its Chemistry department, and had not been able to replicate the relationships with another university. One commented that universities tended to be slow, and they needed to be more proactive and speedier in their innovation. A firm engaged in Health Tech innovation had an Advisory Board, but they were predominantly professors from the US and another pharmaceutical firm struggled to engage UK clinicians:

‘we've had more interest from Clinicians in other countries than in the UK... the NHS is overloaded, and clinicians don't have the time’ **(Pharmaceuticals, 10-20 years, South West)**

One firm which had worked on a Knowledge Transfer Partnership reported that the knowledge gained was useful and they were starting to use it now, a couple of years after the partnership.

5.5 Barriers

As suggested by the earlier information from the UK Innovation Survey, around half of the firms reported finance and resourcing as a barrier to undertaking (further) R&D. For example, as we have seen, the firms interviewed tended to self-fund R&D, and there was a limit to the availability of this resource:

‘Obviously if they (owners) want us to be self-sufficient, we can only develop within our means. So, finance is always a barrier that we come up against’. **(Health Tech, 20+ years, South West)**.

‘The biggest challenge I guess we have at the moment is we got more ideas than we

got resource and because we're self-funding, we can't really spend any more’ **(Advanced manufacturing, 10-20 years, South East)**.

This same firm reported that they lacked the time to get help, and although having recently been advised by Welsh Government, they did not have time to ‘fill in the forms’:

‘we actually tick a lot of the boxes of the Welsh Government. I just need the time to look at all the information they've sent, fill in all the forms, create an innovation plan.....It's almost like I need some funding to get somebody to fill the forms in for me’. **(Advanced manufacturing, 10-20 years, South East)**.

Other reasons were also cited as to why these firms cannot access more resource for R&D. For example, long-lead in times for pharmaceutical research is a barrier to lending money, while for another, they lacked assets to borrow against and sold capital goods, without a regular revenue stream.

'With capital sales, your sales aren't consistent. It's not like you're selling a consumable product where you have that recurring revenue every month. We have peaks and troughs in our sales, so our financial outlook can be difficult to predict'. **(Health Tech, 20+ years, South West)**.

This same firm reported using external Design Agencies to provide additional capacity reporting:

'I can be much more aggressive in my R&D timelines because I use a network of external design agencies around the UK, just to supplement my internal design team. That could be for additional capacity when we require it or because I need a certain skill set for a certain project that we are working on. Obviously, they come at a cost'. **(Health Tech, 20+ years, South West)**.

Another firm was considering this, but also aware that this would absorb time in managing the outsourcing process and activity and for another firm, this sort of support was not available – or they were not aware of consultants with the level of specialism required.

We have reported that some firms did not think they could access funding from Innovate UK because of their size. Another commented that they had been unsuccessful in accessing funding, because they could not demonstrate a path to commercialisation, but were also hampered by the funding criteria:

'A lot of the funding schemes are bids for a single technology and whereas to do a whole aircraft, we're calling on a whole bunch of

technologies.....and the bid systems are completely averse to the information, the quantity of information that we've got to get across'. **(Aerospace, 20+ years, South West)**.

Nevertheless, this firm reported they were often invited to bid, and found this quite damaging:

'The funding bodies in the UK invite us to bid for money repeatedly..... I cannot put in words how hurtful, and how frustrating, and how absolutely, materially damaging it is because the bids take a long time. It takes your key and best people, and we have to raise investment from very precious business angels to bid for these funds because it's a costly and time consuming process'. **(Aerospace, 20+ years, South West)**.

Half of the firms reported recruitment difficulties as a challenge which impacted on R&D. For five of these, the reason was their rural location in North West or South West Wales and difficulty attracting talent. Two reported that Covid, and the use of homeworking, had made this easier and they were now more flexible on where people were located. For the other firm, their recruitment difficulties were more to do with an inexperienced management team due to a recent buy-out, but were learning all the time.

'Finding correct recruits has been tricky, I suppose. And particularly you haven't sort of been in this role for very long. So, I guess we're kind of learning as well as we go along with that type of thing' **(Electronics, 20+ years, South West)**.

Another firm cited skilled people as an issue, but was working with a local college and, because there is a cluster of businesses in the vicinity, there was a recruitment pool, but there was also competition for skilled staff:

'... there's a lot of job hopping, but that's just the world at the moment I'm afraid'. **(Electronics, 20+ years, North)**

5.6 Location

Respondents were mixed on the extent to which being located in Wales helped or hindered their R&D activities. For some, the support they had received from Welsh Government and others was fundamental for their growth, for example:

'We've been very well supported by Development Bank of Wales and by Welsh Government to get to this point... my guess is without that support, we wouldn't have got to where we are now'. **(Advanced manufacturing, 10-20 years, South East)**.

