Life and Health Sciences Industry Survey Report

March 2020

NW CAM
North West Centre for Advanced Manufacturing

Catalyst
Fuelling Opportunity

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Executive Summary

INTRODUCTION

In 2019, the North West Centre for Advanced Manufacturing[1] (hereinafter referred to as "NWCAM") conducted a survey of Life and Health Science (LHS) sector companies in Northern Ireland, Ireland and Scotland. The purpose of the survey included:

- To obtain an understanding of industry interests, capabilities, needs and the challenges that affect the growth and productivity of companies who are operating within the life and health science space within the Region and surrounding areas.
- To capture information relating to regional LHS company Research and Development (R&D) and innovation strategies including cross-border R&D collaborations.
- To bring an awareness of Advanced Manufacturing to the LHS sector and highlight its potential as an enabling technology to enhance industry competitiveness, efficiency and productivity.
- To assess interest and current engagement of Advanced Manufacturing methodologies within their company practices to help inform related public investment within the Region.

The vision of NWCAM is to enhance the innovation ecosystem across the Region i.e. Northern Ireland, the Border Region of Ireland and Western Scotland, where an underinvestment in manufacturing R&D has affected the growth of indigenous companies. NWCAM's core objectives include:

- To increase the level of cross-border collaboration across the Region in the area of applied Advanced Manufacturing research and innovation;
- To enhance the number of regional LHS (including supply chains) sector companies engaged in commercially driven cross-border Advanced Manufacturing research and innovation;
- To grow the regional economy through the development of new products and/or processes within the LHS Sector to Technology Readiness Levels (TRLs) 2-6, developed as a result of the application of Advanced Manufacturing technologies; and
- To raise awareness of the potential of Advanced Manufacturing as an enabling technology within the Life & Health Sciences industry sector and other sectors key to the Region's current and future economic success.

THE SURVEY

This report provides a comprehensive summary of responses from a survey administered by NWCAM. The analysis is based on data captured from a sample of 41 respondents from the Life and Health Science[2](LHS) sector covering the whole of Northern Ireland, Ireland and Scotland. The participating companies that responded represent approximately 29,000 people employed in the sector. The purpose of the survey was primarily to gain a better understanding of industry activities, interests, capabilities, needs and challenges that affect their growth and productivity within the broader regional sector. With regard to the profile of respondents:

- Just over half of respondents resided in Northern Ireland (54%), 39% in Ireland and 7% in Scotland.

[1] https://wearecatalyst.org/research/nw-cam/

[2] *With reference to the EU INTERREG VA definition glossary, the LHS sector covers two broad fields of science: 1) Life Sciences which relates to those organisations researching or applying knowledge in the fields biotechnology, biomedical technologies, life system technologies, genomics, diagnostics, pharmaceutical, nutraceuticals, food processing, environmental and biomedical devices; and 2)) Health sciences which relate to those organisations working in applied science with human and animal health which may include (but not limited to) researching and gaining knowledge of health and the application of that knowledge to improve health, prevent and cure diseases, and understand how humans and animals function; In summary the LHS sector can be defined as those organisations working on the application of biology and technology for health improvement, including biopharmaceuticals, medical technology, genomics, diagnostics and digital health.*

- Companies were predominantly micro-businesses or SMEs with a lesser number of multi-national corporations.
- Over 50% of respondents generated a turnover of less than £5 million per annum and almost a quarter with a turnover of £5-50 million per annum.
- The majority of respondents were either in a stable position or in a period of either slight, moderate or rapid expansion. Few were pre-revenue start-ups.
- Medtech-core, contract research & manufacturing; and medtech-service and supply were noted as the top three most popular descriptions of the respondents' businesses.

RESULTS

This survey illustrated high levels of awareness of Advanced Manufacturing as an enabling technology and interest in engaging in related cross-border focused collaborative R&D. However, respondents also indicated the requirement for additional supports to facilitate this situation, as outlined below:

Key Findings

- 77% [of respondents] reported an awareness of Advanced Manufacturing as an enabling technology with potential to improve commercial performance.
- 61% stated that the adoption of Advanced Manufacturing was very / extremely important to their company.
- 78% confirmed they would be interested in engaging in cross-border collaborative Advanced Manufacturing R&D.
- 66% of respondents said that the most beneficial R&D support was for collaborative R&D with research institutions and/or other industry partners.
- In order to remain competitive, 66% of respondents reported that government investment in manufacturing and innovation was of paramount importance to their success.
- There was an overwhelming agreement amongst 97% of respondents that there is an engineering skills shortage in the Region.

Other findings included the following:

- Additive manufacturing/3D printing was noted as being of most interest to respondents followed by sustainable manufacturing, advanced polymers and nano-manufacturing.
- The top R&D and innovation priorities for respondents included the launch of new/improved products and processes, and internal R&D activities.
- Other forms of beneficial R&D support were noted by respondents as access to highly trained staff, support for skills training, upskilling and professional development and investment in infrastructure, grants and subsidies.
- In addition to government investment, respondents felt that availability of engineering-related personnel & access to world class research expertise, clarity on Brexit policies, modernisation of existing technology, Intellectual Property (IP) strategies and international commercialisation were also essential to increasing R&D related competitiveness.
- Most respondents (73%) reported having an R&D strategy, with horizons varying from 1-5+ years. Almost three quarters of respondents invested between 6-20+% of annual revenue on R&D activities, of which over half that was performed internally.
- For the majority of respondents, R&D development could be categorised within the early to mid-range of TRL2-6 levels; with TRL3 being the most prevalent.
- Few respondent R&D collaborations related to Advanced Manufacturing.
- All respondents received government funding over the past three years primarily from Invest NI, Innovate UK and from EU funding sources; and the majority had availed of R&D tax credits in the past three years though 32% either did not avail and/or were not aware of them.

- Only 20% had availed of the UK Government Patent Box tax relief scheme and a further 29% said that they were not aware of the scheme. 34% had not registered any intellectual property in the past five years.
- Most engineering skills employment occurred through recruitment of graduates, interns or placements rather than PhD students, apprenticeships and post-doctoral researchers.

CONCLUSIONS

Despite the challenges ahead, which include Brexit and global trading issues, the survey reported an optimistic outlook from the wider regional LHS sector, which appears resilient in the face of adversity.

Regional Awareness of Advanced Manufacturing as an Enabling Technology	Advanced Manufacturing is a transformative technology enabling enhancement of sector capabilities and driving prosperity in areas where R&D and innovation are lacking. The survey reported a growing awareness and understanding of the opportunities that these cutting-edge technologies can offer; from boosting more efficient and cleaner productivity and creating new business models; to opening up new overseas markets and export power within the LHS sector. The survey indicated significant appetite to engage or further engage in related R&D among respondents.
Regional Levels of R&D	Regional businesses are clearly investing in R&D and innovation activities to provide a competitive edge. However, they require more support and investment to do so, especially micro-businesses and SMEs, who are often time and resource poor. Many businesses are following the example of the Pharma industry and outsourcing some R&D activities to CROs and/or collaborating with universities and research centres of excellence in order to accelerate their path to market. This report provides clear evidence of a more collaborative culture within the LHS sector, and a willingness for more. The survey also signifies a greater appetite for cross-border and trans-regional strategic industry-academia and industry-industry partnering, along with a rise of interest in joint venture formation.
Regional Commercialisation Levels	The survey reported that many businesses are protecting their intellectual assets but a significant proportion are not. Although UK and Irish governments are rolling out generous R&D tax credit schemes such as the Patent Box and Knowledge Development Box respectively, to incentivize and drive companies to invest in innovative R&D and intellectual property protection, many firms are not engaging. This issue must be addressed by governments and industry alike to understand the barriers to participation and address them accordingly.
Regional Engineering Skills Levels	Engineering skills and recruitment is a fundamental concern for most regional companies. Businesses are beginning to take measures to retrain and reskill their existing employees but more support is required from governments and education leaders. Moreover, sector leaders and champions hoping to recruit the next generation of engineering talent need to do more to showcase what the profession has to offer.

RECOMMENDATIONS

There is now a unique opportunity to build on the solid foundation of the regional LHS sector and proactively drive momentum to create a sustainable, high performing, agile and innovative ecosystem to help the regional economy to thrive in a global market. In the context of NWCAM, the survey has highlighted that regional sector collaborations can make a difference to all sizes of companies where everyone stands to benefit. More regional concentration of R&D funding, more connectedness to address economic gaps in the sector should be encouraged through the converging of new enabling technologies such as Advanced Manufacturing to the LHS and more widely to other industry sectors.

This report concludes with a list of related recommendations, which include the following:

Key Recommendations

- Continue the prioritisation of the LHS as a regional growth sector.
- Champion the adoption of Advanced Manufacturing as an enabling technology to create new, commercially driven products and processes within the LHS and other sectors.
- Optimise opportunities for LHS sector cross-border and trans-regional R&D relationships.
- Increase the levels of collaborative, cross-border and trans-regional R&D funding.
- Provide greater R&D support to micro-businesses and SMEs to scale across the Region.
- Increase intellectual property awareness.
- Rebrand engineering as a rewarding career and champion industry-led PhD and post-doctoral research careers.
- Increase awareness of R&D Tax Credits and other incentive schemes.

Background

North West Centre for Advanced Manufacturing

The North West Centre for Advanced Manufacturing or NWCAM, funded through the EU INTERREG VA Programme was established in April 2017[3]. It is a trans-regional virtual centre spanning Northern Ireland, the West Coast of Scotland and the border areas of Ireland (hereinafter referred to as "the Region'). With a primary focus on Advanced Manufacturing, NWCAM provides an agile and collaborative support structure to deliver applied research expertise and capabilities in Advanced Manufacturing from four world leading academic institutions i.e. University of Glasgow, Ulster University, Institute of Technology, Sligo (IT Sligo) and Letterkenny Institute of Technology (LYIT). Researchers are currently working in partnership with a number of start-ups, SMEs and larger multinationals drawn from the LHS sector performing Research and Development (R&D) of innovative solutions to critical industry problems. These unique partnerships are delivering 15 research projects, which have the potential to create global products, processes and services that can make real economic and societal impact. The programme concentrates on four thematic areas: sustainable manufacturing, advanced polymers, additive manufacturing, and nano-manufacturing.

NWCAM Vision and Objectives

The overall vision of NWCAM is to strengthen and stimulate the economy of the Region, supporting highly skilled value-adding innovative industries to compete in a global marketplace and supporting the growth of a cross-border "super cluster' of geographically concentrated interconnected businesses, suppliers, associated institutions, start-ups, incubators and accelerators within the regional sector.

The primary objectives of NWCAM are:

- To increase the level of cross-border collaboration across the Region in the area of applied Advanced Manufacturing research and innovation.
- To enhance the number of regional LHS (including supply chains) sector companies engaged in commercially driven cross-border Advanced Manufacturing research and innovation.
- To grow the regional economy through the development of new products and/or processes within the LHS Sector to Technology Readiness Levels (TRLs) 2-6, developed as a result of the application of Advanced Manufacturing technologies.
- To raise awareness of the potential of Advanced Manufacturing as an enabling technology within the Life & Health Sciences industry sector and other sectors key to the Region's current and future economic success.

The delivery of NWCAM is managed through Catalyst, a local technology and entrepreneurship innovation hub based in Northern Ireland. Catalyst complements and works collaboratively with existing industry associations, research bodies, investors, funders, government agencies and departments within the Region, providing connected space, helping to build communities of innovators and entrepreneurs and supporting knowledge and technology transfer of research into industry.

[3] https://www.seupb.eu/iva-overview

Strategic Context of EU INTERREG VA Programme to NWCAM

The NWCAM is wholly funded by the INTERREG VA Programme. The EU INTERREG VA programme is a European Territorial Cooperation Programme (CP) funded through the European regional Development Fund (ERDF) within the European Structural and Investment Funds (ESIF). It is informed by Europe 2020 Strategy (EU2020) which is the European Union's main policy instrument, the Common Strategic Framework (CSF), and the European Commission's position papers on the UK and Ireland[4]. The EU2020 set out a ten-year growth strategy for smart, sustainable and inclusive growth and for the achievement of economic, social and territorial cohesion.

The €283m INTERREG VA Programme contributes to the EU2020 plan by helping to overcome the issues arising from the existence of borders by promoting greater economic, social and territorial cohesion and improved cross-border co-operation. Since 1991 it has attracted almost €1.13 billion into the Region which has been used to finance thousands of projects that support strategic cross-border co-operation. In total 85% of the programme, representing €240 million is provided through the European Regional Development Fund (ERDF). The remaining €43 million, representing 15% is match-funded by the Irish Government and the Northern Ireland Executive. Figure 1 outlines the four key priority areas where INTERREG VA funding aims to make significant and sustainable change: Research & Innovation, the Environment, Sustainable Transport and Health.

Figure 1. INTERREG VA Key Priority Areas

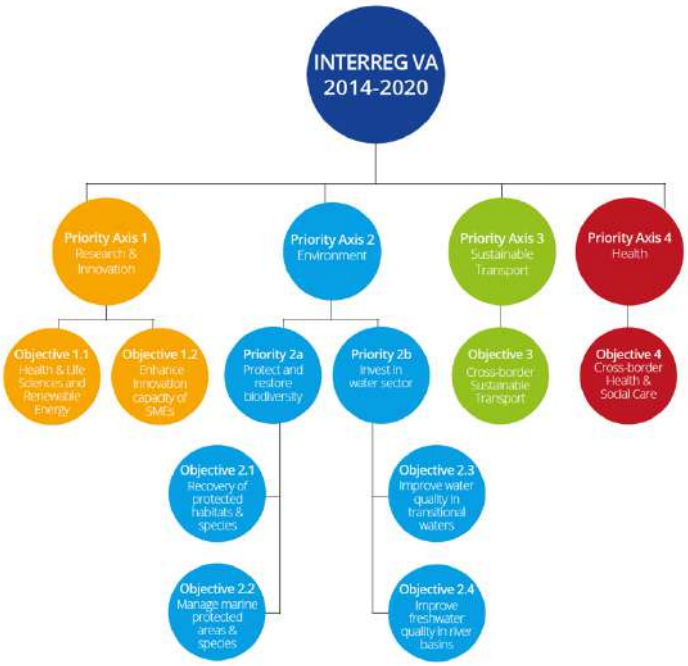
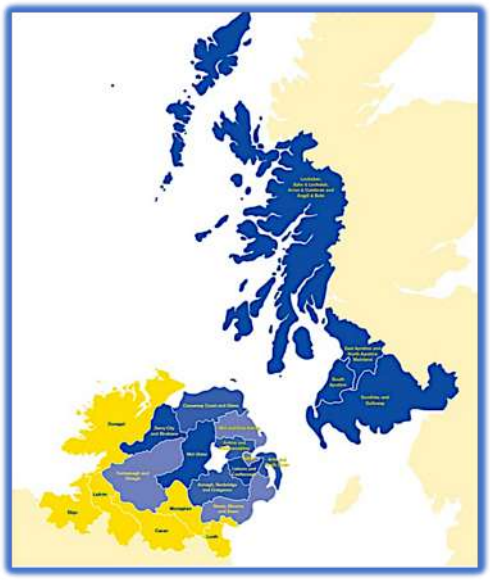


Figure 2 provides a more detailed map of the eligible "Region" of the INTERREG VA Programme which includes Northern Ireland (incorporating Belfast), the Border Counties of Ireland (Monaghan, Leitrim, Cavan, Louth, Sligo and Donegal) and Western Scotland (Dumfries & Galloway, East Ayrshire and North Ayrshire mainland; South Ayrshire; Lochaber, Skye & Lochalsh, Arran & Cumbrae and Argyll & Bute and Eilean Siar/Western Isles).

[4] https://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf

Figure 2. INTERREG VA Programme Map of the Eligible Region



The eligible Region was identified as a key area of concern with a high prevalence of SMEs and under representation of higher value-added sectors. Compounding this was the lack of both government and industry investment in research and innovation compared with other parts of the UK and Ireland. Furthermore, it was widely acknowledged that the economic potential of the regional Advanced Manufacturing sector was not being sufficiently exploited possibly due to a lack of understanding of its potential as a critical enabling technology for key growth sectors such as the LHS sector. Research, Development and Innovation (RDI) of the LHS sector is a key priority growth area for Northern Ireland, Ireland and Scotland in order for them to remain globally competitive. All three jurisdictions have clusters of existing world-leading capabilities and strengths in the LHS sector as well as a critical mass of expertise in Advanced Manufacturing thus presenting a strong foundation upon which to build cross-border co-operation and collaboration.

The Regional Life and Health Science Sector Landscape

Northern Ireland

The LHS sector in Northern Ireland is currently in a strong position. The Matrix NI LHS Foresight Report (2015) highlighted that Northern Ireland's core strengths lie in pharma, diagnostics, personalised medicine, connected health and medical devices with in excess of 250 indigenous companies ranging from start-ups, micro-businesses/SMEs to global diagnostic companies such as Randox, Almac and Norbrook[5, 6]. The LHS sector has generated an annual turnover in excess of £1.1 billion, employs over 8400 people and has increased its investment in R&D over the past 3 years by 90%. Thus, the LHS sector appears to be thriving relative to the country's size (pop. of 1.88 million) and despite the backdrop of current macro-economic and political challenges[7].

Scotland

Scotland with a population of approx. 5.4 million, has one of the largest Life Sciences clusters in Europe[19]. It employs over 40,000 people across some 770 organisations and has a high level of start-ups, SMEs and multinationals particularly across the Edinburgh-Glasgow corridor[8]. With an excellent supply chain and world-class manufacturing expertise supplying chemical and healthcare equipment, pharmaceutical services, medicines, vaccines and diagnostics to the world, productivity has excelled. Scotland boasts 12 world-ranking universities including the NWCAM academic partner, University of Glasgow with some of highest ranking MedTech, Advanced Manufacturing facilities and high performing bio-clusters (e.g. Bio city) in the whole of Europe and it has created more spin-outs than any other region of the UK.

[5] https://matrixni.org/wp-content/uploads/2015/02/MATRIX-life-and-health-sciences-foresight-report-2015.pdf
[6] https://www.hira-ni.com/__data/assets/pdf_file/0011/414110/HIRANI_Brochure.pdf
[7] https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates
[8] https://www.lifesciencesscotland.com/key-subsectors

The Life Sciences Strategy for Scotland 2025[9] along with Scotland's Innovation Action Plan[10], Economic Strategy[11] and local agencies such as Life Science Scotland and Highlands and Islands Enterprise, has overwhelmingly driven the acceleration of Scottish growth and innovation and continues to do so in line with its core mission to increase the LHS industry contribution to the Scottish economy to £8 billion by 2025. However much public and private investment focus has long been located in Central Scotland, primarily along the Edinburgh-Glasgow corridor and less in the West of Scotland were investment, high value jobs and skilled engineers and scientists are in lesser supply. As with Northern Ireland, Scottish businesses are also dealing with the Brexit challenge which has created immense uncertainty and concern arising from Brexit.