For another firm their location, on the English border in the north was an advantage.

'We're a small business in England but we're a bigger business in Wales. So ... because we're so close to England we say we operate in the North West of the UK and but when we're bidding for Welsh projects, we're a North Wales Company so it's nice to be able to pivot one way or the other'. **(Electronics, 20+ years, North)**

Additional benefits of location cited by this firm is proximity to a large and well-known manufacturer, which made the place recognisable. They were also enthusiastic about the support from Business Wales which had supported networking opportunities.

For most firms their location in Wales made no difference to their ability to innovate. But for a few, their location was a hindrance, because of rural locations, rather than anything to do with the quality of the Welsh ecosystem per se. Connected to the recruitment issues reported above, these firms were located in North West and South West Wales. One firm in the West also noted that delivery of goods and parts also took a day longer. None of these businesses intend to relocate because they have historical roots in those places, even though relocation has been (or still is) a topic of discussion within some of the firms.

5.7 Future plans

All of the firms intend to continue or develop their R&D activities in the future and continue to self-fund. The one firm in the sample that was not currently engaged in R&D activities is exploring three commercial options for use of their by-product and have explored this with a university research centre. They report they are now awaiting suitable funding opportunities, as they do not need as much funding as is currently available:

'They're saying they're looking for projects and say 100K to £2.5 million, for example. And we're thinking we don't need that much money...something in the region of 25 to 50K would see this current project through'. **(Pharmaceuticals, 10-20 years, North)**

Firms are considering developing their offer through entering new technologies, through partnership with a major healthcare funder or through seeking more customers for their product and R&D services. For this latter firm, which already conducts research for customers, they recognised the risks that came with this approach:

'We might start advertising a bit more for new customers. But to do that would have to probably expand a little bit and take on a few engineers, and that's kind of risky, I suppose, a double-edged sword. But yeah, that's in the plans when we get a chance in the next year or two'. **(Electronics, 20+ years, North)**

5.8 Support wanted

Most firms interviewed could not think of any additional support they might want from Welsh Government or Development Bank of Wales, as typified by the following respondent:

'No, I can't really think of anything unfortunately'. **(Electronics, mid-supply chain, South West)**.

One respondent in the North was positive about Welsh Government, and particularly that they were increasingly acknowledging that businesses in the North will find it easier to engage with experts and universities in North West England than in South Wales:

'The Welsh Government has always been very helpful, and we have used Welsh Government funding and schemes over the years. So, I would be positive about the attitude and the support we get from the Welsh Government'. **(Pharmaceuticals, 10-20 years, North)**.

The respondent also did not think there was a need to 'throw money at it'. However, a few others reported that additional funding opportunities would be useful, whilst still recognising difficulties such as eligibility, that much of the R&D is on-going essential development of existing products:

'If there is a fund available then we will be more than interested to look at it, but a lot of what we do might not be hugely innovative. It might just be little incremental steps rather than game changer ... it's very rare that a new development actually changes the whole face of the business'. **(Advanced manufacturing, 20+, North)**.

Additional issues respondents noted associated with Government funding are that Government processes are complex and time-consuming, while also not being consistent with the timelines on which business operate. For example, one firm had reported that accessing Government funding was often a slow process, inconsistent with their own timelines and

therefore they had used their own money instead. What they wanted was clearer criteria in support applications, comparing an unclear approach on criteria from Government agencies, with the commercial sector:

'I'm just going to go down this sort of commercial route where you know 'you have to have put this much money down ...and these are the payments, and this is the credit rating that you've got to have.' Alright, we can do that and it was quick and painless ... Whereas I found with the government agencies they want to talk to you, want to get to know you and they want to know what you're doing ... let's be brief. I'd like it to fail fast...or succeed quickly'. **(Electronics, 20+ years, North)**.

Another firm which struggled to invest in sales and marketing resource for their products would value cash injection to support this type of activity because:

'It's very difficult to juggle both our R&D and sales and marketing'. **(Electronics, 5-10 years, South West)**.