Ireland

Ireland with the support of local and EU government policies such as the Innovation 2020 Strategy, Ireland's Action Plan for Jobs 2016, and Project 2040[12] has grown its LHS sector to an unprecedented level. By employing a needs-led approach to innovation and taking full advantage of globalisation and the low corporation tax rate, Ireland has been enjoying an enviable LHS eco-system and is now a global leader in medtech. It has enjoyed much success in competing for foreign direct investment (FDI), accelerating export growth (currently at ~5.5%), continuous upskilling of its people and developing new products adding significant value to business and the economy.

Ireland's top universities, institutes of technology and centres of excellence are working in close partnership with industry to stay at the cutting edge of innovation, whilst safeguarding against society's health challenges by developing global products and services, to address an aging society and maintain quality of life. There are currently in excess of 450 medtech companies in Ireland, employing more than 38,000 people, with 60% of companies indigenous and 80%, SMEs. Nine out of the top ten global medtech corporates such as Siemens, Stryker, and Boston Scientific are located in Ireland making a range of products such as contact lenses, stents, 3D printed orthopaedic knees and diabetes injectables. With the exponential growth in Artificial Intelligence (AI) and robotics integrating increasingly with healthcare, the top ten global IT companies (e.g. Microsoft, Phillips, Qualcomm) have strategically based themselves there. It is the second largest exporter of medtech goods and services in the EU attracting €12.6 billion in exports. Named as an EU Strong Innovator in the European Innovation Scorecard, it is highly innovative and holds the rights to over 13,000 patents[13].

In summary, the NWCAM programme falls under the INTERREG VA Priority Axis 2 of Research and Innovation and aims to redress the existing underinvestment in RDI and upskilling in Advanced Manufacturing in the LHS sector within the Region. NWCAM significantly contributes to achieving the EU INTERREG VA targets and to the success of Europe 2020 Strategy. Its vision and objectives of improving economic performance through increased levels of RDI, creativity and upskilling to create a competitive advantage for the Region strongly align with the wider regional government policies including the UK Industrial Strategy[14], Life Sciences Industrial Strategy[15], Draft Programme for Government Framework for NI 2016-25[16], the NI Innovation Strategy[17] , Ireland's Action Plan for Jobs 2016 [18](DJEI), and the Innovation 2020 Strategy[19]; and The Scottish Programme for Government 2015-16[20].

[9] https://www.lifesciencesscotland.com/wp-content/uploads/2017/08/Life-Sciences-Strategy-for-Scotland-2025-VisionFINALlow-res.pdf
[10] https://www.gov.scot/publications/scotland-innovation-action-plan-scotland/pages/1/
[11] https://www.gov.scot/publications/scotlands-economic-strategy/
[12] https://www.gov.ie/en/policy/project-ireland-2040-policy/
[13] https://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en
[14] https://www.gov.uk/government/topical-events/the-uks-industrial-strategy
[15] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/650447/LifeSciencesIndustrialStrategy_acc2.pdf
[16] https://www.northernireland.gov.uk/consultations/draft-programme-government-framework-2016-21-and-questionnaire
[17] https://www.economy-ni.gov.uk/publications/northern-ireland-innovation-strategy
[18] https://dbei.gov.ie/en/Publications/Publication-files/Action-Plan-for-Jobs-2016.pdf
[19] https://dbei.gov.ie/en/Publications/Publication-files/Innovation-2020.pdf
[20] https://www.gov.scot/publications/programme-government-2015-16/

Purpose of the Survey

With the NWCAM's core vision of strengthening and stimulating the regional economy at its heart, a survey of LHS companies was performed to better understand the sector's commercial needs and concerns, existing R&D and innovation capabilities and strategies; and whether the sector was engaged or would be willing to engage in cross-border state-of-the-art Advanced Manufacturing R&D. The information gathered from the survey will help the NWCAM to align with, and better support the sector to enable enhanced productivity, efficiency and greater economic output.

The purpose of the NWCAM survey is:

- To obtain an understanding of industry interests, capabilities, needs and the challenges that affect the growth and productivity of companies who are operating within the LHS science space within the Region and surrounding areas.
- To capture information relating to regional LHS company R&D and innovation strategies including cross-border R&D collaborations.
- To bring an awareness of Advanced Manufacturing to the LHS sector and highlight its potential as an enabling technology to enhance industry competitiveness, efficiency and productivity.
- To assess interest and current engagement of Advanced Manufacturing methodologies within their company practices to help inform related public investment within the Region.

Methodology

The methodology employed to collate data was an on-line survey questionnaire using Survey Monkey. The questionnaire contained a total of 34 questions (Appendix A). The survey was disseminated to approximately 50 organisations in the LHS sector within each of the three geographical regions i.e. Northern Ireland, Scotland and Ireland. Organisations ranged in size from start-ups, SME, large/global corporates and profit-making R&D organisations. Given the number of LHS organisations within the Region, particularly in the borders area of Ireland and West of Scotland, it was decided to widen the survey catchment area to organisations which operate outside the eligible Region but within each of the three countries in order to a provide a more comprehensive viewpoint. The total number of respondents of the survey was 41.

Results and Key Findings

The survey is comprised of a series of 34 questions as listed in Appendix A. Please note that where the graphical representation of results is shown as percentages (%), the % has been calculated based on the total number of respondents i.e. 41. For single response % graphs i.e. where the respondent chose only one answer, total response percentages should add up to 100%. For graphs representing multiple answer responses where the respondent chose more than one answer (denoted as 'Multiple Responses" on Figure legends), the total response percentage will exceed 100%.

Respondents Profile

Key Findings

- 54% of respondents were from Northern Ireland, 39% from Ireland and only 7% Scotland.
- The respondent cohort predominantly comprised of micro-businesses (24%) or SMEs (54%) with a smaller representation of large and multinational corporations (22%).
- Most respondents (56%) generated a turnover of less than £5 million per annum followed by 24% with a turnover of between £5-50million per annum. Ireland had the highest proportion of organisations with a turnover of greater than £50 million (12%).
- The majority of respondents (80%) were either in a stable position (17%) or in period of either slight, moderate or rapid expansion (63%). 15% of respondents identified as pre-revenue/ start up.
- Few respondents had dual cross-border operations in the North and South of Ireland (2.4%) or cross regional sites.
- The top three activities which best described the core business of the respondents were: 1) Medtech-Core; 2) Contract Research & Manufacturing; and 3) Medtech-Services and Supply.

General information was collated about each respondent organisation namely the location and size of organisation and number of employees, annual turnover, growth status and location of chief operations (Appendix A. Survey Questions Q1-6).

Of the 41 respondents, 22 were from Northern Ireland, 16 were from Ireland and 3 from Scotland. The majority of respondents (78%) were micro-businesses (24%) or SMEs (small businesses = 42%; medium size = 12%), followed by multinational corporations representing 17% (Figure 3a).

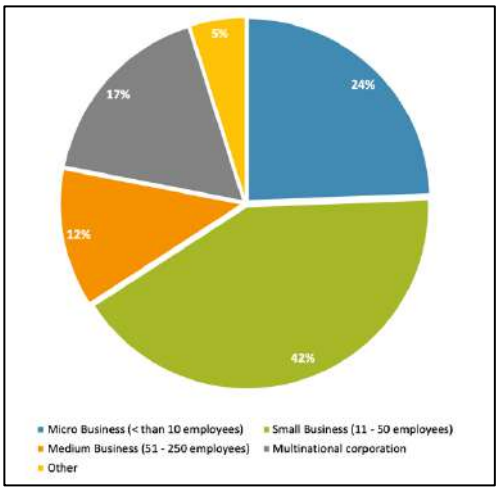
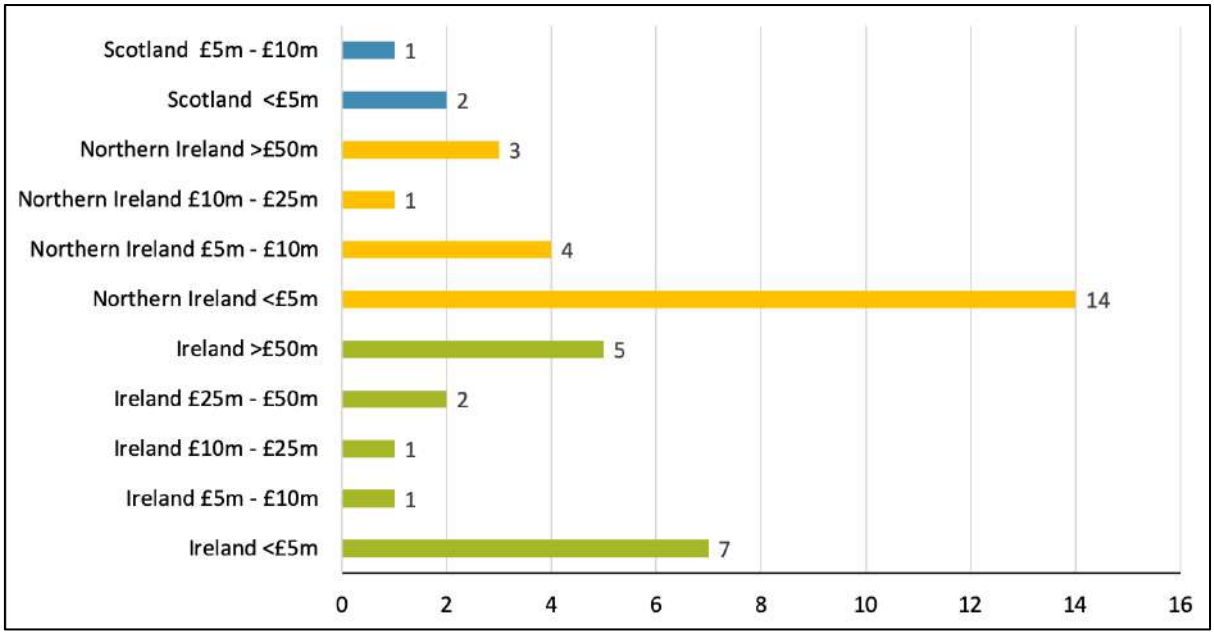


Figure 3a. Number of Employees (Survey Q2)

Of the two companies who identified as "Other", one was a US multinational and the other was a large organisation i.e. greater than 250 employees (5%).

Annual turnover represents the total income of a business and is often used as a key measure of business performance. Just over half the 41 respondents i.e. 23 (56%), comprising primarily micro and small businesses, reported a turnover of less than £5 million per annum (Figure 3b). The majority of these were from Northern Ireland (14) while ~24% of companies turned over between £5-50 million. Ireland had the highest proportion of organisations with a turnover of greater than £50 million (5) i.e. 12% which comprised predominantly large multinationals.

Figure 3b. Annual Turnover for FY17/18 (Survey Q3)



A further beneficial industry health indicator is that of growth. Of the 41 respondents, 63% reported being in a period of either slight, moderate or rapid expansion, while 17% were in a stable economic position. 15% were in a start-up/ pre-revenue stage and 5% who selected "Other" reported that they were unsure. (Figure 4). Taken together, these results demonstrate a high level of business optimism across the sector.

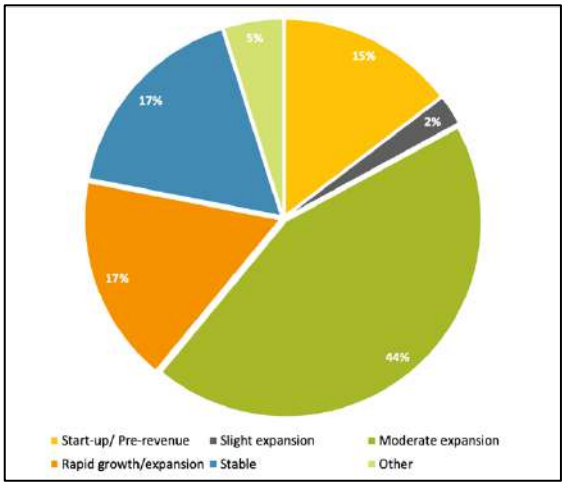
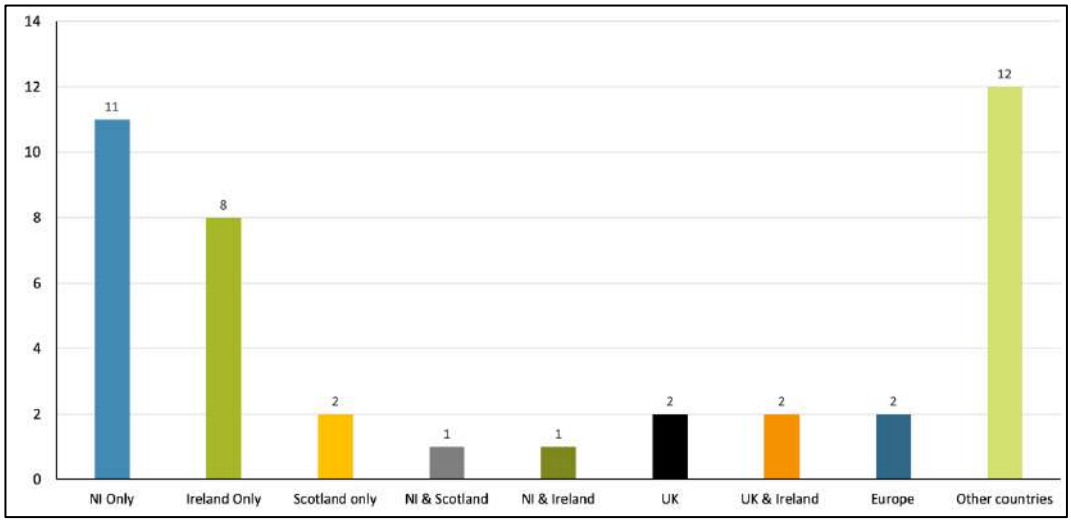


Figure 4. Business Growth Position (Survey Q4)

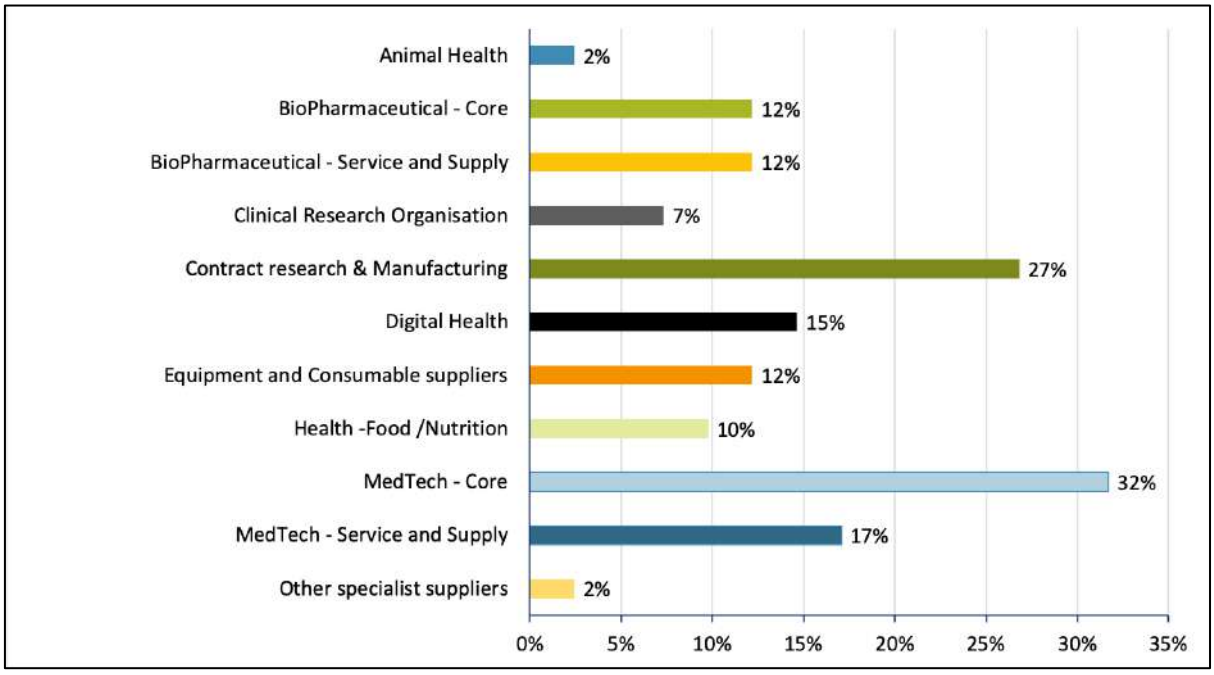
Surveyed companies reported operating right across the broader regional area as well as in other parts of the UK and Europe and globally. Just over a quarter of respondents (11) reported having their principal operations in Northern Ireland only, whilst a smaller cohort reported their main operational bases in Ireland (8), Scotland (2) and mainland Europe (2). A very small proportion of respondents reported having cross-border operations located in both Northern Ireland and Ireland (1), jointly in Northern Ireland and Scotland (1) or Ireland and the rest of the UK (2). No one reported having their main operations in all three areas of the Region. Interestingly 29% of respondents (12) stated their chief operations were located in other countries outside Europe and the Region (Figure 5).

Figure 5. Geographical Location of Company Main Operation(s) (Survey Q5)



Survey respondents were asked to choose which description best fitted their company's activities. Please note that some respondents chose more than one category (Figure 6). The top three activities that respondents felt best described their business interests were: 1) Medtech - Core (32%) 2) Contract Research & Manufacturing (27%); and 3) Medtech - Service and Supply (17%).

Figure 6. Description of Main Business Activities (Survey Q6- Multiple Responses)



Awareness and Interest of Advanced Manufacturing

Key Findings

- A high proportion of respondents (77%) said they were aware of Advanced Manufacturing as an enabling technology and 61% felt it was either very or extremely important to their business.
- 78% of respondents revealed that they would be interested in engaging in cross-border collaborative R&D in Advanced Manufacturing.
- Additive manufacturing/3D printing was noted as being of the most interest to respondents followed by sustainable manufacturing, advanced polymers and nano-manufacturing in that order.

The survey also enquired about the respondents' awareness and interest in Advanced Manufacturing as an enabling technology to help enhance industry productivity, competitiveness and improve the regional economy (Appendix A. Survey Questions Q7-Q10). Encouragingly, 77% of respondents reported that they were aware of Advanced Manufacturing in this context (Data not shown, Survey Q7).

In order of greatest frequency, the topics of interest relating to Advanced Manufacturing of most interest to the respondents were: 1) Additive manufacturing/3D printing; 2) Sustainable manufacturing; 3) Advanced polymers; and 4) Nano-manufacturing.

Additional topics of interest noted by respondents included: microfluidics, advanced bioreactors, low cost high throughput processes, high content imaging, data management systems, adhesives, automation scalability, software to facilitate additive manufacturing, wearable fitness trackers, Industry 4.0 digital enterprise and coating and dipping systems ((Data not shown, Survey Q8).
61% of respondents stated that the adoption of Advanced Manufacturing was extremely (27%) or very (34%) important to their company (Figure 7). 15% stated that Advanced Manufacturing was moderately important whilst the remaining 24% considered it only slightly important or not at all. 78% respondents revealed that they would be interested in engaging in cross-border collaborative R&D focused on Advanced Manufacturing (Data not shown, Survey Q10).

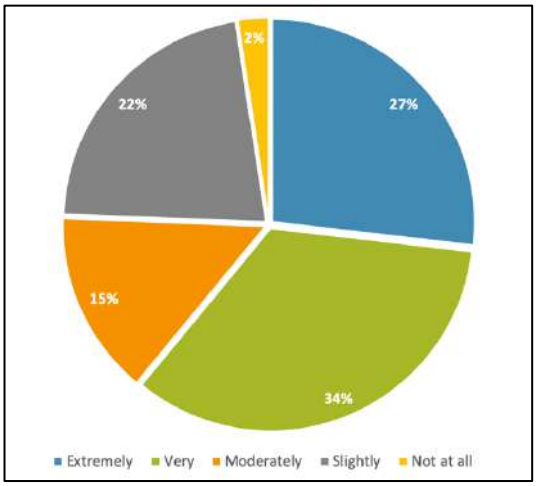


Figure 7. The Importance of Adoption of Advanced Manufacturing to Respondents (Survey Q9)

Innovation and R&D

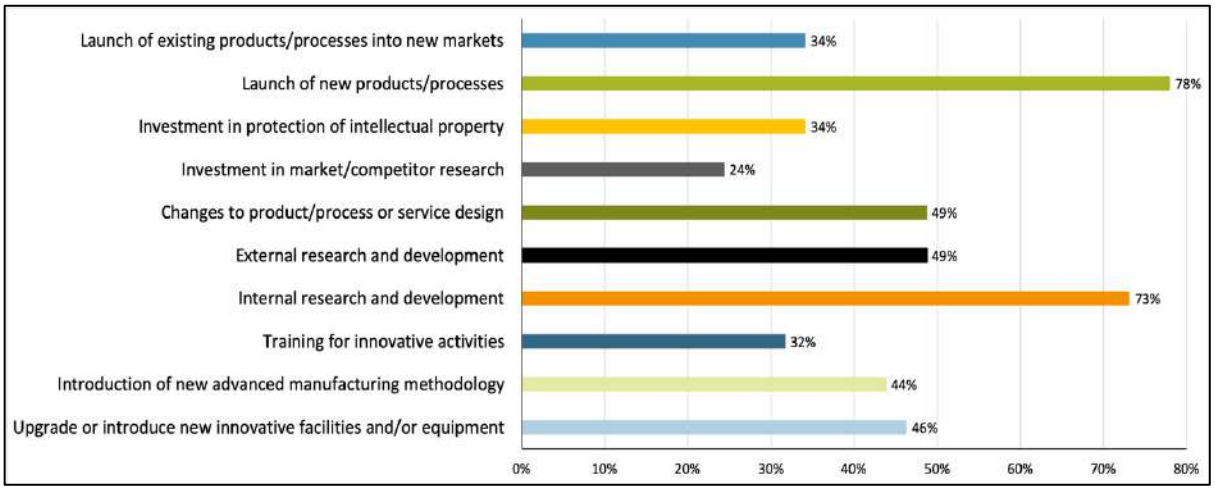
Key Findings

- The top three current innovation activities were sighted as 1) Introduction of new or significantly improved products (goods and services) or processes; 2) Investment activities in areas such as internal research and development, training, acquisition of external knowledge or machinery and equipment linked to innovation activities; and 3) Engagement in innovation projects not yet complete, scaled back or abandoned.
- With regard to respondent innovation future strategies, the top five key innovation activities over the next three years were, in order of importance: 1) Launching new products or processes; 2) Internal R&D; 3a) External R&D; 3b) Changes to product/process or service design; 4) Upgrade or introduce new innovative facilities and/or equipment; and 5) Introduction of new Advanced Manufacturing methodology.
- A strong majority of respondents revealed that launching new products or processes and internal R&D were their top priorities.
- Most respondents reported having an R&D strategy, with horizons varying from 1- 5+ years, and with a principal focus on new products and processes.
- R&D spend varied amongst respondents but it is encouraging that 71% of respondents invested between 6-20+ % of annual revenue on R&D activities.
- A large proportion of respondents (73%) performed over 50% of their R&D internally whilst the remainder outsourced such activities.
- The bulk of R&D development could be categorised within early to mid-range of TRL2-6 levels with TRL3 being the most prevalent.
- A large proportion of respondents (over 71%) reported that less than five of their ongoing R&D projects related to Advanced Manufacturing.
- Just over half of respondents reported cancelling, postponing or dropping up to 10 R&D projects relating to Advanced Manufacturing in the past three years.
- The top three reasons that best described why R&D projects were cancelled, postponed or dropped were reported in order of prominence: 1) Reprioritising of R&D spend, 2) Funding issues; and 3) Other competing business priorities e.g. sales.

The survey also investigated the level of activity of RDI in the sector (Appendix A. Survey Questions Q11-Q28). Respondents reported that the three leading innovative activities undertaken by their organisations were, in order of most responses; 1) Introduction of new or significantly improved products (goods and services) or processes; 2) Investment activities in areas such as internal research and development, training, acquisition of external knowledge or machinery and equipment linked to innovation activities; and 3) Engagement in innovation projects not yet complete, scaled back or abandoned (Data not shown, Survey Q11).

The top five key business activities which respondents reported best described their innovation strategies over the next three years, in order of importance were: 1) Launching new products or processes (78%); 2) Internal R&D (73%); 3a) External R&D (49%); 3b) Changes to product/process or service design (49%); 4) Upgrade or introduce new innovative facilities and/or equipment (46%); and 5) Introduction of new advanced manufacturing methodology (44%). However, the vast majority of respondents revealed that launching new products or processes and internal R&D were of critical strategic importance (Figure 8).

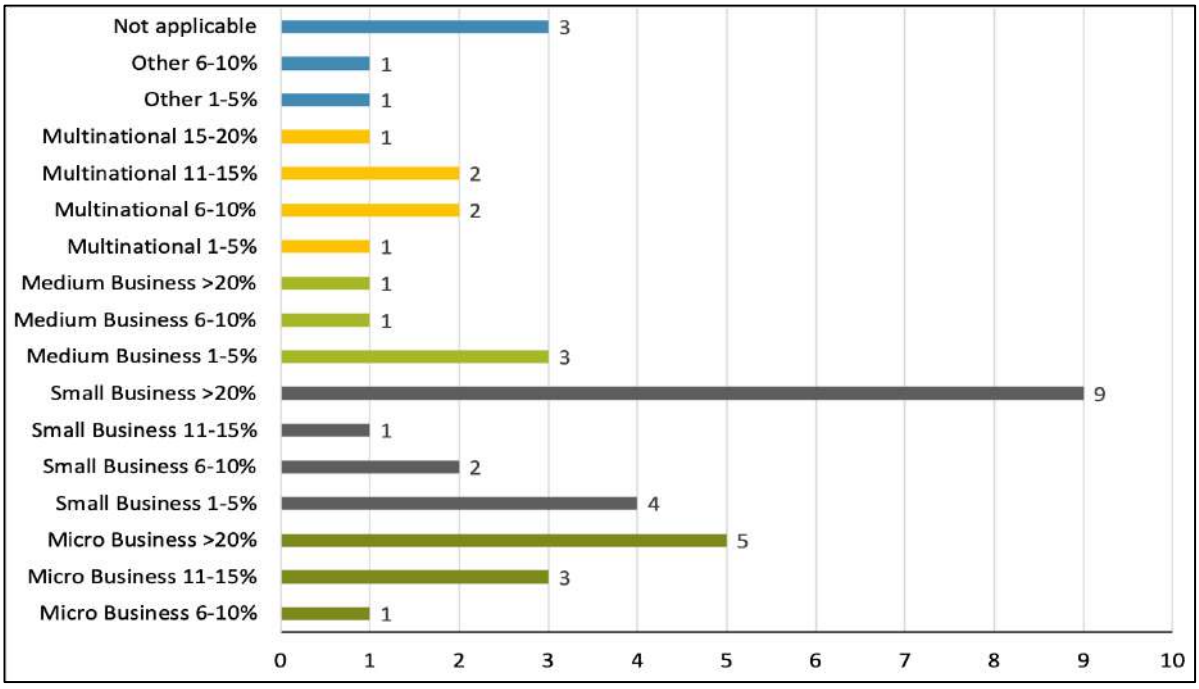
Figure 8. Innovation Strategy Activities Over the Next Three Years (Survey Q12- Multiple Responses)



Most respondents (93%) answered positively to having an R&D strategy (Data not shown, Survey Q13). R&D horizon timelines varied, ranging from 1-2 years (24%), 2-5 years (56%) or greater than 5 years (15%) whilst 5% said they did not have an R&D strategy (Data not shown, Survey Q14). The majority of respondents (93%) stated that the principle direction of their R&D strategies was focused upon new product development activities which corresponded with respondents' innovation strategy activities. Following this, the next four central directions for their R&D strategies in order of most responses were: 1) Development of new production facilities; 2) New sources of finance; 3) Acquisition or mergers with a company operating in a similar market, 4) New joint ventures; and 5) Spin-off or disposal of core business (Data not shown, Survey Q15).

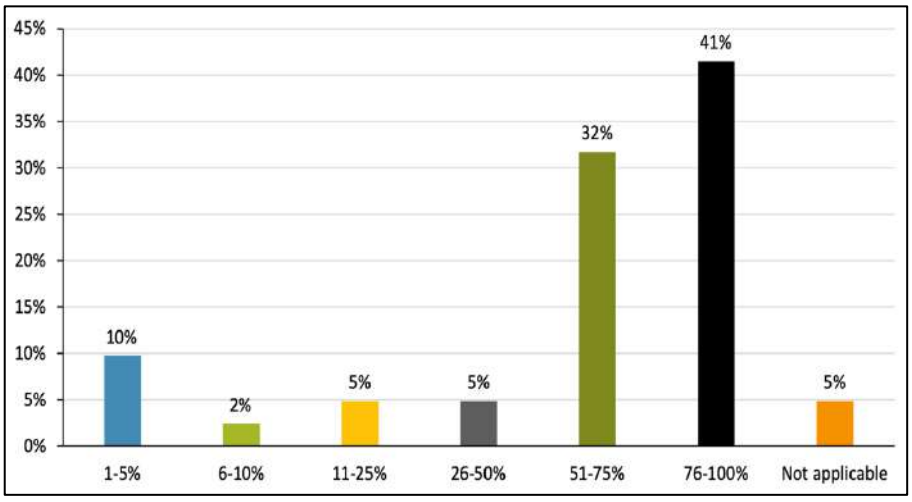
Outside of grant income, a total of 15 (37%) respondents reported their annual R&D spend was over 20% of their annual revenue. Interesting these organisations were primarily small (9) or micro-businesses (5). Smaller levels of R&D investments of between 1-5% and 6-20% were observed by 9 (22%) and 14 (34%) respondents respectively (Figure 9).

Figure 9. Outside of Grant Income, Annual R&D Spend as a Percentage of Annual Revenue (Survey Q16)



Delving deeper into the internal or in-house R&D activities, 41% of respondents said that 76-100% of their R&D activities were performed internally; 32% said that 51-75% were carried out internally while the remaining respondents reported increasingly less internal R&D performance (Figure 10a). A high volume of respondents (73%) stated that they were currently running 10 or less projects whilst only 25% of respondents had greater than 11 projects ongoing, 10 % of which were performing over 50 R&D projects during this period. (Figure 10b).

Figure 10a. Percentage of R&D Activities Performed Internally (Survey Q17)



Another key metric of Innovation and R&D is the technical progression of product portfolios. Technology Readiness Levels or TRL methodology is employed in industry as a consistent approach for assessing the market readiness of technologies throughout product development. It ranges from TRL-1 relating to basic research up to TRL 10, which describes capability validation over a long period, usually closer to market activities. Responses highlighted that although most ongoing R&D projects fell somewhere within the ten TRL categories of product development, the majority were best captured in the TRL2-TRL6 development phase peaking at TRL3 (59%). Only a small minority were categorised under TRL 7-10. (Figure 11).

Figure 10b. On-Going R&D Projects Currently Running (Survey Q18)

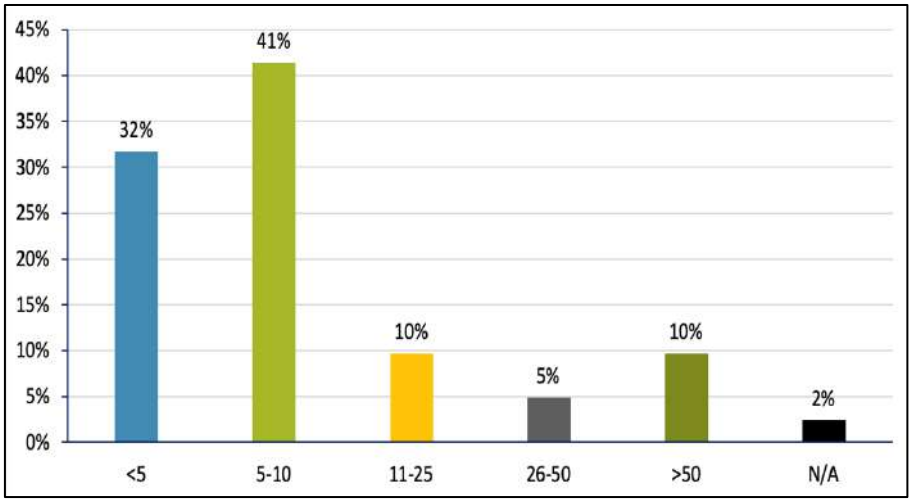
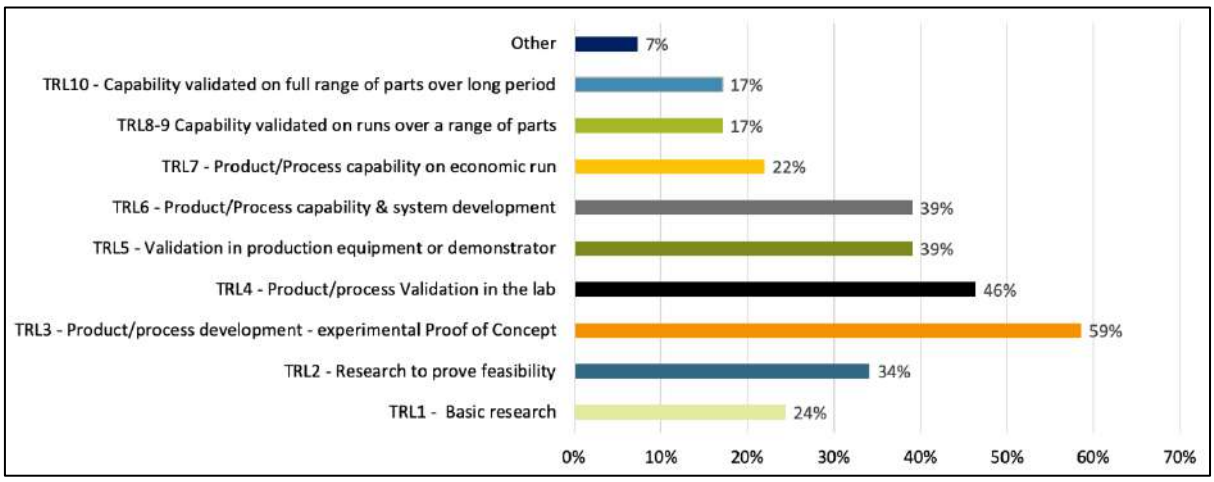


Figure 11. Average Technology Readiness Levels (TRL) of Respondent Organisations (as a % of total no. of respondents) (Survey Q19- Multiple Responses)



The next section of the survey focused upon the general level of R&D projects being performed within each organisation which incorporated Advanced Manufacturing technologies. The majority of respondents (71%) stated that less than five R&D projects related to Advanced Manufacturing. Only 7% of respondents reported having 5-25 on-going projects with an Advanced Manufacturing component whilst a disappointing derisory amount (2%) reported having greater than 50 projects in operation linked with Advanced Manufacturing. 10% reported having no projects at all (Data not shown, Survey Q20).

A total of 51% of respondents reported cancelling, postponing or dropping up to 10 R&D projects relating to Advanced Manufacturing in the past three years. The remaining 49% revealed that they either had no related projects, didn't know or that it was not applicable to their organisations (Figure 12, Survey Q21). The top three reasons that best described why R&D projects were cancelled, postponed or dropped were; 1) Reprioritising of R&D spend; 2) Funding issues; and 3) Other competing business priorities e.g. sales. Other additional reasons provided by the respondents included market competition, lack of success in winning EU funding grants or refocusing business (Data not shown, Survey Q22).