One firm would like a closer relationship and to be acknowledged by Welsh Government and receive promotional support. They see this happens for other firms and don't feel as close:

'(another firm name) seem to have a close relationship with the Welsh Government and the agencies where we don't seem to have the same'. **(Health Tech, 20+ years, South West)**.

At a more macro level, one of the firms which struggled to recruit in South West Wales noted that it would be most helpful for them to have improved local and national transport links:

'The Welsh Government, if they want to make a contribution to businesses based out where we are, they should focus on improving the infrastructure'. **(Pharmaceuticals, 10-20 years, South West)**.

Our profile of firms operating in high R&D intensity sectors in Wales suggests four key findings. First, while high R&D intensity firms constitute only a small proportion of all companies in Wales, they generate a disproportionate share of jobs and sales. Overall, high R&D intensity firms constitute around 0.4-0.5 per cent of all firms in each Welsh region and accounted for 2.1 per cent of employment in Wales, a level which compares well with Northern and Midlands regions of the UK. High R&D intensive firms contribute 2.8 per cent of employment and 4.6 per cent of business turnover in South East Wales, both notably higher than their contributions to other Welsh regions.

Second, the profile of innovative activity in high R&D intensity firms in Wales differs from that in the UK as a whole. Welsh firms were marginally less likely than English R&D intensive firms to introduce product innovations during this period but were slightly more active product innovators than firms in either Scotland or Northern Ireland. Larger differences are evident in the proportion of R&D intensive firms in Wales engaging in process innovation – 24.8 per cent – a level considerably below that in other parts of the UK (30.5-31.6 per cent). Some sectoral differences are also evident. In terms of product/service innovation, Welsh manufacturing companies prove less innovation intensive than those in other parts of the UK, while Welsh services companies have a significantly higher level of product or service innovation than their UK peers.

Third, innovation survey data highlights some similarities and differences in the barriers for innovation in Wales and other parts of the UK. In Wales – and across the UK – economic risks and the high costs of innovation are the main barriers to innovation in R&D intensive firms, followed by skills and the availability of finance. Both the costs of finance and technology and market information gaps were however less often mentioned as significant barriers by firms in Wales than elsewhere. For example, the cost of finance was reported as a barrier

to innovation by 20.8 percent of R&D intensive firms in Wales compared to 28.1 percent of similar firms in Scotland.

Fourth, universities are seen as a slightly less important as a source of information for innovation in Wales than in other parts of the UK, a finding reflected in a level of collaboration with universities in Wales which is considerably below that in England and particularly Scotland. 20.0 percent of Welsh R&D intensive firms were collaborating with universities compared to 35 percent in Scotland. Government research institutes also play less of a role as an innovation collaborator and source of information for innovation in Wales relative to England and Scotland. It is notable in this context that Scotland introduced 'Interface' in 2005 to provide a link for businesses to Scottish universities, colleges and research institutes. In 2022/23 Interface brokered 313 such projects of which 6 per cent related to firms from outside Scotland¹⁰.

Interview data from discussions with high R&D intensity firms largely confirms these findings, as well as suggesting the diversity of innovation activity across Welsh firms. Key points emerging from the interviews with high R&D intensity businesses in Wales were:

- A reliance on internal resources was constraining some firms' innovation activity, although other companies had taken advantage of support from the Welsh government and the Development Bank of Wales.
- Some firms which were interviewed seemed unaware of potential opportunities for public funding, or were misinformed about their relevance. Other firms were put off seeking public funding for their innovation activity due to the time-consuming nature of the application process.
- Customer partnerships were common among the firms interviewed. University links were limited due to institutional changes, response times and a lack of interest on the part of some potential university partners.

¹⁰ See <https://interface-online.org.uk/>.

- Constrained internal resources were limiting innovation in some cases, with other firms referencing recruitment challenges linked to more rural locations. However, there was little consensus across the firms interviewed about any additional support needs.

High R&D intensity firms in Wales emerge as facing very similar challenges to those elsewhere in the UK, linked largely to the risks and costs of innovation and related resource constraints. For example, recent changes to the R&D tax credit in the 2023 Budget, and changes in the definition of R&D intensive firms announced in the 2023 Autumn Statement, may influence the attractiveness of investing in loss-making R&D intensive businesses¹¹. However, the innovation Welsh firms are undertaking differs somewhat to that elsewhere with a stronger focus on product/service innovation and less focus on process change. Levels of university collaboration are lower than those in some other parts of the UK, notably Scotland where Interface provides an accessible means for firms to access expertise within Scottish Universities. These lower levels of collaboration in Wales combine some of the companies interviewed with a strong reliance on internal funding for innovation and limited engagement with potential sources of public funding. Both factors suggest a more 'closed' rather than 'open innovation' model and both may be limiting firms' ability to share the costs and risks of innovation.

In policy terms this suggests that there may be value in promoting the benefits of more collaborative and open approaches to innovation, a measure which would support each of the missions outlined in Wales Innovates. For example, if levels of university collaboration in Wales were similar to those in

Scotland this would equate to an additional 350 high and medium-high R&D intensity Welsh firms collaborating with universities. Promoting open innovation potentially has both strategic and capability related elements. Illustrations or case study examples, for example, may provide the strategic impetus for firms to engage in more collaborative innovation. Implementing collaborative relationships, however, may be complex in contractual and managerial terms – dealing with intellectual property issues for example – suggesting the need for capability building. Sectoral contrasts also suggest the potential value of concentrating measures to promote collaboration on manufacturing firms in Wales, where current levels of product/service innovation are below those in other parts of the UK.

Our analysis also suggests some potential directions for future research. First, we focus here on a sub-sector of innovating and R&D performing firms located in Wales. It is not clear whether the gap in collaboration between these R&D intensive firms and universities also applies to other less R&D intensive firms. Are these firms also less likely to be working with universities than similar firms elsewhere in the UK? Second, it is clear that promoting collaboration has been a central element of a number of EU supported programmes in Wales over the last decade. What does the evidence presented here suggest about the success of these programmes? How does the analysis of the UK Innovation Survey data align with that of related programme evaluations? Finally, it may be worth considering the resilience of R&D intensive firms, compared to other firms, during the COVID-19 pandemic to identify approaches to building future business resilience.

"there may be value in promoting the benefits of more collaborative and open approaches to innovation, a measure which would support each of the missions outlined in Wales Innovates."

¹¹ See <https://www.gov.uk/government/publications/autumn-statement-2023-research-and-development-tax-reliefs-reform/technical-note-on-changes-to-research-and-development-tax-reliefs-at-autumn-statement-2023>.

Annex 1: Identifying high R&D intensity sectors

Annex 1

Identifying high R&D intensity sectors



ONS (SIC2007)	Sector Name	OECD ISCI specific classification	OECD R&D intensity classification
1	Crop and animal production, hunting and related service activities	01-03:Agriculture, forestry and fishing	Low
2	Forestry and logging		Low
3	Fishing and aquaculture		Low
05_06_07_08_09	Mining and support services	05-09: Mining and quarrying	Medium-low
10_11_12	Manufacture of food, drink and tobacco		Medium-low
13_14_15	Manufacture of textiles, wearing apparel, leather and leather products		Medium-low
16	Manufacture of wood, and of products of wood and cork		Medium-low
17	Manufacture of paper and paper products		Medium-low
18	Printing and reproduction of recorded media		Medium-low
19	Manufacture of coke and refined petroleum products		Medium-low
20	Manufacture of chemicals and chemical products		Medium-High
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations		High
22	Manufacture of rubber and plastic products		Medium
23	Manufacture of other non-metallic mineral products		Medium
24	Manufacture of basic metals		Medium
25	Manufacture of of fabricated metal products, except machinery and equipment	25 less 252: Fabricated metal products, except weapons and ammunition	Medium-low
		252: Weapons and ammunition	Medium-High
26	Manufacture of computer, electronics and optical products		High
27	Manufacture of electrical equipment		Medium-High
28	Manufacture of machinery and equipment n.e.c.		Medium-High
29	Manufacture of motor vehicles, trailers and semi-trailers		Medium-High

Annex 1: Identifying high R&D intensity sectors

ONS (SIC2007)	Sector Name	OECD ISCI specific classification	OECD R&D intensity classification
30	Manufacture of other transport equipment		
		301: Building of ships and boats	Medium
		302, 304 and 309: Railroad, military vehicles and transport n.e.c. n.e.c.	Medium-High
		303: Air and spacecraft and related machinery	High
31_32	Manufacture of furniture and other manufacturing	31: Furniture	Medium-low
		32 less 325: Other manufacturing except medical and dental instruments	Medium
		325: Medical and dental instruments	Medium-High
33	Repair and installation of machinery and equipment		Medium
35	Electricity, gas, steam, and air conditioning supply	35-39: Electricity, gas and water supply, waste management and remediation	Low
36	Water collection, treatment and supply		Low
37_38_39	Sewerage, waste collection and remediation		Low
41_42_43	Construction		Low
45	Wholesale and retail trade and repair of motor vehicle and motorcycles	45-47: Wholesale and retail trade	Low
46	Wholesale trade, except of motor vehicle and motorcycle		Low
47	Retail trade, except motor vehicle and motorcycle		Low
49	Land transport and transport vis pipeline	49-53 : Transportation and storage	Low
50	Water transport		Low
51	Air transport		Low
52	Warehouse and support activities for transportation		Low
53	Postal and courier activities		Low
55_56	Accommodation and food & beverage services	55-56: Accommodation and food service activities	Low
58	Publishing activities		
		581: Publishing of books and periodicals	Medium-low