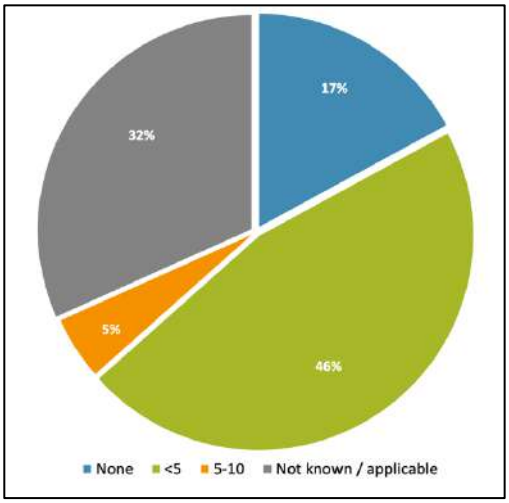


Figure 12. R&D Projects relating to Advanced Manufacturing Cancelled, Postponed or Dropped in the Past Three Years (Survey Q21)

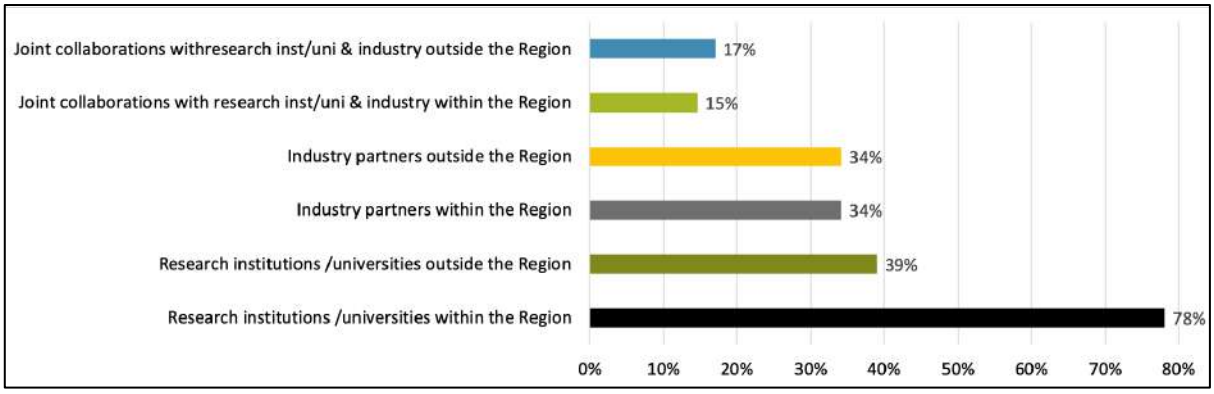
R&D Collaborations

Key Findings

- External R&D collaborations between respondents and research institutions/ universities were of a higher proportion (78%) within the Region compared to outside the Region (39%). Fewer external R&D collaborations occurred with industry partners either within (34%) or outside the Region (34%).
- Joint external R&D collaborative activity with industry and academia, in- and outside- the Region was less prevalent.
- Just over half of respondents said that less than 5 external R&D collaborations related to Advanced Manufacturing with only 7% reporting that were currently running between 5-25 projects that related to Advanced Manufacturing.

The survey also asked questions relating to company cross-border R&D collaborations either with other industries or with the academic and/or research sector (Survey Questions Q23-Q24). Most respondents (78%) indicated that they had conducted external R&D collaborations with research institutions/ universities within the Region whilst 39% had conducted collaborations outside the Region (Figure 13). Industry partnerships were also prevalent both in (34%) and outside (34%) the Region. Joint R&D collaborations with both academia and industry within (15%) and outside (17%) the Region were less prevalent. Some respondents commented that they had applied for research funding for more collaborations outside the Region but had not been successful.

Figure 13. External R&D Collaborations in the Past Three Years (Survey Q23- Multiple Responses)



Of the external R&D collaborations, 54% reported that less than five projects related to Advanced Manufacturing whilst 7% revealed that 5-25 ongoing projects related to Advanced Manufacturing. The remainder of respondents answered that either they had no Advanced Manufacturing projects, did not know or it was not applicable (Data not shown, Survey Q24).

Public R&D Funding

Key Findings

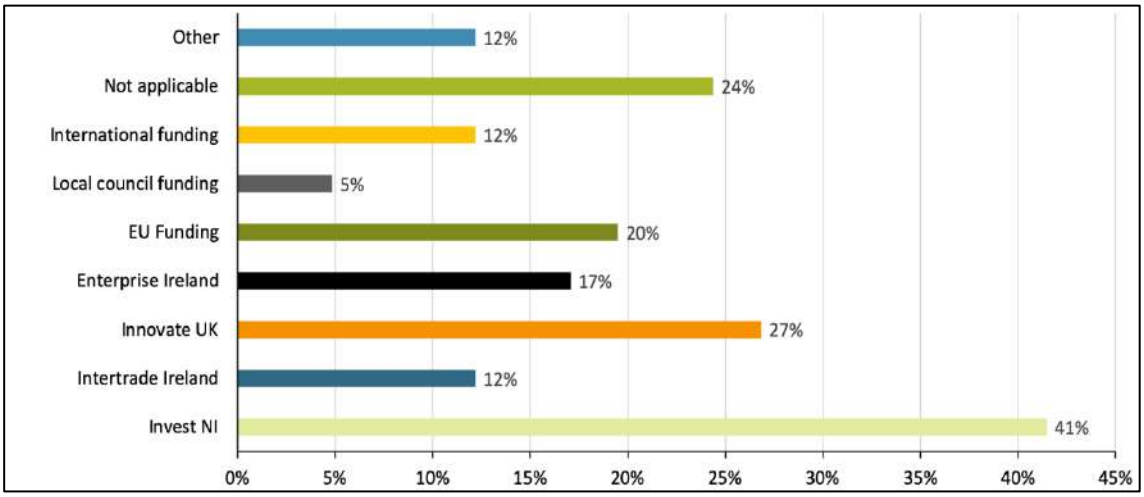
- Respondents received government funding over the past three years primarily from Invest NI, Innovate UK and from EU funding sources.
- The following forms of R&D support were noted as most beneficial to respondents: 1) Collaborative R&D support with research institutions and/or other industry partners (66%); 2) Support for R&D (61%); 3) Access to highly trained staff (59%); 4) Support for skills

training, upskilling and professional development (46%), and 5) Investment in infrastructure, grants and subsidies (41%).

- Although a large number of respondents availed of government R&D tax credits in the past three years, 32% of respondents either did not avail and/or were not aware of the tax schemes available.
- The top seven factors that respondents felt were essential for increasing R&D competitiveness were: 1) Government investment in manufacturing and innovation (66%); 2) Availability of engineering-related personnel (44%); 3) Access to world class research expertise (41%); 4) Clarity on Brexit policies (34%); 5) Modernisation of existing technology (32%); 6) Intellectual property strategies (32%); and 7) International commercialisation (32%).

Lack of funding can be a major barrier for companies hoping to become innovative and globally competitive. Therefore, the survey wished to ascertain to what extent regional companies were accessing public funding and what types of support and factors they required to increase their R&D competitiveness (Survey Q25-Q26). The survey highlighted that in the past three years, all respondents had received government funding from various funding agencies as described in Figure 14.

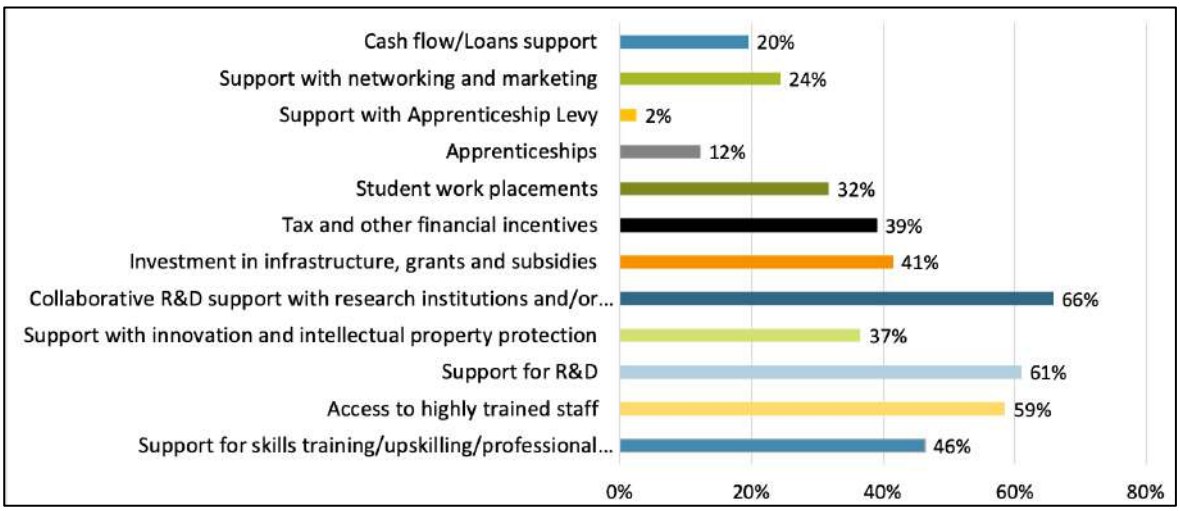
Figure 14. Types of Government R&D Funding Received in the Past Three Years (Survey Q25-Multiple Responses)



The top three most frequently reported funding sources were noted as: 1) Invest NI (41%); 2) Innovate UK (27%); and EU funding (20 %). Other sources of funding reported by respondents included Scottish Funding Council, Scottish Enterprise, Highlands and Islands Enterprise, Zero Waste Scotland, UK Research Councils, Industrial Development Authority (IDA), Science Foundation Ireland (SFI), Small Business Research Initiative (SBRI) and Irish Research Council (Data not shown).

The top five forms of R&D support which respondents indicated would be most beneficial to their company were in order of most responses: 1) Collaborative R&D support with research institutions and/or other industry partners (66%); 2) Support for R&D (61%); 3) Access to highly trained staff (59%); 4) Support for skills training, upskilling and professional development (46%), and 5) Investment in infrastructure, grants and subsidies (41%) (Figure 15).

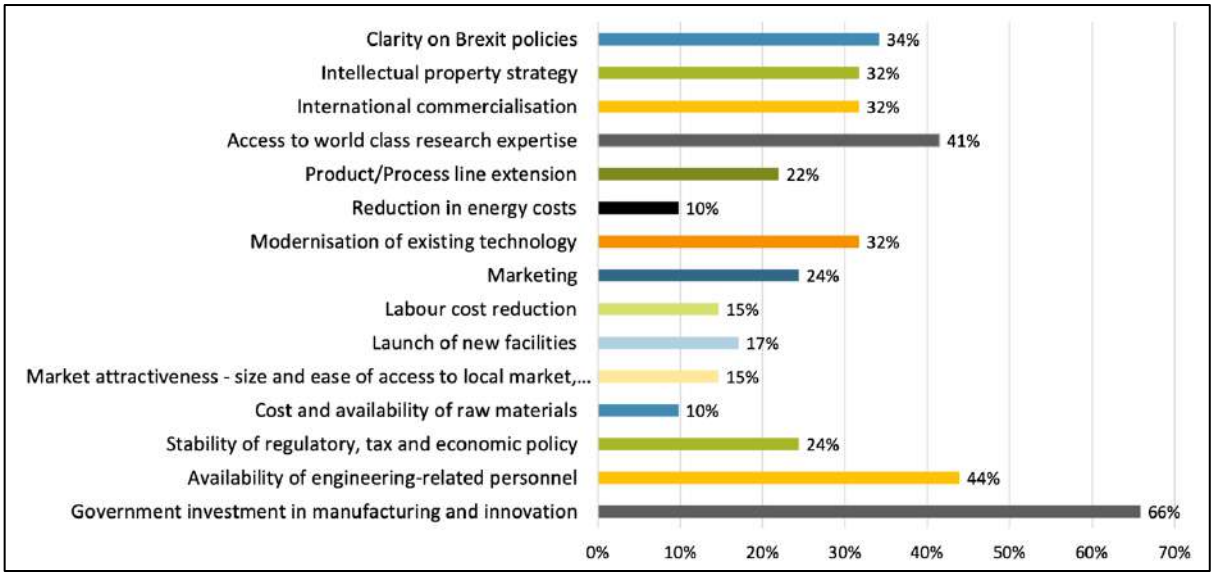
Figure 15. Types of R&D Support Which Would Most Benefit Organisations (Survey Q26- Multiple Responses)



68% of respondents had availed of government R&D tax credits in the last 3 years. However, 24% had not and 8% were not even aware of the scheme (Data not shown, Survey Q27).

The top seven factors that respondents felt were essential for increasing R&D competitiveness were: 1) Government investment in manufacturing and innovation (66%); 2) Availability of engineering-related personnel (44%); 3) Access to world class research expertise (41%); 4) Clarity on Brexit policies (34%); 5) Modernisation of existing technology (32%); 6) Intellectual property strategies (32%); and 7) International commercialisation (32%) (Figure 16). Other essential topics highlighted by respondents were: training, competitor product awareness and access to equipment and facilities (Data not shown).

Figure 16. Factors Considered Essential for Increasing R&D competitiveness (Survey Q28- Multiple Responses)



Intellectual Property Rights (IPRs)

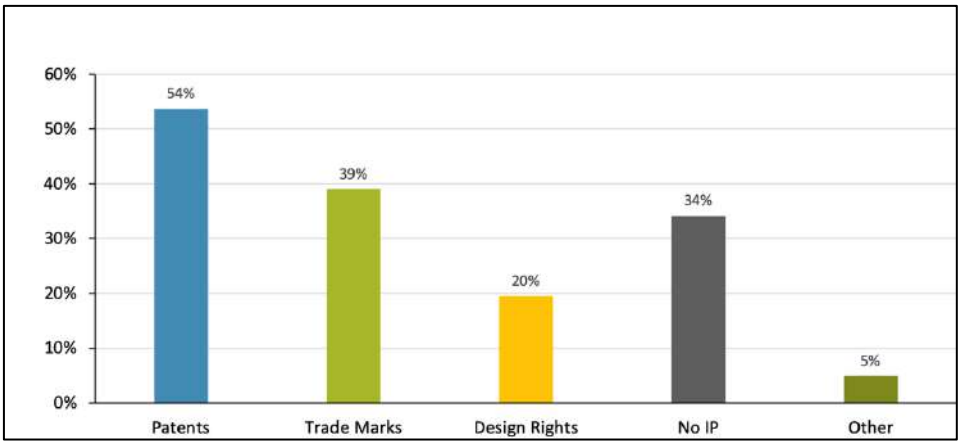
Key Findings

- The most common form of intellectual property (IP) protection that respondents availed of was patents (54%) followed by trademarks, then design right registration (39% and 20% respectively).
- Approximately one third of respondents had not registered any IP over the past five years.
- Almost two thirds of IP rights were noted to be proprietary, whilst just under a third were jointly owned with other parties.
- Only a small proportion of respondents had used the UK Government Patent Box tax scheme and the majority had said they had not availed of it or were not aware of it.

The next section of the survey sought to gain a better understanding of the innovation practices of organisations in relation to the use of intellectual property rights (namely patents, design rights and trademarks) and awareness of IP-related tax relief schemes such as the UK Patent Box (Appendix A, Survey Questions Q29-Q31). Over the past 5 years, 54% of respondents had filed patent applications, 39% had registered trademarks and 20% had registered design rights (Figure 17).

Notably 34% had not registered any IP over this period. 63% of IP rights were under the ownership of the respondent whilst 29% specified that they also had jointly owned IP with other parties. Only a small percentage of respondents in- or out- licenced IP or had assigned IP to a third party. In relation to use of the UK Government Patent Box tax relief scheme, only 20% had availed of this scheme while 51% had not. A further 29% said that they were not aware of the scheme (Data not shown, Survey Q30-31).

Figure 17. Intellectual property Registered within the Past 5 Years (Survey Q29-Multiple Responses)



Engineering Skills, Employment and Engagement

Key Findings

- Respondents focused mainly on employing or engaging the skills of graduates, interns and placement students rather than engineering PhD students, apprenticeships and post-doctoral researchers.
- There was an overwhelming agreement amongst respondents (97%) that there is an engineering skills shortage in the Region.

Advanced Manufacturing capability is primarily enhanced by the level of engineering expertise existing within the sector. Within this context, the survey wished to assess respondents' interest of employment of engineering expertise (Appendix A, Survey Q32-Q33). In the past three years, respondents recruited more engineering graduates (73%) and engineering interns/placement students (51%) compared with engineering PhD students (24%), apprenticeships (27%) and post-doctoral researchers (22%) (Figure 18a). Other additional comments from respondents indicated that some respondents had used different types of student recruitment employed in the US for multinational organisation. When asked if there was an engineering skills shortage in the Region, 97% of respondents either agreed (17%), somewhat agreed (56%) or strongly agreed (24%) whilst 3% strongly disagreed (Figure 18b).

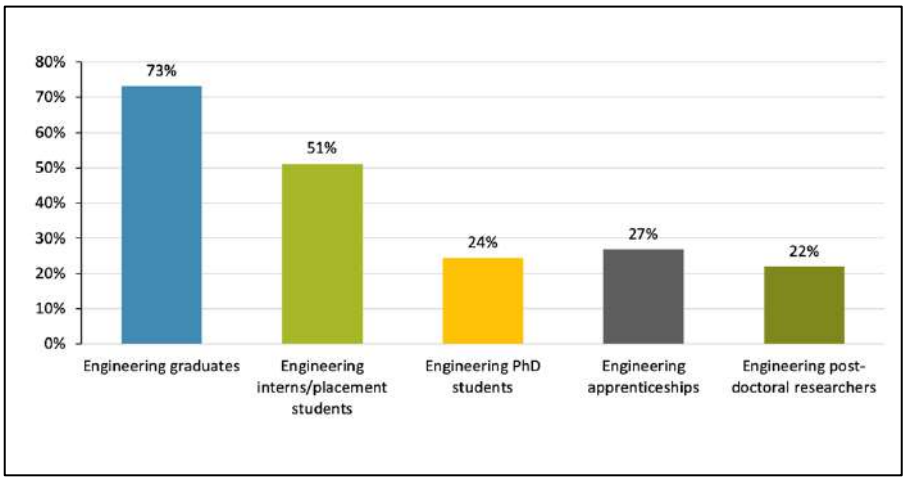


Figure 18a. Types of Engineering Employment or Engagement by Respondents (Survey Q32- Multiple Responses)

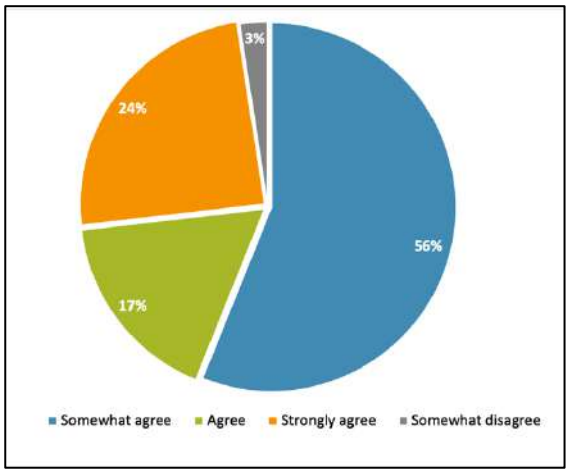


Figure 18b. Respondent Views on Engineering Skills Shortage in the Region (Survey Q33)

Discussion

This report aggregates our survey observations along with some general reflections upon the regional LHS landscape. It is supported by a range of relevant open source documents prepared from business, industry, governments and funding body policies affecting both Advanced Manufacturing and the LHS sector in the wider Region and within other parts of the UK and Europe.

Overview of the Regional LHS Sector

The survey gathered wide-ranging information from 41 respondents from business, industry and R&D. Over half the respondents were from Northern Ireland and 39% from Ireland with only a small fraction from Scotland. Approximately three quarters of respondents reported being in businesses with less than 250 employees, a quarter of which were from micro-business of less than 10 employees and 42% from small businesses (less than 50 employees). Business demographics can vary from region to region but in general micro and small businesses appear to represent the life-blood of the wider regional LHS industry[21,22]. Although INTERREGVA funding supports all sizes of organisations, it has paid particular attention to supporting R&D and innovation pathways for start-ups, micro-businesses and SMEs due to the fact that this sector is often time and resource poor and as such may not engage sufficiently with local government agencies and academia for support. However, such enterprises offer the greatest opportunities for economic growth for the sector and support the growing entrepreneurial ecosystem. This is demonstrated in the successful industrial partnerships created through the creation of NWCAM.

The primary focus of the survey was upon the regional LHS sector, often referred to as a high growth sector. Growth is a major indicator of business health and it is well recognized that vibrant pockets of growth and economic activity exist throughout the broader regional area. However as reported in the introduction, certain geographical zones, such as the Border Region of Ireland, Western Scotland and parts of Northern Ireland, have not benefited directly from higher value-added growth sectors. Nevertheless, it was encouraging to note that the majority of survey respondents reported being in a stable position or on a trajectory of expansion of growth. This was reflected in InterTrade Ireland's latest all-Island Business Monitor (Q3 2019) which revealed that 90% of companies in Northern Ireland and Ireland described being in a stable (44%) or growth phase (46%)[23]. The survey also reported that the top three core disciplines were medtech-core, then contract research & manufacturing followed by medtech - service and supply. These subsectors represent high growth areas, particularly medtech as demonstrated in Ireland which has become a leading manufacturing and innovative hub for medical technologies accounting for almost a quarter of Ireland's economic output[24].

Overall, the LHS landscape of the three geographical regions as described in this report's Background section (i.e. The Regional Life and Health Science Sector Landscape), provides supporting evidence for an optimistic view of the potential for LHS sectoral growth. All three regions are in a strong position and should be prioritised and supported by stronger leadership and bold frameworks and strategies to ensure progression.

Advanced Manufacturing - Regional Awareness and Benefits of Adoption

REGIONAL AWARENESS

Advanced Manufacturing in a broad context can be defined as the deployment of innovative cutting-edge technologies to improve products or processes. A central objective of the NWCAM programme

[21] *Comparative figures from a 2018 UK business survey reported that micro-businesses made up ~96% of all UK businesses while small and medium enterprises cover 3% of business* -Business Statistics, Briefing Paper by Chris Rhodes, House of Commons, Number 06152, 12 December 2018

[22] *Similarly, Irish micro-businesses are thought to make up 92.6% of the total number of business whilst small (6.2%) and medium (1%) business make up the total SME count to 99.8%*-https://dbei.gov.ie/en/Publications/Publication-files/2017-SBA-Fact-Sheet.pdf

[23] https://intertradeireland.com/insights/business-monitor/

[24] https://www.idaireland.com/invest-in-ireland

is to build an awareness of the potential of Advanced Manufacturing to increase productivity, export power and prosperity to the LHS sector. To that end, the survey set out to gain a better understanding of how businesses currently view the discipline and whether they have already integrated relevant technologies into their production systems.

Most respondents were aware of Advanced Manufacturing. Moreover, many considered its adoption as either extremely or very important to their company, with 78% stating that they would be interested in engaging in cross-border collaborative R&D in Advanced Manufacturing. Indeed, regional economic policies and strategies have stressed the importance of the adoption of Advanced Manufacturing for many specialised sectors as a means of augmenting innovation and enhancing productivity. This finding is reassuring and sends a confident message to the many advocacy groups who have been diligently promoting it as a key enabler.

Regionally, traditional manufacturing has been the cornerstone of much economic wealth. For example, in Northern Ireland historically high value manufacturing in aerospace, security and space, materials handling and polymers have been its mainstay. However, the sector has faced challenges as a result of changing times and in 2016, the industry body, Matrix NI published the Advanced Manufacturing, Materials and Engineering (AMME) report[25]. This report optimistically set out the country's stall with regard to the future of Advanced Manufacturing and its potential importance to the local economy as a powerful contributor. However, the report highlighted concerns such as adoption of advanced technologies and recommended that government, industry and academia need to work closer together to maximise the value of their R&D and meet the wider sectoral industry innovation needs.

Given the wider remunerations and opportunities that Advanced Manufacturing can offer, convergence with LHS sector could potentially alleviate the threat to the high value manufacturing sector in Northern Ireland and regionally. Parts of Scotland and Ireland have witnessed the superior benefits of adopting Advanced Manufacturing technologies within certain LHS sub-sectors particularly within medtech, biotech and industrial biotechnology with the support of government-backed enabling levers such as Scotland's £120m Innovation Centres (e.g. IBioC, AMRC, CENSIS, Stratified Medicine)[26], UKRI's Catapults[27] and SFI -funded Research Centres[28] (e.g. CURAM, CONFIRM, I-FORM). Indeed, development of stronger linkages with other UK, Irish and European Advanced Manufacturing and related LHS RDI centres to support more collaborative cross disciplinary research and cluster development involving universities, academics and industry should be encouraged. At the same time, a substantial gap still remains between Advanced Manufacturing awareness, investment and implementation and more work needs to be done by all key stakeholders.

ADVANCED MANUFACTURING KEY INTERESTS: ADVANCED POLYMERS & ADDITIVE, SUSTAINABLE AND NANO-MANUFACTURING

Within the context of NWCAM, the survey investigated the relevance of four Advanced Manufacturing technologies themes i.e. sustainable manufacturing, advanced polymers, additive manufacturing and nano-manufacturing to respondent's businesses. Additive Manufacturing commonly known as 3D printing, came out on top as the topic of greatest interest for respondents. The UK's Industrial Strategy heralded 3D printing as a transformational technology with significant growth potential. 3D printing enables the current global trend of bespoke mass customisation and product personalisation and could fundamentally revolutionize the way products are made. Novel health-related applications are on the rise, for example, bioprinting human tissues and organoids, pre-operative 3D printing patient-

[25] https://matrixni.org/sectors/advanced-manufacturing-materials-and-engineering/
[26] https://www.innovationcentres.scot/
[27] https://catapult.org.uk/catapult-centres/
[28] https://www.sfi.ie/

specific surgical models, cheaper versions of surgical tools and custom-made prosthetics. The global additive manufacturing market is considered to be growing at an annual rate of ~30%. Ambitions are high for the Additive Manufacturing UK National Strategy 2018-2025[29] whose vision is to capture over £3.5bn per year (Gross Value Added (GVA)) for the UK by 2025, supporting 60,000 jobs in the knowledge economy and generating new, highly skilled employment opportunities.

Adoption of additive manufacturing provides huge potential for companies to expand into new overseas markets and novel fields of technology adding value to their current business portfolio. Ireland has attracted major global players in 3D printing of orthopaedic implants such as Stryker and DuPuy Synthes. However, UK businesses have been slow to engage, with suggested reasons being the high cost of transforming factories and production lines, upskilling and retraining staff as well as issues relating to the taxation, regulation and intellectual property of 3D generated products[30,31]. Indeed, the National Strategy reported that the UK additive manufacturing share currently represents less than 0.05% of the world market for manufacturing ($11.4 trillion). Undoubtedly investment is required if industry is to adopt and apply additive manufacturing methodologies into their current practices. The public funded National Strategy (£225 million) is now being implemented to support up-scaled collaborative and private R&D programmes across the entire TRL ranges as well as skills and training including in other Industry 4.0 technologies such as data driven digitalisation, Artificial Intelligence (AI) and machine learning, Internet of Things (IoT) and robotics. These are encouraging steps by the government working with the UK industry. Indeed, these measures should be showcased to improve adoption of all other forms of Advanced Manufacturing technologies.

Sustainable manufacturing is also becoming of urgent significance as a clean technology for industry. Rigorous new regulations, environmental levies and measures to ban single use plastics and non-recyclable plastics are coming into effect imminently through government policies designed to help create a circular economy. Industry will be forced to consider their carbon footprint and investments must endeavour to be carbon-proofed to ensure the lowering of greenhouse gases and reduction in plastics scrappage[32]. As well as the obvious benefits to the environment, these policies also make sound economic sense in helping businesses to reduce their manufacturing costs by lowering use of materials by e.g. introducing recycling programmes, reducing scrappage or better monitoring and management of energy usage. Sustainable manufacturing techniques facilitate significant financial savings and adoption thereof should be encouraged widely by government, industry and environment bodies alike.

Likewise, advanced polymers and nano-manufacturing are both of significant economic importance as underpinning enabling technologies within many sectors. As the progress in improving and manipulation of polymer structures continues, particularly from a recycling perspective, the market for advanced polymers is growing significantly. This is due to the exponential growth and cost effectiveness of new applications and processes, particularly in the LHS sector such as in production of critical clinical and healthcare products. Similarly, nano-manufacturing i.e. the manufacturing at the nano-scale involving scaled-up, reliable and cost-effective manufacturing of nano-scale materials, structures, devices and systems has seen an exponential rise in use over the past ten years. It comprises research, development and integration of top-down fabrication processes and increasingly complex bottom-up or self-assembly processes, leading to the production of improved materials and new products which can be translated at scale into dynamic applications in the LHS sector. The benefits of investing in these technologies for the growth of the regional LHS sector should be

[29] https://am-uk.org/additive-manufacturing-national-strategy-sets-establish-uk-world-leader/
[30] https://www.themanufacturer.com/reports-whitepapers/manufacturer-annual-manufacturing-report-2019/
[31] https://www.ey.com/en_gl/digital/what-the-3d-printing-revolution-could-mean-for-business
[32] With the rising global awareness of climate change, the UK and Ireland have committed to net zero greenhouse gas emissions by 2050 target through the Climate Change Act 2008; Scotland has already committed to reducing greenhouse gas emissions to net zero by 2045-http://www.legislation.gov.uk/ukpga/2008/27/contents

championed by the regional stakeholders with the support of evidence-based success stories and case studies.

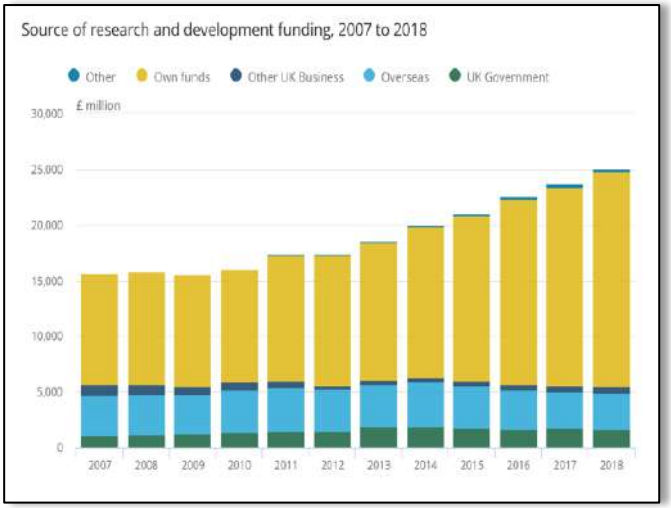
Regional R&D and Innovation - Strategies, Investment and Outsourcing

R&D EXPENDITURE AND INVESTMENT

With regard to R&D expenditure, the survey revealed that respondents are using private capital to invest in R&D and innovation with 71% having invested between 6-20+ % of their annual revenue on R&D activities. Encouragingly most respondents reported having an R&D strategy with a core purpose of developing new products and processes and the majority reported having strategies extending over a 2 to 5+ year period. Since R&D is largely a longer-term investment, it is reassuring to observe that companies are future proofing their businesses to ensure they remain competitive.

In a broader context, it has been widely evidenced that companies that consistently invest in R&D are 13% more productive than firms that do not[33]. Business Expenditure on Research and Development (BERD) is crucial to the competitiveness of the Region's economy and is considered to be a key determinant of productivity growth and economic performance. According to UK Office for National Statistics (ONS), expenditure on R&D performed by UK businesses as a whole continued to grow in 2018, expanding by £1.4 billion to £25.0 billion in 2018, an increase of 5.8% from 2017[34]. Furthermore, most R&D funding came from the businesses' own funds at £19.3 billion, an increase of £1.5 billion (8.5%) since 2017 as seen in Figure 19.

Figure 19. Source of R&D Funding 2007 to 2018. *Source: ONS[34]*



Catalyst's Knowledge Economy Report[35] highlighted that in 2018 business expenditure on R&D as a % of workplace GVA in Northern Ireland has remained constant across 2016 and 2017 at 1.4%. This is above the UK average and Ireland which were 1.3% and 0.8 % respectively. Interestingly, the latest BERD data for Scotland[36] shows that in 2017, Scotland's R&D expenditure growth outpaced UK growth. 71% of 2017's R&D expenditure in Scotland occurred in just four local authorities, West Lothian, Edinburgh, Aberdeen and Glasgow i.e. £880 million out of Scotland's £1.25 billion expenditure, whilst 40% of total R&D expenditure came from just five major companies demonstrating a vulnerable over reliance on a few major players. Comparably Irish owned enterprises reported an increase in R&D expenditure spend of 6% or €49 million, up from €810 million in 2015 to €859 million in 2017, whilst foreign owned enterprises accounted for 69% of all Irish R&D expenditure[37].

Overall it appears that investment in R&D is increasing within the wider Region and this is supported by the latest UK and Ireland statistics on R&D activity. However, it must continue to remain a priority especially for smaller enterprises in the LHS sector in order to build upon proven successes.

[33] https://www.gov.uk/government/publications/innovation-report-2014-innovation-research-and-growth
[34] https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/bulletins/businessenterpriseresearchanddevelopment/2018
[35] https://wearecatalyst.org/research/our-research/
[36] Scottish BERD expenditure as a proportion of UK BERD expenditure has increased, from 3.5% in 2007 to 5.3% in 2017. BERD expenditure was equivalent to 0.80% of GDP in Scotland compared to 1.15% of GDP in the UK. At the same time the average BERD spend per head of population was £230 in Scotland, considerably lower than the £359 average spend per head of population across the UK -https://www2.gov.scot/Resource/0054/00544541.pdf
[37] https://www.cso.ie/en/releasesandpublications/er/berd/businessexpenditureonresearchdevelopment2017-2018/

In addition, the over reliance of a small number of high export performers such as FDI corporations and larger local businesses to "prop" up productivity and the local economy is concerning and should be monitored carefully and addressed by key industry and government stakeholders.

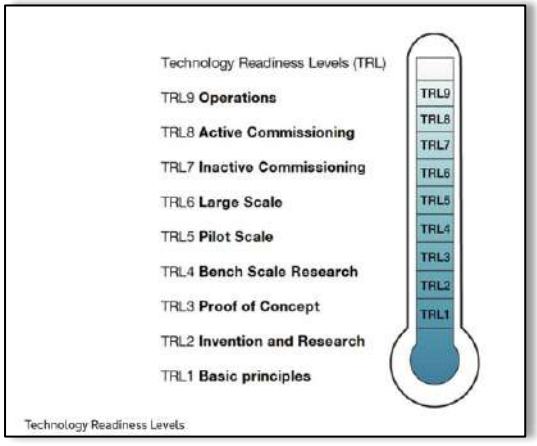
RDI STRATEGIC ACTIVITIES

Survey respondents reported on a range of RDI activities and what their future strategies held for the next three years. The principle effort was focused upon launching of new or improved products or processes along with more investment in R&D. Engagement in innovation projects that had not been completed or had to be scaled back or stopped, possibly due to lack of finance capital to continue was also highlighted as a key activity. Internal and external R&D also made it top of the list. Product design development, upgrading of facilities and introduction of new Advanced Manufacturing processes where also key components. In the context of adopting new Advanced Manufacturing technologies, upgrading or building new facilities or factories is highly capital intensive and although a key enabler for enhancing productivity, many businesses do not have the ready private capital to do so. Access to new sources of finance was noted as fundamental to respondents' strategies for without a continual and constant supply of capital, many businesses cannot survive. Therefore, government investment is a vital life line. Indeed, it is often the case that smaller businesses with competing financial interests view R&D and innovation financing as a 'nice to have" component of their business plan and for this they are likely to suffer and remain vulnerable. Other R&D activities which were reported in respondents R&D activities included acquisition or mergers, new joint ventures, and spin-off or disposal of core business.

TECHNOLOGY READINESS

A further noteworthy survey observation was that most ongoing internal R&D projects could be categorised within the early to mid-range of TLR levels with the majority at a surprising low TRL3 or Proof of Concept stage of maturity. The qualitative assessment of maturity uses a nine-point scale as described in Figure 20[38]. This could signify a number of scenarios, for example, that the next stage of development is being performed via an external R&D collaboration or possibly the final assembly of products are performed off-site prior to deployment. Alternatively, it could indicate a lack of funding or capital to accelerate innovative R&D projects through the technology development maturity scale to be market ready. Respondents were also asked whether any of their internal R&D projects related to Advanced Manufacturing. Responses varied but overall the consensus was that few companies are engaging with these new technologies in their current R&D programmes. However, despite this, respondents reported that they sought to introduce these new methodologies into their innovation strategies and practices so the interest and need clearly exists.

Figure 20. Technology Readiness Levels *Source:*[38]



R&D OUTSOURCING

The survey also noted that respondents conducted over 50% of their R&D in-house whilst the remainder was mainly outsourced. Outsourcing of R&D is an excellent de-risking tool for costly processes such as bringing a drug to market, testing new materials or gaining support with prototypes or demonstrators. As well as supporting with costs, it is an excellent tactic for acquiring expertise, intelligence and knowledge not found within the company's walls, that will ultimately give a company

[38] https://www.gov.uk/government/news/guidance-on-technology-readiness-levels

the competitive advantage and improve their export performance. The rise in the formation of external alliances particularly in the biotech, medtech and pharmaceutical industries is partly due to companies attempting to lower costs and de-risk costly product development processes. Over the past decade, pharma has seen a decline in profits, possibly due to patent cliffs or high-risk overinvestment in internal R&D for failed drug candidates[39]. Thus, there exists a growing trend for outsourcing R&D consultancy to academic institutions, commercially focused research centres and contract research organisations (CROs). Interestingly, the CRO sector has grown exponentially over the past decade providing specialist R&D services for a wide spectrum of activities to a widening range of disciplines. This is also reflected in the survey cohort given the high number of CROs who responded.