Annex 1: Identifying high R&D intensity sectors

ONS (SIC2007)	Sector Name	OECD ISCI specific classification	OECD R&D intensity classification
		582: Software publishing	High
59_60	Film, television programming and broadcasting	59-60: Audiovisual and broadcasting activities	Low
61	Telecommunications		Medium-low
62_63	Computer programming and information service activities		Medium-High
64	Financial service activities, except insurance and pension funding	64-66: Financial and insurance activities	Low
65	Insurance, reinsurance and pension funding, except compulsory social security		Low
66	Activities auxiliary to financial services and insurance activities		Low
68	Real estate activities		Low
69_70	Legal and accounting services and activities of head office	69-75 (less 72): Professional, scientific and technical activities except scientific R&D	Medium-low
71	Architectural and engineering activities; technical testing and analysis		Medium-low
72	Scientific research and development		High
73	Advertising and market research		Medium-low
74_75	Other professional, scientific and veterinary activities		Medium-low
77	Rental and leasing activities	77-82: Administrative and support service activities	Low
78	Employment activities		Low
79	Travel insurance, tour operator and other reservation service and related activities		Low
80_81_82	Security services and office support		Low
84	Public administration and defense; compulsory social security		
85	Education		
86	Human health activities		
87_88	Residential and other social care		
90_91_92	Art, entertainment, libraries, museums, gambling and betting activities	90-99: Arts, entertainment, repair of household goods and other services	Low
93	Sports activities and amusement and recreation activities		Low
94	Activities of membership organizations		Low
95	Repair of computers and personal and household goods		Low
96	other personal services activities		Low

Annex 2: Interview schedule

Introduction

We are working with the Development Bank of Wales to better understand the specific challenges faced by a small group of R&D intensive businesses in Wales. We would like to ask you some brief questions about how R&D fits into your business, what your aspirations are for R&D and innovation over the next year or two, and how you aim to finance these developments.

The aim is to help the Development Bank and Welsh government to better support high R&D intensity firms in Wales.

If necessary: We selected your business based on the industry in which you operate. Firms in your sector are typically R&D intensive.

Interview schedule

- Q1.** Can you tell me something about your business and the markets in which you operate? How long have you been established? What was the background to the business (spin-out, VC backed firm, long-established)?
- Q2.** What are the main technology areas you are involved in? How do these contribute to the products or services you offer?
- Q3.** Have you introduced any new products or services over the last year? What were these? New to market or new to firm? Product/service/process? How have they contributed to the success of the business (or how will they contribute in future)?
- Q4.** Thinking about all of the R&D you have undertaken over the last year or two. How was it funded? Did you get any government financial support from Welsh government, Innovate UK or elsewhere?
- Q5.** What are the main external information sources for your R&D and innovation? Were any partners in Wales or elsewhere? Have you worked with any universities or other organisations on these developments? How did they find them and how did these relationships work?
- Q6.** Overall, what are the most significant challenges you face in undertaking R&D and innovation?
- Prompt as necessary:** are these linked to: cost of R&D, Finance (access, availability, cost), skills, markets and customers, intellectual property?
- Q7.** Does being in Wales help or hinder your R&D and innovation activities? Is the situation better or worse than that for your competitors based elsewhere? How supportive is the local environment and different partners?
- Note:** If based in sites across the UK, ask respondent if they have a perspective on how this works for their own firm.
- Q8.** Is your business planning to engage in R&D or new product/service development over the next 12 months? If yes, are you aiming to keep investment at current levels, increase or reduce it? What do you see as the key challenges in making this investment and ensuring its success? How are you planning to fund this investment?
- Q9.** What could the Development Bank of Wales and/or Welsh Government do to better support your R&D and innovation activity in future?

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