Furthermore, the survey highlighted regional industry engagement with universities and research centres of excellence has also increased with most respondents (78%) indicating that they had conducted external collaborations with research institutions/universities within the Region, whilst about half (39%) of those conducted similar collaborations outside the Region. These outsourced partnerships set the foundations for trusted strategic relationships which will benefit all parties. Indeed, universities have revised their research and innovation strategies and provided easier access to their facilities and expertise thus supporting industry innovation needs. Collaborative R&D support with research institutions and/or industry partners and general R&D support were noted as crucial to the respondents' organisations. In addition, easier and more streamlined access to core university and research facilities is critical to business outsourcing as reported herein as a further "ask" by the respondents of the survey. Investment in infrastructure, grants and subsidies were all noted as essential support required.

MANAGING R&D AMBITION

Business owned funding of R&D activities can be costly and business decisions regarding apportioning budgets can be challenging depending on resources and need. This is perhaps why those respondents who reported having internal R&D programmes were mostly managing small numbers of projects at a time (less than 5 ongoing). Challenges such as a lack of ready internal R&D capital are often a major barrier of enterprise scaling and growth and more particularly, investment in introducing new technologies such as Advanced Manufacturing. Indeed, almost half of respondents reported cancelling, postponing or dropping up to 10 R&D projects relating to Advanced Manufacturing in the past three years. The top three reasons that best described why R&D projects were cancelled, postponed or dropped were associated with reprioritising of R&D spend, funding issues and other competing business priorities. Many unforeseen forces can shape and alter the course of a well-crafted R&D strategy and businesses often encounter difficult commercial decisions on a daily basis. Moreover, the adoption of new technologies which are likely to involve the breaking of traditional boundaries of manufacturing, facilities upgrading and the training of staff and/or recruitment of new skills requires excessive capital investment and can be high risk. Hence support is vital to enable such industry transformation to progress. To that end greater R&D investment and access to external expertise to allow indigenous businesses to realise their R&D ambition is a major "ask" from the respondents.

Interestingly, the Irish Medtech Association recently commissioned Technopolis Group, jointly funded by the Skillnet Ireland and Irish Medtech Skillnet to develop a useful 7 step guide for medtech companies in Ireland which sets a roadmap for doing just this[40] (Figure 21). Using the 7-step framework, 31 recommendations have been provided including organisation of peer to peer learning groups and exchanging of best practices on how to increase R&D in the medtech sector in Ireland. In order to ensure a more inclusive growth, significant work needs to be done to support smaller

[39] https://www.pwc.com/gx/en/pharma-life-sciences/assets/pwc-r-and-d-outsourcing-in-hi-tech-industries.pdf
[40] https://www.ibec.ie/connect-and-learn/media/2019/12/09/report-reveals-74-of-medtech-businesses-plan-to-increase-rd-in-ireland

businesses and start-ups to grow which will in turn support a more balanced economy. This framework could be implemented as a useful tool within the Region.

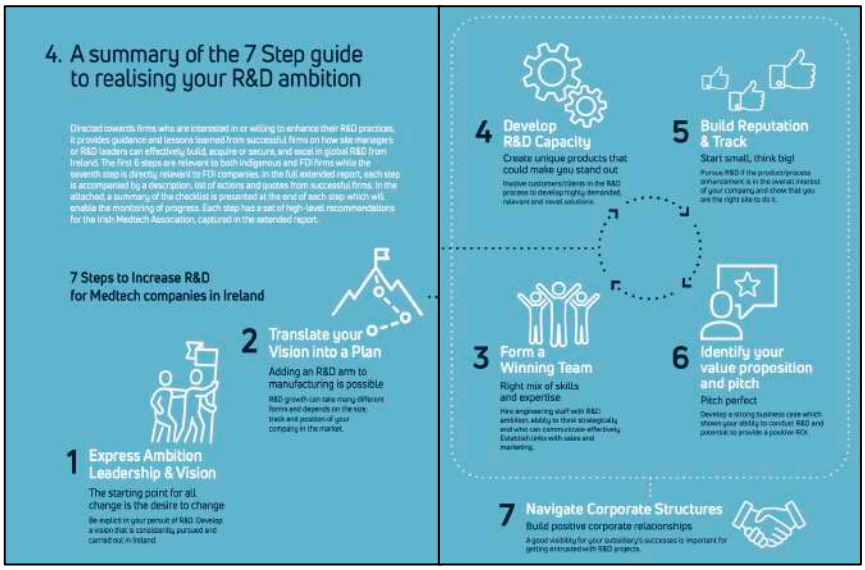


Figure 21. A Summary of the Seven Step Guide to Realising your R&D Ambition. *Source: Realise your R&D Ambition*[40]

Public R&D Support to Build Commercial Competitiveness

All respondents reported availing of at least one source of government funding for R&D in the past three years which is critical to business growth and scaling. UK Research and Innovation (UKRI) summarised the importance of investment in R&D stating that on average £1 of public R&D investment generates around £7 of net benefit to the UK[41]. The principal aim for public investment of RDI is to provide funding and a toolkit to foster and improve productivity and provide a richer innovative ecosystem where industry, business, universities, and public service organisations can work together, helping to attract and retain global investment. Regional governments, associated funding bodies, as well as charitable organisations, provide numerous critical funding levers for industry to allow greater engagement with academia and the research base. This helps to build trusted research collaborative relationships and strategic R&D partnerships, which in turn support with adding value and moving technologies up the TLR levels to becoming market ready. Examples of such programmes include: Invest NI Innovation Vouchers, InterTrade Ireland's Fusion Programme, Horizon 2020 consortium programmes and Horizon 2020 SME engagement scheme, Innovate UK Industrial Strategy Grand Challenges (ISGC) and partnerships through EU funded programmes such as INTERREG VA - NWCAM.

The UK government through the Industrial Strategy gave a firm commitment to increase investment in R&D by 2.4% of GDP by 2027, with a longer-term goal of 3%. In 2017, £34.8 billion was invested in R&D in the UK (up from £33.1 billion in 2016) totalling 1.69% GDP. The EU's Horizon 2020 has provided over €76 billion to ensure that the best ideas and discoveries are brought to the market faster, offering significant opportunities for the Region[42]. The Irish Government have set out as part of the Innovation Strategy 2020, a commitment to increase public and private investment in RDI to 2.5% of GNP by 2020. The R&D Budget 2017-2018 showed that direct Exchequer funding of RDI increased from €739.3 million to an estimated €751.7 million in 2018, the highest amount since 2012. A key target in Innovation 2020 is to secure €1.25 billion from Horizon 2020. Ireland has won €760 million from 2014

[41] http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/science-and-technology-committee/balance-and-effectiveness-of-research-and-innovation-spending/written/90702.html

[42] The EU Framework Programmes and ERDF have provided UK organisations with an income of around €1.1bn a year i.e. ~10% of total government support for UKRI and is around 5% of UK gross domestic expenditure on R&D (GERD)-https://royalsociety.org/~/media/policy/Publications/2017/2017-05-technopolis-role-of-EU-funding-report.PDF

to June 2019 in competitive funding from Horizon 2020 which is equivalent to 1.73% of the total budget committed to date.

Brexit has created an undercurrent of concern that EU funding streams may come to an end or that there will be less cross-border UK-Irish collaborative R&D but given that 80% of respondents stated that they would be interested in engaging in more cross-border R&D in Advanced Manufacturing, it is hoped that these forms of funding streams will continue and increase in the amount of funding available

Business Cross-border and Trans-regional Partnerships

Only a small percentage of the respondents reported having dual cross-border operations in the North and South of Ireland or in Scotland. However, it is thought that the business landscape is likely to change over the coming months and years with a possible increase in joint ventures in Ireland or both sides of the Irish border in response to Brexit and the rising customs and trade tariffs that may be imposed on goods and services as well as complex, expensive regulatory changes to the law. Indeed, joint ventures were noted as being one of the top five principle directions of R&D strategies and can be crucial vehicles for enhancing R&D expertise, expanding facilities and improving trade by moving into new overseas markets from a cross-border perspective. The UK and Ireland currently have an impressive trade history[43]. Ireland is the UK's fifth biggest customer for UK exports and the UK is third biggest customer for Irish exports. Both countries have close economic ties and deep collaborative relationships in relation to the LHS sector, in particular pharma and medtech. In addition, the Life sciences industry comprises 5.6% of UK total trade of which 48% is EU exports while 74% is EU imports.

The effect of Brexit on trade and investment is being felt throughout the Region resulting in a general decline in optimism and confidence. According to aforementioned InterTrade Ireland Business Monitor report, almost one third of larger business said it has had a negative impact on their investment decisions[44]. With the UK having finally left the EU on 31 January 2020, this leaves many businesses concerned about their futures. Brexit is currently one of the greatest challenges for the sector. Therefore, further clarity on the Brexit transition phase must be provided so that industry can prepare. In the meantime, regional businesses should continue to maintain and build upon valued cross-border and trans-regional relationships which will continue to be mutually beneficial from a societal and economic perspective. To enable this, governments, industry, academia (including HE/FE and universities), industry bodies and other relevant stakeholders must identify multiple ways that all stakeholders can engage in a developing and supporting innovation and to ensure relationships continue and new partnerships are forged.

Protecting Innovation through Intellectual Property Rights

There is much evidence to demonstrate that IPR-intensive industries contribute more to the economy compared with those who are non-IPR intensive and pay on average 47% more in wages than other non-IPR sectors[45,46]. The survey considered in more detail the innovation practices of the respondents including whether or not they had invested in IPRs. IPRs are a well-recognised indicator of innovation. They can be the single most valuable asset in a company and can be used as security for raising finance. There are legal rights provided by governments which afford the owner of the right to take legal action against anyone who makes, uses, sells or imports their protected IP without permission. There are four principle forms of IP protected by statute law namely: patents, copyright, design rights and

[43] https://www.gov.uk/government/organisations/hm-revenue-customs
[44] https://intertradeireland.com/insights/business-monitor/
[45] A recent joint study by the EPO and EUIPO over the period 2014-2016 highlighted that IP-intensive industries directly generated 45% of GDP (EUR 6.6 trillion) in the EU annually and account for 63 million jobs (29% of all jobs)- https://www.epo.org/news-issues/news/2019/20190925.html?utm_medium=social&utm_source=linkedin&utm_campaign=postfity&utm_content=postfityd2e08
[46] 22 million jobs supply goods and services to IP-intensive industries thus accounting for ~38% of jobs- https://euipo.europa.eu/tunnel-web/secure/webdav/guest/document_library/observatory/documents/IPContributionStudy/performance_in_the_European_Union/performance_in_the_European_Union_full.pdf

trademarks though this list is not exhaustive and other types of unique rights exist e.g. plant breeder rights, performer's rights and database right. They can be bought, sold, licensed or bequeathed just like any other type of property. In addition, trade secrets and Know-How which can often form a critical part of the business assets, are protectable under the law of confidentiality[47].

Almost two thirds of respondent said they had protected IP in the past five years. Patents represented the most common and strongest IPRs as part of respondent IP portfolios followed by trademarks and then design rights. This is very encouraging that companies are investing in protecting their vital IP assets so as to deter others from copying or taking unfair advantage of their inventive or creative endeavours. In addition, many businesses are recognising the benefit of incorporating trademarks and design right protection into their broader IP portfolios. Design rights can sit alongside trademarks, providing a different level of protection and, crucially, a different means of enforcement. The European Innovation Scoreboard provides a comparative analysis of innovation performance in EU countries and supports countries in identifying areas of risk that may need addressing. Although Ireland remains a "Strong Innovator" and is noted as one of the top ten most innovative Member States, performing above the EU average, its intellectual assets, particularly design applications, is one of the weakest innovation indicator scores. The UK has dropped from the top rank of "Innovation Leader" status to the "Strong Innovator" category and observed similar patterns whereby intellectual assets including PCT applications, trademarks and design rights performed poorly compared with the rest of the EU[48,49,50.]

Another concerning survey observation was that almost one third of respondents had not registered any form of IPR over the past five years. There are several conceivable reasons for this. One barrier may lie with a lack of awareness of the process of IPR protection or that companies simply are not sure of what is potentially valuable new IP or indeed who to contact for advice. It would benefit industry if more financial and IP awareness support was available from government to ensure that technology and product development portfolios are regularly reviewed by an experienced IP professional such that commercially valuable IP can be captured and protected before the products are launched publicly. New technologies such as additive manufacturing present complex challenges for IP advisors and more needs to be done to educate businesses creating IP in these emerging sectors. The cost of protecting and defending patents for an invention can also be a major obstacle for any business with limited resources particularly if, for example it comprises the convergence of a number of technologies into a single product. Thus, other cheaper forms of IP registration such as design rights should be considered in IP strategies to provide another layer of protection. The low cost of design registration, matched by the speed to grant unencumbered by lengthy examination and review, means that design rights are ideal for manufacturers seeking to protect wide and ever-changing product ranges. Design rights are an exceedingly useful inexpensive tool to protect products yet the survey revealed that design registrations were less commonly used by respondents. This was further reflected in the aforementioned European Innovation Scorecard for UK and Ireland in relation to design rights. Likewise, awareness of unregistered design rights, copyright and Know-How which do

[47] The EU definition of "Know-how" can be found in Art. 1 (1)(i) EC Block Exemption Regulation on Technology Transfer Agreements No. 316/2014 and is defined as another form of IP- https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0316&from=EN

[48] https://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en

[49] In a broader context, the EPO's Annual Report highlighted that the number of patent applications filed with the European Patent Office (EPO) grew by 4.6% in 2018 to a new high of 174 317 compared to 2017 (166 594). Of these 47% originating from the 38 EPO member states, 3% and 0.5% where from UK and Ireland respectively. The medical technology field is where the most patent applications are filed at the EPO (up 5% in 2018), followed by digital communication and computer technology. The strongest growth among the top ten fields was recorded in life sciences, with pharmaceuticals and biotechnology combined growing by 13%. Thus, for those innovative companies operating in the LHS sector who have not protected their IP assets, they are less likely to beat the competition who have invested in their IP portfolios. -https://www.epo.org/about-us/annual-reports-statistics/annual-report/2018.html

[50] A primary aim of the Innovation 2020 Strategy was to transform Ireland into a Global Innovation Leader driving a strong sustainable economy and a better society. Ireland appears to have achieved this status in specific sectors and demonstrated excellence in research and knowledge-based innovation activities particularly in the LHS sector. Irish patent applications filed at the EPO rose by 21.4% in 2018, noted as their highest growth rate in a decade compared to the average growth of 3.8% of the EPO 38 member states. Ireland ranks 21st place among the 25 largest patent-filing countries in terms of application volumes. Most notably, Eastern and Midland regions lead the Irish regional ranking with a share of 65% (+26% growth) of all patent Irish applications at the EPO, ahead of Southern Ireland (20% share, +15% growth), and the Northern and Western region (14% share, +11% growth). These latter statistics in part echo the lack of investment in innovation in the more northerly border regions of Ireland. - https://www.patentsoffice.ie/en/news-events/news-categories-/announcements/ireland-posts-strongest-growth-in-patent-applications-at-the-european-patent-office-in-a-decade.html

not require any formal registration should be considered as highly valuable IP assets in an organisation's IP portfolio.

Furthermore, the survey revealed that almost two thirds of IP rights were under the ownership of the respondent and just under a third specified that they also had jointly owned IP with other parties. The latter statistic would positively indicate that a substantial level of collaboration, commitment and co-operation is ongoing with third parties. These may include e.g. universities, CROs, funders, investors, key suppliers, technology developers, content providers, or technology design houses[51].

Respondents reported having low levels of in- or out-licencing or assignments of IP or Know-How. Licencing either exclusively or otherwise, is a useful mechanism to generate revenue, share risks or raise finance and should be widely promoted. Licences provide the rights to a licensee to manufacture and sell products, whilst the licensor receives revenues but does not have to take the risk of manufacturing, promoting or selling the products. The licensee then has the right to use the IP but without the added expense of developing the product. In-licencing can be an efficient means of increasing market penetration by using existing licenced IP in territories that a business does not have cover in or to market more quickly. It is a highly beneficial tool for building upon an existing IP portfolio to create greater profitability. In summary, IPRs are a critical factor that enables innovative businesses to scale and grow. Businesses should be aware of the regional support provided for IPR protection by the many regional IP agencies [52,53,54,55,56].

Building Awareness of the Benefits of R&D Tax Credits

R&D Tax Credits are government initiatives that have been developed to encourage innovation within small and large UK and Irish business providing a valuable source of financial benefit and help to accelerate growth and productivity with tax relief of up to 33% to be claimed for R&D activity[57,58.] There are a number of different forms of schemes and for the purposes of the survey, the focus is primarily on the Patent Box. The survey revealed that only a small proportion of respondents had availed of the UK Government Patent Box tax scheme in the past three years whilst most reported having not taken advantage of it or not been aware of it highlighting a lack of awareness and/or engagement with the scheme. It should be noted that respondents were not surveyed about the equivalent Irish IP tax instrument known as Knowledge Development Box (KDB).

In the UK, the Patent Box allows companies to take advantage of 10% corporation tax rates (compared to the current 19% corporation tax) on profits earned from income from sales, licence fees and/or royalties of patented inventions and/or other equivalent forms of IP[59]. The Patent Box is not only available for patent owners but also to those who hold an exclusive licence to a patent. The Knowledge Development Box is a similar tax relief scheme to support Irish enterprises[60]. The scheme applies a lower rate of corporation tax of 6.25% (compared to the normal rate of 12.5%) on profits on IP assets resulting from qualifying research and development activities carried out in the European Economic

[51] It is worth noting that joint IP ownership, although appearing as a reasonable solution where two or more parties are involved, can be problematic. For example, written consent is required from one party for the other party to enforce its rights and may comprise limitations specified for the sub-licensing and/or licensing of rights and with an obligation to share license revenues. In addition, decisions are required by all parties for practically any or all disposal of the IPRs. Licencing, divestment, litigation and valuation of the IP can also be challenging with the risk of devaluation should the parties have different business strategies. Better approaches are always worth considering instead of agreeing to jointly owned intellectual property.

[52] https://www.gov.uk/government/organisations/intellectual-property-office

[53] https://www.patentsoffice.ie/en/

[54] https://www.epo.org/index.html

[55] https://euipo.europa.eu/ohimportal/en

[56] https://www.wipo.int/portal/en/index.html

[57] https://www.gov.uk/guidance/corporation-tax-research-and-development-tax-relief-for-small-and-medium-sized-enterprises

[58] https://www.revenue.ie/en/companies-and-charities/reliefs-and-exemptions/research-and-development-rd-tax-credit/index.aspx

[59] Patents should cover a product that is sold by the company or a component which is incorporated in the product or indeed a patented process e.g. a new method of manufacturing. Companies are required to notify HMRC if they wish to claim relief under the Patent Box within two years once the accounting period has ended and during which the relevant profits and income were gained- https://www.gov.uk/guidance/corporation-tax-the-patent-box

[60] "Small" companies for the purposes of KDB are companies with income arising from IP/qualifying assets of less than €7.5 million. Qualifying patents include Irish long-term patents and equivalent patents in other jurisdictions provided the patents have been substantially examined for novelty and inventive step. The majority of KDB claims will be for income derived from inventions protected by granted patents. Claimants can avail of KDB for accounting periods that commence on or after 1 January 2016 and before 1 January 2021- https://www.revenue.ie/en/companies-and-charities/reliefs-and-exemptions/knowledge-development-box-kdb/index.aspx.

Area. Qualifying IP include inventions protected by patents and inventions of small companies which are patentable but remain trade secrets or are software. Such R&D tax credits should be on the radar of all senior management of companies who can maximise the financial benefits. Regular advice should be sought from trusted IP specialists and tax accountants to ensure that they are familiar with tax credit qualifying criteria and can demonstrate both the overall income from the qualifying asset as well as a clear link between these expenditures and the profit derived from them.

Prioritising Engineering Skills and Engagement

Engineering skills make up the vast proportion of the capability required to bring Advanced Manufacturing to the LHS sector. The survey highlighted that in the past three years, organisations typically only recruited engineering graduates or engineering interns/placement students with much lower intake of engineering PhD students, apprenticeships and post-doctoral researchers. Moreover 97% of respondents agreed that there was an engineering skills shortage in the Region indicating that skills demand is not being met. This is not just the sentiment of the NWCAM survey; other recent industry studies agree that there is a worrying skills gap in the manufacturing/engineering sector and that companies are not attracting the calibre of trained personnel that they would like. A recent survey by Barclays noted that manufacturing businesses of all sizes are finding skills recruitment difficult at present, both from a skill supply and gap perspective[61].

From a government perspective, in the past few years policies and strategies have prioritised the skills agenda backed by generous funding and bold implementation plans to guarantee that all industry sub-sectors have access to pools of talented people[62]. The Barclays study stated that of the 2012 surveyed young people in the Generation Z (age 16-23) category across the UK only 6% said they would consider manufacturing as a career compared with 23% who were interested in digital /tech and 22% in IT/ computing. Furthermore only 3% of young women said that they would contemplate a career in manufacturing, compared with 9% of young men.

In order to attract a new gender diverse talent pipeline, Barclays have proposed a useful list of "strategies for success" for manufacturing and engineering companies to consider (Figure 22). These include apprenticeships, Knowledge Transfer Partnerships (KTPs), student placements, university consultancy and core facilities access, schools' partnerships and better marketing of the manufacturing sub-sectors to young people. Vocational apprenticeships play a crucial role in supporting skills yet uptake has been slow. In the UK the government-led Apprenticeship Levy came into force in 2017. This is a compulsory tax on all employers with an annual pay bill above £3 million, to help fund the development and delivery of apprenticeships. Perceived barriers to engagement include resistance by enterprises being taxed for a programme they may never use, the complexity of the levy process, and the lack of alignment of the apprenticeship programme with company needs. Yet apprenticeships could carry huge value-add to industry in terms of supporting the skills gap. Other programmes in partnership with higher education such as Innovate UK's KTP program enable businesses to introduce new skills and the latest academic thinking to deliver on a specific, strategic innovation project, both regionally and globally. In addition to traditional skills training in engineering and manufacturing, many new initiatives to address skills of the future are currently being implemented. With the emergence of disruptive data-driven technologies such as additive manufacturing, automation, AI and machine learning, IoT, robotics, Augmented Reality (AR),

[61] Of the 504 manufacturing companies surveyed, 80% said they were finding it hard to recruit to meet existing and new orders, 25% of businesses were finding it hard to recruit skilled workers, with over 20% finding it hard to find experienced staff in advanced technology skills. Over 40% of large companies expected to see availability worsen and 3 in 10 had already noticed a negative impact since the EU referendum vote. In 2017, manufacturing organisations spent £916m on temporary workers, recruitment fees, inflated salaries and training as a result of skills lacking in the UK labour market. The study also highlighted that manufacturers believe that their sector has an image problem e.g. 4 in 10 said perception of careers in the sector have worsened over the past 20 years- https://home.barclays/content/dam/home-barclays/documents/misc/Manufacturing-skills-northern-ireland%20regional%20report.pdf.

[62] At grass roots level UK implementation plans such as "The Post-16 Skills Plan and Independent Report on Technical Education" published by Lord Sainsbury in 2016 have shown some value-add for industry- https://www.gov.uk/government/publications/post-16-skills-plan-and-independent-report-on-technical-education.

Figure 22. Strategies for Success, A New Image for Manufacturing.Source: *Barclays Report*[61]

Virtual Reality (VR) and Mixed Reality (MR), future workforce needs are changing. To ensure that industry is ready for the digital smart age, the Made Smarter Commission and UKRI have empowered Digital Catapult centres to roll out bespoke Industry 4.0 training programmes for local enterprises[63, 64]. These programmes and design-thinking focused training initiatives aim to provide the workforce with a broader range of skills to ensure that industry can work smarter and be prepared for the future of work. It is hoped that such industry preparedness will attract more young people interested in cutting edge Advanced Manufacturing into the sector. Indeed, the Barclays report suggests that "*by targeting 'Generation Z" group, manufacturers could derive an extra 6bn a year by 2023*" and by "*widening and deepening manufacturers' involvement in strategies to address skills shortages*", the manufacturing sector will grow by 11.2% by 2023.

Our survey also suggested a concerning lack of engagement with PhDs and post-doctoral researchers. PhD and post-doctoral programmes provide the opportunity to create a pipeline of talented scientists and researchers with future careers in academia or industry, helping to support economic growth. Industry has much to gain by engaging with young talent early in their career path either through placement, joint sponsorship or through industry-focused challenge-based programmes such as NWCAM. The EU funded NWCAM programme comprises a unique cross-border approach to PhD training through the Marie-Curie Innovative Training network. The research training programmes provide experience outside academia, hence developing innovation and employability skills and where more than one geographical region stands to benefit. Another example of an excellent cross-border PhD training initiative is the €39m Ireland-UK joint partnership between Science Foundation Ireland (SFI) and the UKRI's Engineering and Physical Sciences Research Council (EPSRC) in creating seven new joint Centres for Doctoral Training (CDTs). Such programmes should be applauded in helping to cultivate and develop collaborations between Ireland and the UK, as well as globally.

Other examples of universities and industry working together to support applied R&D and upskilling of industry include what The Manufacturer's Annual Manufacturing Report 2019[65] describes as "lighthouse models". One such model is a partnership between Imperial College London and the Institute for Advanced Manufacturing and Engineering at Coventry University, where industry ready

[63] https://www.madesmarter.uk/governance-partners
[64] https://www.digicatapult.org.uk/
[65] https://www.pwc.co.uk/industries/assets/2019-annual-manufacturing-report-final-web.pdf

students provide digital and technical upskilling support to SMEs by acting as “digital catalysts”. These are akin to co-mentorship-type relationships with the existing staff allowing for the creation of a “natural upskilling environment” with low levels of investment required. Such low cost, high impact programmes should be encouraged and championed throughout the region to help embed new advanced technologies and impart knowledge to industry. Clearly there are many creative methodologies which have been deployed to improve the engineering skills shortage. However, more needs to be done to improve the image of engineering and it should remain a top agenda item for governments, industry and academia alike to attract and retain more young people into the profession.

Conclusions

THE REGIONAL LHS SECTOR

The survey has provided some insights into how the LHS sector is currently thinking within the wider Region of Northern Ireland, Ireland and Scotland. The LHS sector as a high priority growth area delivers innovative research, products and services to global customers in areas such as precision medicine, diagnostics, consumer healthcare, connected health, clinical trials and data analytics. Regional businesses are currently operating in a challenging climate of political, economic and regulatory instability. Separated by land and/or sea borders, the three surveyed regions of Northern Ireland, Ireland and Scotland may be further impacted by Brexit, which has created uncertainty with regard to future trade and exports.

However, despite the challenges, our survey reported an optimistic outlook from the wider regional LHS business community, which appears resilient in the face of adversity. The surveyed sector comprises companies ranging in size from micro-businesses and SMEs to FDI corporations and multinationals. Some operate within robust medtech/biotech clusters and life science corridors of high growth with healthy supply chain. Others particularly those in the Border Region of Ireland, Western Scotland and parts of Northern Ireland operate in areas of growth and investment deficiencies.

AWARNESS & UPTAKE OF ADVANCED MANUFACTURING AS AN ENABLING TECHNOLOGY

Advanced Manufacturing is a transformative technology enabling enhancement of sector capabilities and driving prosperity in areas where R&D and innovation are lacking. The survey reported a growing awareness and understanding of the opportunities that these cutting-edge technologies can offer from boosting productivity and creating new business models, opening up new overseas markets and export power, to ultimately working smarter and more efficiently. Yet despite regional businesses seemingly understanding the benefits of Advanced Manufacturing, they have not fully embraced the technology.

REGIONAL LEVELS OF R&D

The process of integrating new systems into existing production lines is complex, generally requiring long term, high levels of R&D investment and targeted upskilling. Optimistically surveyed respondents demonstrated that they are investing in R&D to some extent but research has shown that larger companies with deeper pockets are more equipped to becoming early adopters of new technologies than SMEs and micro-companies. The latter are more reluctant to invest, inclined to hold back and learn from the mistakes of others before progressing into a high-risk procurement exercise.

Furthermore, anecdotal evidence is suggesting that decisions relating to investment in R&D have been put on hold due to the uncertainty of the Brexit transition whilst resources are being ringfenced in order to cope with the ensuing impact of Brexit. This is a real concern for most micro-companies and SMEs. Larger companies are more likely to thrive, leaving smaller enterprises vulnerable and creating an imbalanced economy. This is perhaps why many, particularly smaller businesses, are beginning to realise they cannot do it all on their own and are reaching out to collaborate. The survey provides clear evidence of a more collaborative culture within the LHS sector, and a willingness for more.

Furthermore, the survey signifies that businesses want to participate in more cross-border and trans-regional engagement, not less. This is despite a backdrop of political turbulence and trading wars resulting in a move from globalisation to nationalism in relation to trade. To that end, governments, industry and other key regional stakeholders should be considering how to forge new ties in imaginative ways to ensure relationships continue within the Region and beyond. It is important that regional governments (including UK, Irish and European) continue to support collaborative and

strategic industry focused R&D in key priority areas such as healthcare and advanced manufacturing. Public investment in RDI must also be able to strike a balance between aligning with global megatrends and challenges that are shaping the economy as well as supporting smaller businesses with their specific challenges and encouraging them to collaborate better.

REGIONAL COMMERCIALISATION LEVELS

It is universally acknowledged that new innovations provide a competitive edge to any business. Our survey reported that many businesses are protecting their intellectual assets but a significant proportion are not. Although governments are rolling out generous R&D tax credit schemes such as the Patent Box and Knowledge Development Box to incentivize and drive companies to invest in innovative R&D and intellectual property protection, many firms are not engaging. This issue must be addressed by governments and industry alike, to understand the barriers to participation and tackle them accordingly.

According to survey respondents, the top seven factors essential to increasing R&D related competitiveness are:

1. Government investment in manufacturing and innovation.
2. Availability of engineering-related personnel.
3. Access to world class research expertise.
4. Clarity on Brexit policies.
5. Modernisation of existing technology.
6. Intellectual property strategies.
7. International commercialisation.

Other essential topics highlighted by respondents were: training, competitor product awareness and access to equipment and facilities.

REGIONAL ENGINEERING SKILLS LEVELS

The survey stressed that skills and recruitment, particularly of engineering talent is a fundamental problem for most regional companies. This is partly because Brexit has forced many EU workers to return to their countries causing a worrying skills shortage within the sector. Furthermore, as the Fourth Industrial Revolution is coming into effect and emerging technologies such as Advanced Manufacturing, digitalisation and automation become mainstream, fears over job displacement for existing workforces remain of deep concern. There is no doubt that adoption of new technologies will reduce the manufacturing workforce but on the other hand, it will bring more value-add roles to equip companies for the future. Businesses are beginning to take measures to retrain and reskill their existing employees but more support is required from governments and education leaders. Moreover, sector leaders and champions hoping to recruit the next generation of engineering/manufacturing talent need to do more to showcase what the profession has to offer.

To conclude, in the context of NWCAM, the survey has highlighted that more regional sector collaborations can make a difference to all sizes of companies where everyone stands to benefit. More regional concentration of R&D funding, more connectedness to address economic gaps in the sector should be encouraged through bringing together new enabling technologies such as Advanced Manufacturing to the LHS and more widely to other industry sectors. There is now a unique opportunity to build on the solid foundation of the regional LHS sector and proactively drive momentum to create a high performing, agile and innovative ecosystem to help the regional economy to thrive.

General Recommendations

Based on the results of the survey and other relevant open source information, we have provided a list of useful recommendations to support the NWCAM consortium and the wider stakeholder network including regional governments (in particular, Departments responsible for economy, health and finance), regional development agencies, industry and key business bodies, funders, sector leaders, industry and academia (FE/HE). We hope that these recommendations will help shape and create a future framework for growing the LHS sector further in the context of NWCAM and deploying Advanced Manufacturing as an enabling technology. It should be noted that identification of who should play lead or supporting roles in each action and costs/ resources for implementation have not been fully considered and will require more detailed discussions with our stakeholders.

Recommendations	Actions to Enhance Advanced Manufacturing in the LHS Sector	NWCAM in Lead or Supporting Role
1. Continue to prioritise the LHS sector as a successful growth sector.	• All stakeholders should come together with one voice and increase dialogue in relation to enhancing sustainable growth and productivity in the LHS with the support of Advanced Manufacturing and other Industry 4.0 technologies.	Support
2. Champion the power and adoption of Advanced Manufacturing as an enabling technology to boost the LHS sector performance alongside other emerging technologies and global trends.	• The adoption of new technologies such as Advanced Manufacturing along with other emerging technologies such as data driven- digitalisation IoT, AI, robotics etc should be encouraged within the LHS sector to futureproof the regional healthcare and wider LHS sector; this will help support diversification, creating new overseas markets, customers and product line expansion for industry to provide a competitive edge. If companies are to capitalise on the benefits of Advanced Manufacturing, a clear strategy and strong leadership from top management/ key stakeholders is vital. • The power and potential of Advanced Manufacturing technologies should be communicated better especially to industry to demonstrate how they can confer benefits: industry must think global! NWCAM can support by building strong case studies to support Advanced Manufacturing canvasing. • At a government and industry body level, consideration should be given to adopting the National Strategy recommendations as applied to Additive Manufacturing to all Advanced Manufacturing themes.	Support Support Support
3. Optimise opportunities for sector networking and building trusted cross-border and trans-regional relationships.	• Key stakeholders should aim to create more opportunities/events to meet and build trusted connections and meaningful interactions within and between research and business communities across sectors, disciplines and borders. This will in turn support a better understanding of industry challenges, leverage cross-border R&D opportunities and maximize the value of R&D for a wider global impact. • Governments, industry, academia (including HE/FE), industry bodies and other relevant stakeholders should identify creative ways that stakeholders can engage in developing and supporting innovation and to ensure relationships continue and new partnerships are forged.	Support Support
4. Develop stronger linkages with other UK, Irish and European Advanced Manufacturing and related LHS research and innovation centres to support and provide opportunities for more collaborative cross-	• NWCAM and other relevant stakeholders should build strong links with UKRI's Catapults e.g. High Value Manufacturing Catapult and related research centres such as the Advanced Manufacturing Research Centre (AMRC), Sheffield, National Composites Centre (NCC), Bristol and Advanced Forming Research Centre (AFRC), University of Strathclyde; build links with other relevant local and regional Catapults e.g. Digital, Medicines Discovery, Cell and Gene Therapy Catapults[66]; Develop upon existing relationships and forge new ties with Ireland's SFI centres such as I-Form, CURAM, AMBER, BEACON,	Lead and Support

[66] https://catapult.org.uk/catapult-centres/

disciplinary research and cluster development.	and CONFIRM[67]; Work closer with Scotland's government backed Innovation Centres such as AFRC, IbioC, CENSIS and Stratified Medicine[68].	
	• Local universities should work more closely with industry, both locally and internationally, to enhance collaborative efforts and attract major industry players to the Region which in turn will help to accelerate productivity and regional cluster and economic development.	Support
	• NWCAM and other relevant stakeholders should collaborate with other EU INTERREG cross-border programmes with cross cutting themes e.g. Centre for Precision Medicine (CPM)[69], Eastern Corridor Medical Engineering (ECME)[70] and CALIN[71] to support cluster development of organisations working in converging fields such as medical/biomedical technologies, AI, computing and engineering; and ultimately to enhance the health innovation ecosystem in the Region.	Lead and Support
	• All stakeholders should align their strategies and policies, where appropriate, with major regional government initiatives such as The Belfast and North West Region City Deal[72] and cross-border North West Strategic Growth Partnership[73] (and similar initiatives in Scotland and Ireland) to leverage their value.	Support
	• Local government regional agencies should champion exemplary models of MedTech cluster growth in the Region given their success in the South West and West Coast region of Ireland. (See discussion and reference to The Irish Medtech Association's Strategy "The Global MedTech Hub) and develop closer relationships with West of Ireland MedTech zones who have led the way in medtech cluster development.	Support
5. Continue to increase the level of collaborative cross-border and trans-regional RDI Funding.	• Stakeholders should market different funding opportunities in the Region to ensure industry takes full advantage of current funding calls e.g. the forthcoming EU PEACEPLUS programme[74], UKRI, SFI, EU/INTERREG/Horizon 2020, Royal College of Engineers, charitable funds (e.g. Wellcome Foundation) etc. There should be a focus on the next wave of Industrial Strategy Challenge Funds and other relevant open funding calls.	Support
	• NWCAM should continue to build upon the NTERREG VA model of applied R&D funding for industry in Advanced Manufacturing and LHS in the Region. It is vital that such cross-border and trans-regional research and innovation programmes such as EU's INTERREG VA continue to be supported by government to build upon existing bonds that currently provide economic benefit.	Lead
	• Local regional agencies e.g. Invest NI should support business with signposting the right R&D funding routes relevant to their needs.	Support
6. Provide greater support for micro-businesses and SMEs to scale and realise their R&D ambition.	• Greater support by regional government agencies for companies especially micro-businesses/SMEs with outsourcing R&D and supporting innovation strategies in order to commercialise and move product development up the TRL scales and diversification. Models such as the seven-step guide provided in "Realise your R&D Ambition", Irish Medtech Association, could be implemented as a useful tool within the Region; signpost and enable access to new sources of finance; promote the best research and market research base better so that industry knows how to access core facilities and expertise through consultancy within FE and HE institutions; provide better support with managing key issues such as Brexit /contingency planning, improving international trade and export capability.	Support
	• Companies can increase their manufacturing exports by rapid scaling; Engagement with accelerator programmes such as Catalyst's Springboard/Way to Scale programmes and collaboration with relevant and	Lead and Support

[67]https://www.sfi.ie/
[68] https://www.innovationcentres.scot/
[69] https://www.ulster.ac.uk/cpm
[70] https://www.ulster.ac.uk/medical-engineering/home
[71] https://irelandwales.eu/projects/calin
[72] https://www.brcd-innovation.co.uk/
[73] https://www.lgma.ie/en/irish-local-government/highlights/north%20west%20strategic%20growth%20partnership.html
[74] https://www.seupb.eu/peaceplus

	international regional Innovation centres (as mentioned above) may be highly beneficial to their growth strategy and new business models.	
	• Regional government to develop and manage a capital investment support programme to help improve and update facilities and equipment; more infrastructure investment.	Support
7. Increase Intellectual Property (IP) Awareness.	• Regional government agencies should manage initiatives to improve the regional IP scores as part of the European Scoreboard in relation to IPR awareness, support, engagement and formal filings of IP; they should ensure greater awareness of the different types of IP available to business; including more affordable forms such as registered and unregistered design protection regimes within Ireland, UK, EU and internationally.	Support
	• Greater financial and IP protection support should be made available by regional government agencies to ensure that technology and product development portfolios are regularly reviewed and actions taken by an experienced IP professional such that commercially valuable IP can be formally searched, captured and protected before the product or process is publicly launched.	Support
	• Businesses in the LHS should consider developing an Intellectual Property strategy as part of their Innovation or R&D strategy.	Support
8. Rebranding of engineering as a rewarding career and champion industry-led PhD and post-doctoral researcher careers.	• Regional governments, academia and industry and other relevant stakeholders must work together to change the perception of engineering and manufacturing careers - develop an inspiring guiding vision that describes a future with the best engineering talent in the world; this could include building a set of Case Studies showcasing "Lighthouse Models" to demonstrate novel methodologies of workforce upskilling and training through Knowledge Exchange programmes (e.g. KTP[75]) industry-challenge PhD and post-doctoral research programmes (e.g. NWCAM) and under- and postgraduate co-mentorships with industry.	Support
	• NWCAM, regional governments, academia and industry and other relevant stakeholders can help to identify key areas where industry-academia collaboration could be beneficial and create more funding opportunities for PhD and post-doctoral programmes with a focus on Advanced Manufacturing and other Industry 4.0 related technologies.	Support
	• Regional academia should combine strengths and competencies to run bespoke training courses to support engineering careers in the LHS sector and other related sectors. NWCAM/Catalyst can support through our wide range of entrepreneurial programmes such as Co-Founders, Invent, Frameworks, Way to Scale[76] to support early stage technology development, business creation, scaling for industry-academic collaborations and a host of other entrepreneurial activities.	Lead and Support
	• Endorse the Apprenticeship Levy with industry working closer together with further education colleges to ensure that training is clearly aligned with business core interests, technologies and methodologies.	Support
9. Increase awareness of R&D Tax Credits.	• Further government support/resources should be given to increase awareness and/or engagement of regional R&D tax credit schemes with business e.g. the Patent Box and Knowledge Development Box.	Support
	• Further support for specialist advice from trusted tax accountants to ensure that companies are familiar with the qualifying criteria for R&D tax credits.	Support

[75] http://ktp.innovateuk.org/
[76] https://wearecatalyst.org/programme/our-programmes/

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Glossary of General Terms

BERD	Business Expenditure on Research and Development
CP	Co-operation Treaty
EU2020	Europe 2020 Strategy
CSF	Common Strategic Framework
CRO	Contract Research Organisation
ERDF	European Regional Development Fund
ESIF	European Structural and Investment Funds
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on R&D
GVA	Gross Value Added
KDB	Knowledge Development Box
LHS	Life and Health Sciences
ONS	Office for National Statistics
R&D	Research and Development
RDI	Research, Development and Innovation
SME	Small and Medium Enterprises
TRL	Technology Readiness Level

Appendix A: Copy of LHS Industry Sector Survey

1. NWCAM Life and Health Sciences Industry Sector Survey

The growth of the regional economy depends on our ability to develop highly skilled, value-adding innovative industries that can compete in a global marketplace. The newly formed North West Centre for Advanced Manufacturing or "NWCAM" supported by EU Interreg VA funding aims to do just that. NWCAM is a virtual cross border centre providing a collaborative support structure to bring applied research expertise and capabilities in advanced manufacturing from 4 world class research institutions to a number of start-ups, SMEs and multinational companies in the Life and Health Sciences (L&HS) sector.

Our vision is to enhance the innovation ecosystem across three specific geographical regions i.e. Northern Ireland, the border region of Ireland and the West of Scotland (the Region) where an underinvestment in manufacturing research and development has severely affected the growth of indigenous companies. NWCAM's core objectives include; increasing the number of cross border industry-to-academia strategic collaborations and partnerships; disseminating and sharing new knowledge from the NWCAM research programs; improving the regional skills requirement; enhancing workforce productivity and efficiency of the L&HS sector; providing tools to scale up, and driving growth through the development and diffusion of new products and processes. For more information, please view the NWCAM website.

We are conducting a survey with a sample of L&HS companies within the Region in order to better understand how NWCAM can support you as an industry. We would like to know more about your company including your commercial needs and concerns, your existing R&D and innovation capabilities and strategies; and whether you have engaged or would be willing to engage in cross border state-of-the-art advanced manufacturing R&D. The information we gather from this survey will help us align our objectives to better meet your needs.

We greatly value your input to this survey. The survey will take approximately 12 minutes.

Privacy Notice

* 1. **For guidance, Questions 1 to 6 relate to general information about your company**

Please provide contact details of your company

Name	
Company	
Address	
Address 2	
City/Town	
State/Province	
ZIP/Postal Code	
Country	
Email Address	
Phone Number	

* 2. What is the approximate total number of employees (i.e. total number of employees registered on the payroll and working proprietors) in your company?

- ◯ Micro Business = less than 10 employees
- ◯ Small Business = less than 50 employees
- ◯ Other (please specify)/Additional Comments
- ◯ Medium Business = Less than 250 employees
- ◯ Multinational corporation

* 3. What is the approximate annual turnover of the company for FY17/18?

- ◯ Less than £5 million
- ◯ Between £5 - £10 million
- ◯ Between £10 - £25 million
- ◯ Other (please specify)/Additional Comments
- ◯ Between £25 - £50 million
- ◯ Greater than £50 million

4. What is the current position of your company?

- ◯ Start-up/Pre-revenue
- ◯ Rapid growth/expansion
- ◯ Moderate expansion
- ◯ Slight expansion
- ◯ Stable
- ◯ Reducing
- ◯ Winding down
- ◯ Other (please specify)/Additional Comments

5. Where does your company mainly operate in?

- ☐ Northern Ireland
- ☐ Scotland
- ☐ Republic of Ireland
- ☐ Rest of UK
- ☐ Rest of Europe
- ☐ All other countries

* 6. Which of the following best describes the activities of your company?

- ☐ BioPharmaceutical - Core
- ☐ BioPharmaceutical - Service and Supply
- ☐ MedTech - Core
- ☐ MedTech - Service and Supply
- ☐ Digital Health
- ☐ Health -Food /Nutrition
- ☐ Other (please specify)
- ☐ Animal Health
- ☐ Contract research & Manufacturing
- ☐ Equipment and Consumable suppliers
- ☐ Clinical Research Organisation
- ☐ Other specialist suppliers

* 7. **For guidance, Questions 7 to 10 relate to your company's general interests in Advanced Manufacturing.**

Is your company aware of the potential of Advanced Manufacturing as an enabling technology to enhance industry productivity, competitiveness and improve the regional economy.

- ◯ Yes
- ◯ No

* 8. What are the topics of interest in Advanced Manufacturing that your company would be most interested in?

- [ ] Sustainable Manufacturing
- [ ] Nano-Manufacturing
- [ ] Advanced Polymers
- [ ] None of the above
- [ ] Additive Manufacturing/3D Printing
- [ ] Other: -Please identify any other type of Advanced Manufacturing interests that you consider important to your company

* 9. How important is the adoption of Advanced Manufacturing to your company?

- ( ) Extremely
- ( ) Slightly
- ( ) Very
- ( ) Not at all
- ( ) Moderately

* 10. Is your company interested in engaging in cross border collaborative R&D in Advanced Manufacturing?

- ( ) Yes
- ( ) No

If No, please specify reasons why?

11. **For guidance, Questions 11 to 28 relate to your company's interests in Innovation and Research and Development (R&D).**

Which of the following best describes your company's innovation activities?
Please note that the definition of "innovation" in this survey is taken from the EU-wide definition adopted by Eurostat.

- [ ] Introduction of new or significantly improved products (goods or services) or processes
- [ ] 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
- [ ] Other (please specify)/Additional Comments
- [ ] Investment activities in areas such as internal research and development, training, acquisition of external knowledge or machinery and equipment linked to innovation activities
- [ ] None of the above

12. Which of the following best describes your company's innovation strategy over the next 3 years?

- [ ] Upgrade or introduce new innovative facilities and/or equipment
- [ ] Introduction of new advanced manufacturing methodology
- [ ] Training for innovative activities
- [ ] Internal research and development
- [ ] External research and development
- [ ] Changes to product/process or service design
- [ ] Other (please specify)/Addtional Comments
- [ ] Investment in market/competitor research
- [ ] Investment in protection of intellectual property
- [ ] Launch of new products/processes
- [ ] Launch of existing products/processes into new markets
- [ ] None of the above

* 13. Does your company have an R&D strategy?

- ◯ Yes
- ◯ No

If No, please specify reasons why you do not have an R&D strategy or plan

* 14. What is your company's R&D strategy horizon?

- ◯ 1 - 2 years
- ◯ 3 - 5 years
- ◯ Other (please specify)/Addtional Comments
- ◯ Greater than 5 years
- ◯ Not applicable

* 15. How would you best describe the principal directions of your company's R&D strategy?

- ☐ New product development activities
- ☐ Development of new production facilities
- ☐ Acquisition or mergers with company operating in similar market segment
- ☐ Spin-off or disposal of non-core business
- ☐ Other (please specify)/Additional Comments
- ☐ New joint venture
- ☐ New sources of finance
- ☐ Not applicable

* 16. Outside of grant income, what is your company's annual R&D spend as a percentage of annual revenue?

- Less than 1%
- 1-5%
- 6-10%
- 11-15%
- 15-20%
- Greater than 20%
- Not applicable
- Other (please specify)/Additional Comments

* 17. What percentage of your company's R&D activities are performed internally?

- Less than 1%
- 1-5%
- 6-10%
- 11-25%
- 26-50%
- 51-75%
- 76-100%
- Not applicable
- Other (please specify)/Additional Comments

* 18. How many on-going R&D projects is your company currently running?

- Less than 5
- 5-10
- 11-25
- 26-50
- Greater than 50
- None
- Not applicable
- Other (please specify)/Additional Comments

* 19. With regard to Technology Readiness Levels (TRL) on average how would you best describe the TRL of the ongoing R&D projects in your company?

- [ ] TRL1 - Basic research
- [ ] TRL2 - Research to prove feasibility
- [ ] TRL3 - Product/process development - experimental Proof of Concept
- [ ] TRL4 - Product/process Validation in the lab
- [ ] TRL5 - Validation in production equipment or demonstrator
- [ ] TRL6 - Product/Process capability & system development
- [ ] TRL7 - Product/Process capability on economic run
- [ ] TRL8-9 Capability validated on runs over a range of parts
- [ ] TRL10 - Capability validated on full range of parts over long period
- [ ] Other (please specify)/Additional Comments

* 20. How many of your company's on-going R&D projects relate to Advanced Manufacturing?

- ( ) Less than 5
- ( ) 5-10
- ( ) 11-25
- ( ) 26-50
- ( ) Other (please specify)/Additional Comments
- ( ) Greater than 50
- ( ) None
- ( ) Don't know
- ( ) Not applicable

* 21. In the past three years, how many R&D projects relating to Advanced Manufacturing has your company cancelled, postponed or dropped?

- ( ) Less than 5
- ( ) 5-10
- ( ) 11-25
- ( ) 26-50
- ( ) Other (please specify)/Additional Comments
- ( ) Greater than 50
- ( ) None
- ( ) Don't know
- ( ) Not applicable

* 22. Which of the following reasons best describes the reasons for cancelled, postponed, scaled down or dropped projects in the past three years?

- [ ] Reprioritising R&D spend
- [ ] Board and/or investor strategic focus shift
- [ ] Staff changes
- [ ] Other competing business priorities for example sales
- [ ] R&D project milestones not met
- [ ] Funding issues
- [ ] Other (please specify)/Additional Comments

* 23. Does your company have external R&D collaborations with any of the following?

- [ ] Research institutions /universities within the Region
- [ ] Industry partners outside the Region
- [ ] Research institutions /universities outside the Region
- [ ] Joint collaborations with both research institutions/universities and industry within the Region
- [ ] Industry partners within the Region
- [ ] Joint collaborations with both research institutions/universities and industry outside the Region
- [ ] Other (please specify)/Additional Comments

* 24. How many external R&D collaborations are related to Advanced Manufacturing?

- ( ) Less than 5
- ( ) Greater than 50
- ( ) 5-10
- ( ) None
- ( ) 11-25
- ( ) Don't know
- ( ) 26-50
- ( ) Not applicable
- ( ) Other (please specify)/Additional Comments

* 25. Which of the following governement funding agencies have you received R&D funding from in the past three years?

- [ ] Invest NI
- [ ] Intertrade Ireland
- [ ] Innovate UK
- [ ] Enterprise Ireland
- [ ] EU Funding
- [ ] Local council funding
- [ ] International funding
- [ ] None of the above
- [ ] Other (please specify)/Additional Comments

* 26. What types of R&D support would most benefit your company?

- [ ] Support for skills training/upskilling/professional development
- [ ] Access to highly trained staff
- [ ] Support for R&D
- [ ] Support with innovation and intellectual property protection
- [ ] Collaborative R&D support with research institutions and/or other industry partners
- [ ] Investment in infrastructure, grants and subsidies
- [ ] Tax and other financial incentives
- [ ] Student work placements
- [ ] Apprenticeships
- [ ] Support with Apprenticeship Levy
- [ ] Support with networking and marketing
- [ ] Cash flow/Loans support
- [ ] Other (please specify)/Additional Comments

* 27. Has your company availed of Government R&D tax credits in the last 3 years?

- ( ) Yes
- ( ) No
- ( ) Not aware of it

* 28. Which of the following factors do you consider are essential for increasing the R&D competitiveness of your company?

- [ ] Government investment in manufacturing and innovation
- [ ] Availability of engineering-related personnel
- [ ] Stability of regulatory, tax and economic policy
- [ ] Cost and availability of raw materials
- [ ] Market attractiveness - size and ease of access to local market, local competition
- [ ] Launch of new facilities
- [ ] Labour cost reduction
- [ ] Marketing
- [ ] Other (please specify)/Additional Comments
- [ ] Modernisation of existing technology
- [ ] Reduction in energy costs
- [ ] Product/Process line extension
- [ ] Access to world class research expertise
- [ ] International commercialisation
- [ ] Intellectual property strategy
- [ ] Clarity on Brexit policies

* 29. **For guidance, Questions 29 to 31 relate to your company's interests in Intellectual Property.**

Has your company registered any of the following intellectual property (IP) within the past 5 years?

- [ ] Patents
- [ ] Trade Marks
- [ ] Other (please specify)/Additonal Comments
- [ ] Design Rights
- [ ] None of the above

* 30. Does your company currently hold the rights to any of the following:

- [ ] Proprietary intellectual property- owned solely by the company?
- [ ] Proprietary intellectual property- owned jointly by the company and other party(s)?
- [ ] In-Licences for intellectual property/Know-How?
- [ ] Out-licences for intellectual property /Know-How?
- [ ] Assignments of intellectual property/Know-How?
- [ ] Other (please specify)/Additional Comments

* 31. If you are a UK company, has your company availed of the Government's Patent Box tax relief scheme?

- ( ) Yes
- ( ) No
- ( ) Not aware of it

* 32. **For guidance, Questions 32 & 33 relate to your company's interests in engineer employment.**

Has your company employed or engaged any of the following in the past three years?

- [ ] Engineering graduates
- [ ] Engineering interns/placement students
- [ ] Engineering PhD students
- [ ] Other (please specify)/Additional Comments
- [ ] Engineering apprenticeships
- [ ] Engineering post-doctoral researchers

* 33. Do you agree that there is a engineering skill shortage in the Region?

- ( ) Strongly agree
- ( ) Somewhat agree
- ( ) Agree
- ( ) Somewhat disagree
- ( ) Strongly disagree

* 34. Are you willing to discuss this survey further with Catalyst Inc?

- ◯ Yes
- ◯ No
- ◯ Other (please specify)/Additional Comments

Interreg
EUROPEAN UNION
Northern Ireland - Ireland - Scotland
European Regional Development Fund

Special EU Programmes Body
Foras Um Chláir Speisialta An AE
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Funded by the EU's INTERREG VA Programme which is managed by the SEUPB.
Catalyst is the lead partner in the delivery of the project.

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